Arsénio Reis · João Barroso ·
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Communications in Computer and Information Science 1720

Technology and Innovation in Learning, Teaching and Education

Third International Conference, TECH-EDU 2022
Lisbon, Portugal, August 31–September 2, 2022
Revised Selected Papers

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Preface

Over the last decade, the idea of integrating digital learning technologies and innovations in schools, higher education institutions, and lifelong learning settings has received a growing educational and research interest. In addition, it is further supported by the current educational policies in Europe and worldwide as well. On the other hand, the scientific debate regarding the integration of the emerging digital technologies in education is directly related to the objective of preparing primary, secondary, and higher education students to become competent and effective members of the 21st century society as critical thinking, creative, independent, and self-directed learners.

In addition, it is widely agreed that the COVID-19 pandemic had a significant impact on education in terms of accelerating the adoption of digital technologies and e-learning practices in schools and higher education institutions. Primarily, the experience of emergency remote teaching affected educators' thinking about the role of digital technologies in 21st century classrooms and the need to adopt new educational practices that promote students' engagement, critical thinking, communication, and collaboration. In this perspective, the affordances of online technologies and digital innovations are expected to support learners' cognitive and social engagement in many flexible and blended ways; for example, by connecting in-class and outside learning activities. Moreover, educators are expected to have enhanced opportunities to transform their traditional practices and create effective learning environments that are more participatory, authentic, collaborative, and self-directed.

The papers included in this book were originally presented at the 3rd International Conference on Technology and Innovation in Learning, Teaching and Education (TECH-EDU 2022) which took place at NOVA-IMS, Lisbon, Portugal, during August 31 – September 2, 2022. TECH-EDU is an international forum for academicians and researchers to present their current research regarding theoretical, technological, pedagogical, organizational, instructional, and policy issues about learning technologies and innovations in education. The first in-person conference, TECH-EDU 2018, was hosted in Thessaloniki, Greece. TECH-EDU 2020 was organized online due to the COVID-19 pandemic. The third edition was a hybrid conference and all sessions included both in-person and online presentations.

This book comprises a set of high-quality scientific papers presenting theoretical perspectives, pedagogical innovations, original empirical investigations, case studies, and educational practices based on emerging learning technologies. Bringing together contributions from different educational systems and countries internationally, like Portugal, Greece, Germany, Lithuania, Romania, Brazil, and the United Arab Emirates, this volume is expected to serve as a multidisciplinary forum that reflects a comprehensive view of the current research trends about digital technologies and innovations in education.

The original papers were submitted and peer reviewed through the T4People Conference Management System. A total of eighty contributions were submitted for review and 40 papers were accepted after a double blind review process. The contributions presented at TECH-EDU 2022 received positive criticism and suggestions from at least two independent reviewer-experts in the field. The accepted papers were presented in ten sessions distributed over three conference days.

The final outcome of TECH-EDU 2022 is the present book of 39 chapters dealing with specific topics in the research field of learning technologies and innovations. The diversity of papers opens up new discussion links among researchers and they constitute seven thematic areas as follows:

- Emergent technologies in education (5 papers);
- Online learning and blended learning (6 papers);
- Computer science education and STEM (4 papers);
- Digital tools and STEM learning (4 papers);
- ICT and critical thinking in higher education (8 papers);
- Digital transformation in higher education (6 papers);
- Artificial Intelligence in Education (6 papers).

On behalf of the Organizing Committee we want to thank all authors for submitting their contributions to TECH-EDU 2022 – especially because they reworked their manuscripts to reach the final form presented in this book. We are also grateful to the reviewers for their constructive comments and suggestions, which contributed to an overall improvement of the chapters' quality.

I am hopeful that this book will have a positive impact and will be accepted by the international community of learning technologies and digital innovations as a valuable contribution to this research field.

October 2022

Arsénio Reis
João Barroso
Paulo Martins
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Structuring Collaborative Setting in the Learner Centered Learning Environment

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Abstract. In computer supported collaborative settings there is a need to structure collaboration in order to foster productive interactions. In the Learner centered Learning (LcL) environment, which is an activity-oriented learning environment, the structuring of collaborative setting addresses issues related to the formation and collaboration model followed by the groups and to the structuring of the dialogue. The communication tool supports both the free and the structured form with different scaffolding communication means. The teacher can adapt the collaborative setting, i.e. the model of collaboration and the communication tool according to the collaborative activity designed. The results of the preliminary study conducted, revealed that the students used the structured form adequately resulting into more coherent conversations and they acknowledge the added value of the structured form.

Keywords: Collaborative activities · Communication · Structured dialogue

1 Introduction

The traditional model of teacher-centered learning gives ground to constructivist learning settings that give focus to student [1]. Within higher education institutions, student-centered learning environments have been adopted as they underpin blended learning [2]. The learning characteristics of a student-centered learning environment may include an active and guided learning process, as well as collaborative learning [1, 3]. In collaborative settings, students become aware and construct their own knowledge when they represent their concepts/ideas to the others, explain/justify their points of view, articulate their reasoning and elaborate/reflect upon their knowledge [4]. However, there is no guarantee that students will have the desired skills to communicate and collaborate in productive ways [5, 6]. Productive collaboration entails skills to ask questions, to provide explanations, to make proposals and counter proposals, to summarize, to manage conflicts and make decisions.

Collaboration can be supported by appropriate means. According to Dillenbourg, there are two approaches [7] "collaboration can be influenced anticipatively by structuring the collaborative process to favour the emergence of productive interactions, or

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retroactively, by regulating interactions". The structuring approaches focus either on the application of scripts for collaboration or by designing and providing communication tools for structured communication [7]. Scripting may enable the integration of individual and collaborative activities, may define the roles and the framework that students should follow while collaborating. The structured dialogue may be fully or semi-structured, implemented through communication interfaces, which utilize predetermined Scaffolding Sentence Templates (SST) that enable learners to compose their message and denote their underlying intention. Two types of SST are used in synchronous and asynchronous communication tools: sentence openers and communication acts.

Results from various research efforts indicate that the use of structured dialogue supports and increases learners' task-oriented behaviour, leads to more coherence in discussing argumentatively the task, facilitates learners to follow the sequence of messages and respond appropriately [8–10, 19]. Ak [11] examined the effects of technology-based scaffolding (message labels and sentence openers) in an online asynchronous discussion process structured with problem-based learning strategy. The technology-based scaffolds were composed through the use of the seven-stage problem-based learning process theoretical framework (e.g. for the "Understand all terms" stage, sentence openers like "The difficult term is…", "The explanation is…" were used). The results generally showed that using technology-based scaffolding might be an effective way to enhance students' task-related learning activity. In this direction, Avci [12] examined the role of sentence openers, role assignment scaffolds and self-determination in collaborative knowledge building. The research results stress that sentence openers help the group members to express their ideas clearly; also, sentence openers have an important contribution to the self-determination of the group and the knowledge building process. The structured form of dialogue, and in particular sentence openers, are used in dialog game tools [21] and role-playing games [22] showing a tendency for scaffolds to raise the potential learning value.

A number of approaches and communication tools have been developed, forming a broad spectrum of possibilities, from the unstructured to the structured. These differ in the form of dialogue they support; for example the communication tool of LeCS [13], Conference MOO [14] and Co-Lab chat [15] support both the structured and the free form of dialogue whereas the communication tools of EPSILON [6], C-CHENE [16] and BetterBlether [17] support only the structured dialogue. In case of structured dialogue, they usually support only one form (sentence openers). The work of [11] considers message labels, sentence openers or both in a problem-based online asynchronous discussion. The exchanged messages are presented in chronological sent order or in tree structure (i.e. threads of messages), having most of the tools present the dialogue in chronological order. A final critical issue in structuring collaboration is whether the scaffolding communication means can support any type of collaborative context and whether capabilities for adaptation are provided.

The work presented focuses on the modelling of the collaborative setting in the Learner centred Learning (LcL) environment [18], and in particular on the communication tool developed. The collaborative setting in LcL follows a structured approach in terms of scripting the activity and structuring the communication. The design principles of the communication tool take into account the research results in structuring dialogue in order to promote collaboration in an activity oriented learning environment that can support any subject area. In the following, an overview of the collaborative setting is given, a detailed presentation of the communication tool is provided and finally the results from a pilot empirical study are discussed.

2 Structuring Collaboration and Communication

2.1 The LcL Environment

The LcL environment serves learning and assessment by engaging learners in different forms of activities [18]. The design of the activities is based on certain pedagogical principles. First of all, the activities may support either learning (knowledge construction) or assessment (ascertainment of students' prior knowledge, formative assessment or summative assessment). In both cases, an educational method is followed and specific educational tools may be prescribed. For example in the context of a programming subject matter, learning activities may follow the problem-based learning approach and propose the use of a specific educational programming environment while for assessment purposes the use of concept map tool may be considered appropriate. The activity addresses specific learning goals (i.e. learning outcomes on the basis of the revised Bloom's taxonomy) and applies an action framework. The action framework models attributes related to the type of the activity (i.e. individual or collaborative), the difficulty level, the degree of importance for the accomplishment of the defined learning goals and any accompanied educational material (e.g. a case study, the code of a program). Depending on the educational function and the underlying learning goals, the assessment is automatic or is carried out by the educator in case of open-ended questions, questions that don't have a unique answer or questions that require justification. Also, the environment provides multiple types of informative and tutoring feedback components at activity and task-question level and deploys open learner model to promote self-regulation [18].

2.2 Model of Collaborative Activities

In case of a collaborative activity, the action framework structures the collaboration so that the appropriate conditions are established before the collaboration begins [6]. Figure 1 presents the model of the collaborative activities in LcL. Collaborative activities may consist of a number of collaborative or individual tasks-questions (Fig. 2) attempting to achieve specific learning outcomes. The task requests from the student or the group to elaborate on specific concept issues and submit the answer either in closed or opened form or as an attached file. During activity assignment, the teacher defines the groups either automatically or by selecting specific students to form each group. The group members may collaborate following specific roles (e.g. the roles of "Driver" and "Observer" in case of pair–programming model or "Reporter", "Recorder", "Innovator", etc. in the context of a project (Fig. 3)). The teacher may adapt the predefined roles or define new ones on the basis of the collaborative activity (Fig. 3).

As far as the communication is concerned, the students may have access to the communication tool for

i. conversations on a task-question that needs to be answered as a group (generated automatically upon assignment),
ii. conversations on an individual task-question (the teacher, depending on the learning outcomes, may enable students' collaboration for clarifying issues and exchange opinions, but the answer is composed and submitted by each student separately), or
iii. conversations that are created by the teacher after the assignment to cover any need that arises during the preparation of the work.

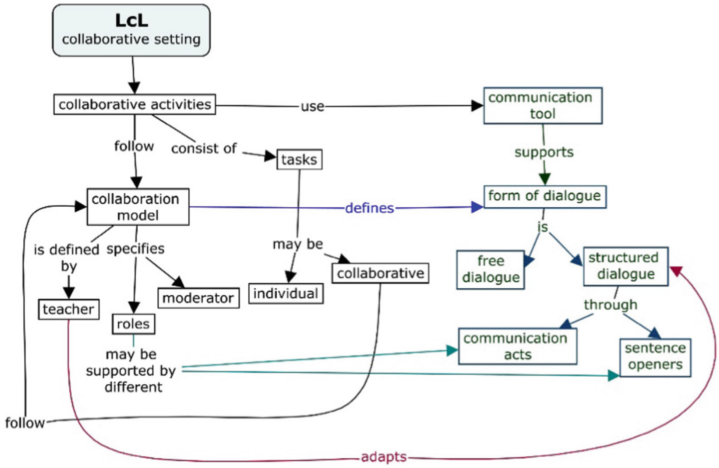

Fig. 1. The model of collaborative activities in LcL.

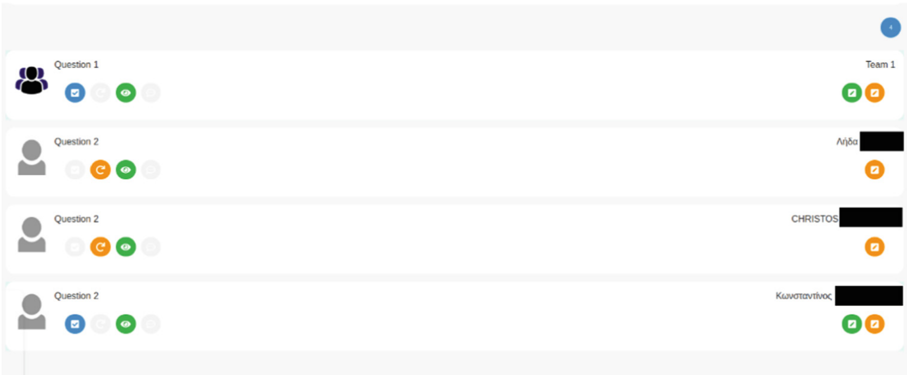

Fig. 2. The collaborative activity consists of two tasks-questions; the first one is answered by the group while the second one by each member separately.

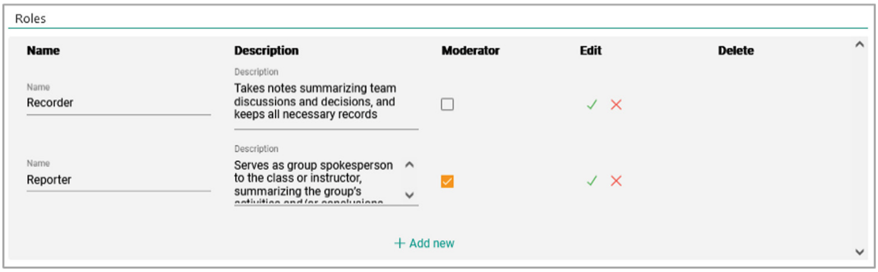

Fig. 3. Defining roles.

2.3 Communication Tool

The communication tool supports multiple conversations per group in order to cover the needs of collaboration in the context of a specific activity. The group members may use either the free or the structured form of dialogue, depending on the teacher's specifications. The structured form may be accomplished either through sentence openers or communication acts. The provided sets of SST are quite general, as LcL is an environment that can be used in any subject matter and the context of any collaborative activity. Specifically, the definition of the provided set of communication acts and sentence openers was based on the work of [19]. The following discourse categories are provided: Proposal (P) exhibiting skills in making proposals/counter-proposals, Opinion (O) exhibiting skills in expressing an opinion/belief, Question (Q) exhibiting skills in posing a question or asking for clarification/justification, Reason (R) exhibiting skills in justifying a proposal/agreement/etc., Clarification (C) exhibiting skills in clarifying/explaining an issue, Agreement (A) exhibiting skills in arguing positively, encouraging, and/or confirming a contribution, Disagreement (D) exhibiting skills in expressing an opposite view or a doubt, Inference (I) exhibiting skills in summarizing and/or concluding a debate, Motivation (M) exhibiting skills in stimulating interlocutors to participate, Need (N) exhibiting skills in asking for help/support and Social Comments (S) characterizing off-task messages. The predetermined set of the SST includes:

a. a subset dedicated to the development/cultivation of cognitive skills (e.g. the sentence openers: "I propose", "I agree with"; the communication acts: "Proposal", "Agreement"),
b. a subset facilitating the communication (e.g. the sentence openers: "I don't know. Can you help me?", "Can you explain ?"; the communication acts: "Social Comments", "Comments on the Activity"), and
c. a subset available only to the moderator of the group (e.g. the sentence openers: "We conclude that the answer is", "Let's move on to the next question"; the communication acts "Answer", "Group Coordination").

The set may be adapted according to the roles assigned to each member. The teacher can enrich the provided set of SST taking into account the context of the activity and the model of collaboration followed (Fig. 4).

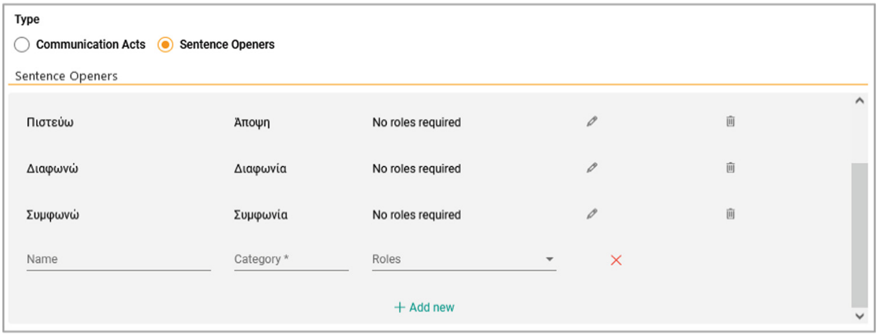

Fig. 4. Editing of SST. The teacher may define the SST label, category and relation to roles.

The messages are represented in threads form facilitating the monitoring of the conversation flow (Fig. 5). The teacher can supervise and manage the conversation (e.g. delete improper messages, "close" a conversation).

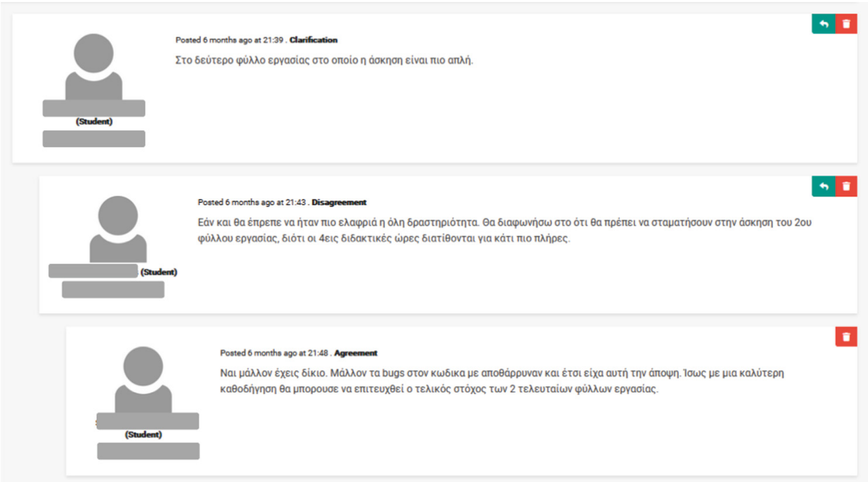

Fig. 5. Two students are discussing using communication acts

2.4 Empirical Study

Within the course "Didactics of Informatics" at the Department of Informatics & Telecommunications in the winter academic semester 2021–2022, the communication tool was used and evaluated by both the teacher and the students. The research questions involved the following

Q1: Is the proposed form of dialogue in accordance with students' preferences? Which are the students' preferences?

Q2: Is the dialogue on-task and coherent? Did the students use the appropriate SST?
Q3: Is the provided functionality of the communication tool adequate and easy to use?

The evaluation is based on students' subjective estimations revealed from their answers to a questionnaire provided online and on the analysis of students' dialogues. The 25 students participated had no experience in the LcL environment and in discussion using the structured form. The teacher (one of the authors) monitored students' conversations during assignment in order to provide help, if needed, and also evaluated the provided functionality and the user interface. Two of the authors analysed the conversations to draw conclusions about the participation, the flow of the conversation and the use of SST.

Activities: The teacher designed and assigned two activities. Both concerned the peer-assessment of a learning design developed for a specific computer science concept following specific educational principles and using specific technological tools. The first assignment was defined to be carried out using the structured form of dialogue (i.e. communication acts) while the second one using the free form of dialogue. The students collaborated in groups of two while one group consisted of three members. The teacher formed the groups taking into consideration students' performance during the course to ensure as much as possible productive, efficient, and equal contributions. The groups had to discuss and assess their peer's learning design on the basis of specific criteria and submit a common rubric as their answer. The students were assigned both activities at the same time and each group could handle completing the tasks on their own pace and preferred sequence.

Results

Q1: Is the proposed form of dialogue in accordance with students' preferences? Which are the students' preferences?

Students' answers to a related question, showed that they prefer the free form of dialogue at a rate of 70%. The free form gives them the opportunity to communicate with their fellows in a more familiar way; indicative answers include "*Although, I had no problem to use both types, I think that free dialogue is more natural, you do not need to filter what you will write*", "*Free dialogue allows for free expression and each evaluator expresses his / her opinion following his/her personal style for the purpose of the evaluation*". On the other hand, the structured form needs experience and time in order to be acquainted with. Although they prefer the free form, in their answers, they acknowledge the contribution of structured form of dialogue to more coherent conversations "*With structured dialogue, I had to process my thoughts more before answering, so I could better control their structure, coherence, and content. In the end, I felt that my answers were more complete and conveyed what I wanted to say.*", "*When you go to read a message in structured dialogue, you have a "preview" of the intention / importance of the message that helps to understand it faster and avoid* *misunderstandings.*", "*I really liked the ability to choose the type of message, and I consider important that I had a plethora of options that covered all the posts I made.*"

Q2: Is the dialogue on-task and coherent? Did the students use the appropriate SST?

The conversations were analysed in terms of (i) whether students used the most appropriate communication act with respect to the context of the dialogue, (ii) whether students tried to make references to their interlocutor's messages, and (iii) whether the form of dialogue influences the coherence/readability of the conversation.

The students exchanged 227 messages using the structured form and 185 messages using the free form of dialogue. Table 1 presents the messages per group and per form of dialogue as well as the forms of SST used in the case of structured dialogue.

The analysis of students' structured form of dialogue revealed that most groups tried to use various SST categories. As expected, the most common ones lie in the category of Proposal, Opinion, Agreement and Disagreement, as students expressed their views for the work they were assessing and their response to their fellow.

Two of the authors analysed the conversations and classified each message according to the SST categories used [19]. The inter-rater agreement was 90%. The analysers discussed and resolved any differences and proceeded to rating the SST category of each message (e.g. Proposal, Agreement, etc.) as correct or incorrect with respect to the context of the message. The inter-rater agreement of the two analysers was 100% but the degree of variation from the students' selection was about 82%. This was due to the double meaning and intention of some messages (e.g. disagreement, justification, and proposal or agreement and opinion); the students used a single contribution-post and one SST category. For example in the following excerpt, the student expresses his agreement and justification and continues with a new proposal in a single message-post:

> *I agree for the criterion of completeness to give the rating level of '3' because they were not extended to other computing systems.*
>
> *For creativity I would suggest the rating level of '5' because in general I liked the case study and it seems extra "creative" because they used web 2.0 tools.*

The analysis of the conversation of the three groups (T7, T11 and T12) that used only the Proposal SST, unveiled that the students used expressions denoting agreement, question, disagreement, but seemed to be reluctant in choosing the appropriate SST category. The number of messages exchanged, reveals differences between groups, as some groups discussed analytically each criterion of the rubric (like the T3 group), while others addressed more than one criteria in one message-post.

In the case of the free form, most groups intended to discuss the work they assessed in its entirety, attaching the rubric form in their message-post; this resulted in a limited number of posts (e.g. groups T1, T2, T4, T9) and in reduced number in comparison to the number of posts exchanged in the structured form (e.g. T1, T2, T7, T12). Also, the conversations show that the students were reluctant to use phrases like "I agree", "I disagree", "I believe", "what do you think", and they just preferred to exchange rubrics.

Overall, it seems that the structured form urged students to think of their intended post as well as of their fellow's post and contribute to the conversations using the appropriate

SST. This observation is in accordance with students answers (Fig. 6 and Results of Q1); they appreciate the benefits of the structured form as the majority considers that it can help in the cultivation of communication skills.

Regarding the level (depth) of the exchanged messages, it is worthwhile mentioning that in the case of structured form some conversations unfolded to four levels, while in the free form of dialogue, the conversations were flat, without any linking replies.

Table 1. Number of messages and type of SST per group and form of dialogue

Group	No of messages free form	No of messages structured form	Types of SST used in structured form
T1	10	31	Social comment, Proposal, Opinion, Agreement, Question, Clarification, Disagreement
T2	5	16	Proposal, Opinion, Agreement
T3	79	56	Proposal, Agreement, Question
T4	8	9	Social comment, Proposal, Opinion, Approval
T5	21	24	Proposal, Opinion, Agreement, Clarification, Approval
T6	9	11	Proposal, Opinion, Agreement, Disagreement
T7	12	20	Proposal
T8	11	11	Proposal, Agreement, Disagreement, Question
T9	6	10	Proposal, Opinion, Agreement
T10	16	18	Proposal, Opinion, Agreement, Question, Justification
T11	7	7	Proposal
T12	1	16	Proposal

Q3: Is the provided functionality adequate and easy to use?

The teacher evaluated the provided functionality as quite adequate but mentioned the following points as critical for improvement.

– possibility to change the group moderator and the name of the group
– present the names of the members in the list of assignments
– access to the group's answer while monitoring the conversation

As far as the students' opinion is concerned, their answer to relevant questions revealed that it is necessary to receive notification message for any new posts in the conversation they participate. Although the majority of groups used the communication tool in synchronous mode (only two groups collaborated in asynchronous mode) and the tool supports both modes adequately, there were students that expressed their willingness for a synchronous tool with facilities like auto-correction and notification/labeling of new messages. This view is strongly influenced by the tools that students use for social purposes in their everyday life.

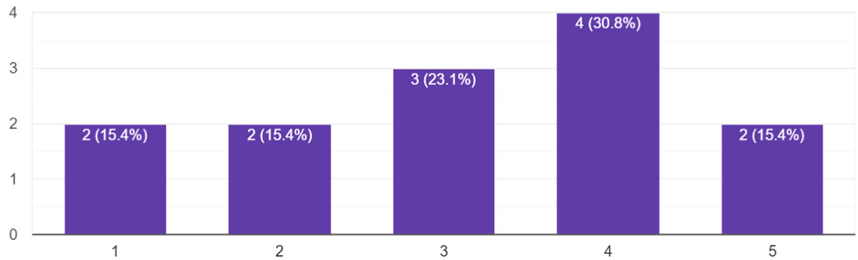

Fig. 6. Student's answers in the question "Is the structured form of dialogue helping in the cultivation of communication skills?" (1: Not helping - 5. Helping a lot).

3 Conclusion

The structuring of collaboration, especially the structured form of dialogue aims to favor focused and coherent interactions. In the LcL environment the structuring of collaborative setting addresses issues related to the formation and collaboration model followed by groups and the structuring of dialogue as promising approaches to influence anticipatively the collaborative process [7]. The presented work focused on the communication tool developed in the context of LcL. In line with research directions in the field [9–11], the communication tool supports both the free and structured form. In an attempt to guide learners in following the conversation and composing clear and to the point messages, and ultimately cultivating communication skills, the environment enables teachers to define appropriate sets of SST tools taking into account the intended learning outcomes and the model of collaboration followed. Taking into consideration the work of [19], it is quite challenging to investigate the possibility of enabling students to enrich the provided set with the desired sentence opener or communication act by denoting the discourse category. Although, the students may have the possibility to personalize the communication process and to exceed any potential restrictions imposed by the use of the predetermined sets of SST, the results show that the user-defined phrases could be avoided as the predefined SST cover the underlying intention of the student's defined

SST and message-post [19]. On the other hand, the personalized SSTs may stimulate students to adopt the structured form and consequently improve their communication skills.

Despite that this study is limited by the specific sample, the results comply with the results of similar studies in investigating the effectiveness of structuring scaffolds in improving task related interactions. It seems that structured dialogue results in more coherent and threaded conversations [3]. As in the current study, we made use only of the communication acts as scaffolding type, we plan to design and study various collaborative settings that attempt to combine alternatives of structuring of the collaboration model and of structuring of the communication means. Issues that are of interest and open in the field concern the support of adaptation mechanism in terms of how learners' individual preferences on the form of dialogue and the type of SST could be exploited in the direction of forming groups, providing different means of adaptation [20] and how the structuring scaffolds can be complemented with regulating ones in order to improve discussions and collaboration [3, 6].

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Adaptation and Personalization of Learning Management System, Oriented to Employees' Role in Enterprise Context - Literature Review

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Abstract. In the digital age, the training in companies can be facilitated through a proper system to the company's demand. A learning platform personalized to the profile of employees can facilitate the selection of training that tailored to their roles. This research aims to investigate the existence of adaptation and personalization of learning management systems (LMS) in enterprise context, that facilitate the selection of learning's content suited for employees' roles. This study focuses on literature review to understand the importance of a personalized LMS in company, especially in selection of content that adequate to role of each employee.

Keywords: Enterprise · Professional training · e-Learning · Learning Management Systems · Personalization · Adaptation

1 Introduction

Nowadays, an organization's training system is essential for its growth to reach its objectives, increasing competitiveness. From the employee's perspective, following training in the company where they work is seen as a right and duty that allows them to be valued in the job market, guarantee employability, obtain self-confidence, and perform their function. It enables the employee to achieve their personal performance [8].

An effective training process can facilitate the training and promote the contribution of knowledge flow to all functional sections within the organization. A well-structured learning system permits the acquisition of available knowledge and improves employees' skills [23].

Mass corporate training is sometimes ineffective and may not allow alignment between the company's objectives and the interests of its employees. Therefore, exist a need for the development and implementation of a method with personalization in the enterprise (or organizational) training system that provides a quick and easy adaptation to the context and requirements of any organization and its employees [3].

Disorientation in the selection of learning content can demotivate the learners. This demotivation can lead to various causes such as rejection of training, the employees

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following training that is irrelevant to their function, cost increase for the organization in the training process, or it is not fit for employee's competence. Therefore, to achieve the success of a training process, consider it is necessary to develop training programs that adapt to each position and employee´s role [4]; considering the learning system that adapts to participants' characteristics and facilitates the choice of adjusted content to the different groups of training is essential [8]. n this regard, it is fundamental that the platform feature must allow a personalization that concerns performance and facilitates the choice of content. Personalization can increase the efficiency and quality of training [7].

It was reported that despite the LMS's feature allowing for adaptation and personalization, e-learning in companies still faces resistance, such as technical issues, with the possibility that the companies are not taking full advantage of the LMS feature [1]. Some companies face it due to the lack of direction as to who uses it and what it is used for or does not enhance the interests of employees [6].

According to the consulted literature, the problem that motivates this investigation is a reduced number of learning management systems that facilitate employees to select training content essential to perform their function.

In order to search for scientific evidence about the problem above presented, we conducted a literature review. The papers that were obtained with this methodology can lead to understanding the type and existence solution of Learning Management Systems (LMS), the possibility for an adaptive and personalized LMS, and the reason to personalize the LMS in companies.

To achieve the objective of this investigation, we formulated three research questions (RQ). Through the review, we found the literature that we will use as references to answer the RQ, as follows:

1. What types of Learning Management Systems (LMS) allow content adaptation and personalization?
2. How do the adaptation and personalization of an LMS facilitate the selection of learning content?
3. Why do companies need to personalize their LMS?

2 Literature Review

Based on [14], this research follows three phases as follows:

- Planning the review - identification of the review need, the research questions specification, and developing a review protocol (illustrated in Fig. 1). This step is presented in Sect. 2.1.
- Conducting the review - primary papers selection and data extraction using the review protocol developed in the first step. This step is presented in Sect. 2.2.
- Reporting the review - summarize the extracted data and report the results. This step is presented in Sect. 2.3.

2.1 Planning the Review

This section presents our motivation for this work and then the Review Protocol.

Motivation. A learning process in an organization must be organized carefully to achieve success. Its benefits are not only for employees but also for the organization. Through the development of training within an organization, employees can gain knowledge and skills that can help to prosecute their role.

A learning structure is an essential element in organizations or companies. The development of a learning structure and choosing the right LMS as a tool to manage the learning system in an organization are fundamental to reaching the goals [1].

To achieve the success of a learning process, the company must consider the importance of the learning system that adapts to the characteristics and profile of each participant and adjust content to the different groups of trainees [8, 21].

The personalization of the LMS implemented in the company must take into account the satisfaction of employees in using it [6]. The adoption of LMS allows companies to personalize learning content [10]. A platform that clearly indicates the content adjusted for employees can facilitate the selection of training [3]. In addition, content that is suited to their role can benefit and improve their performance.

Review Protocol. The first step of the Review Protocol (see Fig. 1) is started by defining the search string that will be used to search in the chosen databases to obtain the maximum number of papers that can answer the proposed research questions.

Fig. 1. Review protocol

The search string and databases used in our research are list below:

Search String: (Enterprise OR organization OR corporate OR company) AND (professional training OR e-Learning OR "distance learning") AND ("Learning Management Systems" OR LMS OR "Learning Content Management Systems" OR LCMS OR "Content Management Systems" OR CMS OR "Knowledge Management Systems" OR KMS).

Databases: EBSCO and Scopus.

The second step is defining the Inclusion and Exclusion Criteria and applying them to filter the set of papers that we obtained in the first step. The criteria are presented in Table 1.

The set of papers that was obtained after applying the defined criteria must be analyzed by all abstracts and conclusions to decide whether they were relevant to the research. The chosen papers were fully read to get the final paper set.

Rayyan was utilized as a tool to facilitate the selection of papers.

Only the complete papers, available in the chosen databases, written in English, Portuguese, and Spanish, with the author identification, including title, year, objectives, volume, methodology, results, and conclusion were considered. The search was limited to the last 5 years, that is, from 2016 until 2021, considering that e-learning and LMS are becoming a trend in the digital era with rapid development in many aspects. Hence, the period of five years is ideal to be referenced in this research.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Full text	Language: German, French and Russian
Peer reviewed	Date published: before 2016
Source types: academic journal and conference materials	Source types: books and reports
Date published: 2016 - 2021	Duplicates papers
Language: English, Portuguese, and Spanish	Title out of context, abstract, and inaccessible

2.2 Conducting the Review

The second phase of the literature review consists of conducting the review, where the selection of primary studies occurs according to a given inclusion and exclusion criteria. It started by performing the search using the search query to the databases selected in the defined review protocol and then analyzing the extracted data.

Selection of Studies. The paper selection was based on the search string. By applying it to the databases defined in the review protocol, we obtained 328 papers. By application of the inclusion and exclusion criteria, 41 papers were retrieved for more detailed analyses. Each one of the 41 papers was read completely, getting a total of 20 relevant papers for our research. The paper's selection process is illustrated in Fig. 2.

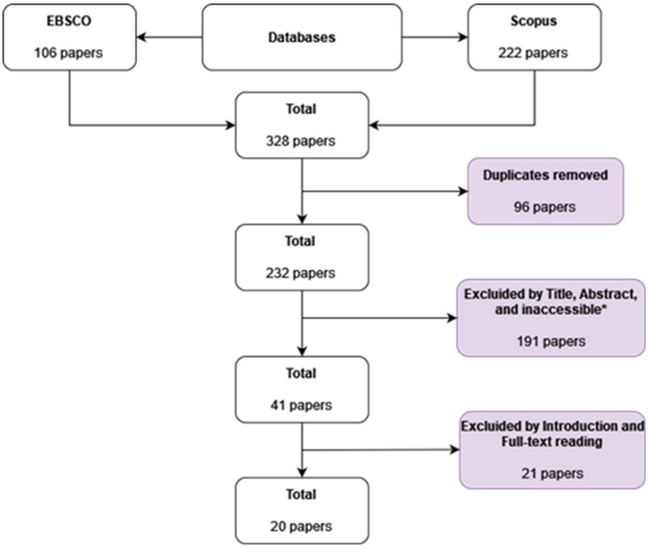

Fig. 2. Papers selection process

Data Extraction Analysis. In this section, we present the different parameter analyses of the selected papers, such as the distribution over the years and the type of publication. As it is possible to notice in Fig. 3, most of the papers selected for this research are from 2021.

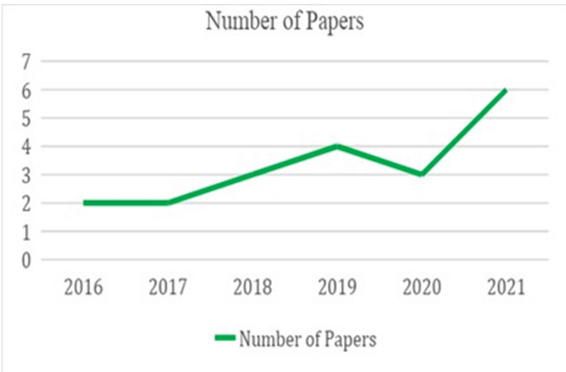

Fig. 3. Distribution of the selected papers over the years

The most common source type among selected papers is Journal, about 80%. Other papers are 5% from conferences and 15% from magazines. This distribution is illustrated in Fig. 4.

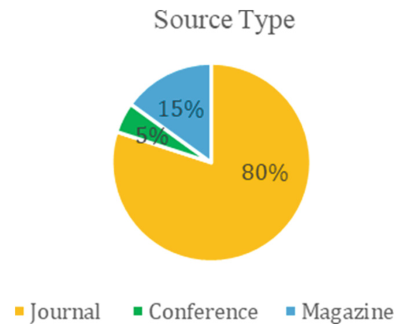

Fig. 4. Publication type of the selected papers

2.3 Reporting the Review

We present here, the last phase. The results from the analysis of each selected paper and the corresponding collected information, allowing to answer the previously defined research questions. Table 2 presents the list of 20 papers obtained through the execution of the literature review.

Table 2. List of papers obtained based on the Search string

Author (year)	Title	Objective of study
Alazemi, B. F. et al. (2021)	Learning Management Systems (LMS) and future vision	Identify the current Learning Management Systems (LMS) applications and future vision
Angelova, M. (2019)	Corporate trainings–opportunities and challenges for employees and managers	Explores the opportunities of training to the employees and managers and explains the challenges of corporate training
Anton, C., et al. (2018)	The method of personalized corporate e-learning based on personal traits of employees	The method of personalized corporate e-learning
Bakanova, A. P., et al. (2018)	The concept of personalized e-learning with the use of mobile applications based on ontologies	Describes the content of the developed concept of personalized corporate e-learning using mobile applications based on ontologies

(*continued*)

Table 2. (*continued*)

Author (year)	Title	Objective of study
Bentaib, M., et al. (2021)	Adaptive help system based on learners "Digital Traces" and learning styles	Investigate the benefits of integrating learning styles in the web-based educational systems
Díaz Redondo, R. P., et al. (2021)	Integrating micro-learning content in traditional e-learning platforms	Introduce a proposal to add micro-learning content to traditional LMS
Gladilina, I., et al. (2020)	Efficiency of employee learning in small companies under conditions of digital economy: searching for optimum solutions	analysis of main features of modern e-learning systems (LMS) and employee training systems (TMS) in small IT companies
Hamse et al. (2021)	Identification and learning styles' variation factors for a hybrid and distance learning professional training ODL-SPOC	Analyze the learning styles' variation of Physical Education and Sports'(PES) trainee teachers in relation with demo-graphic factors, type of hybrid or distance training
Herrera-Cubides, J. F., et al. (2019)	LMS SaaS: Una alternativa para la formación virtual	Exploration about the alternative of using SaaS LMS as alternative management in e-learning
Kavitha, V., et al. (2019)	A critical study on the use of artificial intelligence, e-learning technology and tools to enhance the learners experience	The role of artificial intelligence (AI) to enhance the virtual learning environment in e-learning
Kotova, E. E. (2017)	Use of intelligent agents in the learning process management tasks	The educational process management at the point of view of computer technology

(*continued*)

Table 2. (*continued*)

Author (year)	Title	Objective of study
Lalitha, T. B., et al. (2020)	Personalised self-directed learning recommendation system	Propose the solution for e-learning recommendation issues on SDL (self-directed learners) method
Oliveira, P. C. et al. (2016)	Learning Management Systems (LMS) and E-learning management: an integrative review and research	Analyze the available literature about the application of LMS for the e-learning management
Sadikin, M., et al. (2019)	Load balancing clustering on moodle LMS to overcome performance issue of e-learning system	The implementation of Load Balancing Clustering (LBC) mechanism applied to moodle LMS in an HE institution to deal with the poor performance issues
Shurygin, V., et al. (a) (2021)	Universal models and platforms in e-learning	Search for the best solutions, models, and platforms to ensure the success of e-learning,
Shurygin, V., et al. (b) (2021)	Learning management systems in academic and corporate distance education	Learning management systems in academic and corporate distance education
Ülker, D., et al. (2016)	Learning management systems and comparison of open source learning management systems and proprietary learning management systems	Discuss e-learning and the concept of LMS and examine open source LMSs

(*continued*)

Table 2. (*continued*)

Author (year)	Title	Objective of study
Vesin, B., et al. (2018)	Learning in smart environments: user-centered design and analytics of an adaptive learning system	Apply user-centered design approach to further develop ProTuS with additional components that will support users to utilizing smart content
Wu, W., et al. (2021)	E-learning based on cloud computing	Provides a theoretical overview of e-learning cloud architecture layers and models of its deployment in the education system
Zahari, A. S. M., et al. (2020)	Knowledge management and e-learning in organisations	Discuss the importance of knowledge management in organising e-learning

Based on the list above, we will summarize in three tables, which papers related to each research question (RQ):

- Table 3 the list of papers to answer the RQ1
- Table 4 the list of papers to answer the RQ2
- Table 5 the list of papers to answer RQ3.

RQ1. What types of Learning Management Systems (LMS) allow content adaptation and personalization?

Type and Solution of LMS. An LMS is a tool that can provide a learning and e-learning environment in an organization. Conform [2] one of the benefits of enterprise e-learning is the possibility to personalize the training; specifically, the author in [2] wrote that "Russian researchers probe maybe one of the most indisputable benefits of the corporate e-learning – the possibility to personalize the training. They focus on the specific situation when an employee changes its position in the company and obviously needs support, new knowledge, and skills which e-learning could provide and elaborate a method for personalization of e-learning corporate training".

Adopt an LMS in companies that intend to modify specific courses for their employees allows them to personify the e-learning contents and satisfy the needs of unique groups or particular characteristics of employees [10].

Various authors mention the types of LMS such as the open-source, those are free versions (e.g., Moodle, Canvas, Dokeo, Breeze, Sakai) and commercial versions (e.g., Blackboard, E-Front, WebAula) [1, 10, 17–22]. Further, they describe open-source LMS as a viable solution for e-learning that is available worldwide, robust, reliable, personalizable, and secure [1]. Commercial (or private) platforms are designed to meet the organization's specific needs [24]. Another example is the customization of LMS Moodle can be integrated with the library system in order to facilitate the training references requirement [18].

A variety of LMS such as Moodle, Canvas, and TalentLMS, is easy to use and usually used in corporate learning [19]. The author in [1] explains that as an open-source LMS, Moodle is designed for e-learning. It uses the most advanced object-oriented programming. The programming makes Moodle an efficient and effective platform, allowing any users to personalize according to their characteristics and needs.

Other authors describe that the learning system uses virtual platforms, allowing one to adapt and select information, learning resources, and collaboration. The personalization of the learning environment can be reached when companies focus on the individual potential development of each trainee [19].

Using LMS under SaaS (Software as a Service) like Blackboard, is an alternative cloud-based e-learning ([1, 5, 12, 19, 21, 24]), enabling companies to offer users a personal experience tailored to their own contexts, as written in [12] "permite a las empresas ofrecer a los usuarios experiencias personales adaptadas a sus propios contextos, lo que permite una experiencia más centrada en el usuario".

To enhance the user experience, facilitate learning, and adjust the course content to the needs of each learner, artificial intelligence (AI) has been integrated into the LMS [19]. In [21] confirm that divers platforms used in education, develop and create more personalization and adaptive experience in learning. For that, they introduce data-driven learning activities and learning analytics (LA) in their utilized system..

Moreover, [13] explain that utilizing AI could improve the learning experience, personalized resources, and the best outcomes. The system with AI integrated could collect essential user data, cross the information, and search the adjusted content for the learner.

Table 3 presents the types and solutions proposed by the authors of 13 papers analyzed and respective references.

Table 3. Type and solution of Learning Management System (LMS)

Type		Source
Private LMS	Blackboard, E-Front, WebAula	[1, 10, 17, 20–22, 24]
Open source LMS	Moodle; Canvas, Breeze, Sakai,	[1, 10, 17–19]
Integrate the micro-learning (micro-content) approach into LMS	Grovo, Moodle	[9]
SaaS LMS	BlackBoard, Canvas, TalenTLms	[12]
Artificial intelligence (AI) in LMS	Docebo	[13, 19, 21]
LMS cloud-based and self-hosted	ELearning247, eDucativa	[1, 5, 12, 19, 21, 24]

Figure 5 is captured from [10], illustrates the comparison between commercial (private) and open source LMS. As shown in line of *development,* we can assume that all the types of LMS permit an adaptation according to organizations' demand.

Criterion	Open source LMS	Commercial LMS
Cost	Nearly all products are free.	Licensed products and their updates are supplied for fee.
Technical support	Technical support is based on questions and answers in user forms and open documentation of provider. In some cases, participation of professional consultant is stipulated.	Supplying company provides technical support according to service agreement.
Hardware	LMS is hosted on company's own server. Qualified personnel is required for maintenance. The server can be rented out or outsourced	According to the agreement, LMS can be hosted on its own server or on the supplier servers.
Scaling up	LMS can be scaled up so that to serve 50 or 5,000 users with the same quality.	The scaling up is guaranteed by supplying company.
Development	Using the LMS programming language, it can be unlimitedly developed according to company's demands. Ready solutions can be obtained by purchasing appropriate plugins.	Development is performed by supplier's initiative. The supplying company, aiming at high level of satisfaction of customers, improves the product, though, the result may not meet demands of a specific company. In this case, according to the agreement, solutions to such issues can involve supplemental payments.
Safety	The company should protect all data in LMS. Since the open source systems are being developed by thousands of persons, their vulnerability can be rapidly detected and eliminated.	In general, the safety is guaranteed by supplying company. Safety failures can be accompanied by data loss and leakage. In order to avoid such consequences, before contract conclusion it is necessary to analyze reliability and competence of the supplying company.
Integration	Since the source codes are open for adaptation to existing external systems, all projects can be implemented as it is provided by LMS architecture.	Since the source codes are closed, the integration depends on the supplying company. Possible integration and availability of special offers should be agreed preliminary with the supplying company.

Note: on the basis of expert survey

Fig. 5. Comparative analysis of commercial and open-source LMS captured from [10]

RQ2. How do the adaptation and personalization of the LMS facilitate the selection of learning content?

The Base of Adaptation and Personalization of LMS. The LMS features describes that is possible to adapt and personalize the LMS. That can be "focus the adaptation and personalize of the learning platform on the requirements and needs of the participants" [1], "provide different solutions to the particular needs" [9] or individual needs [16, 19, 21]. The authors have proposed to use the employee's basic profile to personalize the training system in corporate training [3].

Particularly, the authors in [2] assume that corporate training is initially delineated by enterprise needs, but the training is an individual performance of an employee. Hence, a personal path construction of an employee as e trainee is considered necessary to provide training that meets the individual requirements.

Other bases of adaptation and personalization of LMS are the employee's role [3], the employee's profile [4, 23], and individual characteristics [15] or personal traits of the learner [2, 21]. Conform [19], the LMS features allow to fill each student's needs and provide a unique experience in learning, through the creation of a learning path utilizing the different courses.

Training based on employees' gained knowledge and desired career paths in the company is another approach that can be implemented to personalize the LMS [11, 16]. This strategy allows employees to follow adaptive learning as desired [20].

The introduction of the learning analytic (LA) components in the learning system facilitate the learning context [21].

In [10] explains, companies can use LMS to modify certain training, adapt for their employees, and manage the training content.

Table 4 presents the base elements for the adaptation and personalization of LMS, referring to 11 papers analyzed to answer this RQ.

Table 4. The base of adaptation and personalization of LMS

The base	Paper
Requirements and needs of the participants	[1, 7, 16, 19, 21]
Individual/personal traits of learner	[2, 3, 15, 16, 19, 21, 23]
Tailor to employee's role	[3]
Employee's profile	[4, 23]
Knowledge level and relevancy of the learner	[11, 16]

RQ3. Why do companies need to personalize their LMS?

Reasons for Personalization of the LMS. The literature evidence that the personalization of the system to manage the learning process has several important objectives. Several authors have mentioned personalization, both, in learning systems in general and in an enterprise context.

In [19], the authors have linked personalization with the significance of the influence of students' involvement in their learning and outcomes. Therefore, personalization is the essential key to reaching effective learning and career growth.

The personalization of the training system according to individual educational paths can facilitate the analysis and assessment of an employee's skills, allowing the provision of the necessary training to improve performance in their current role or eventually a new one [2]. The strategy permits the company can guarantee training effectiveness and efficiency since it focuses on individual and professional needs. The personalization of the learning system in the company is also related to employees' motivation regarding their training. Considering the individual character of training, the company should provide training that satisfies the determinate need of its employees to improve satisfaction in the training process [2].

Analyzing the diagram in Fig. 6 can lead to understanding how the personalization of the training system, according to the need for new knowledge of the employee, can affect the individual result in the work and the improvement level of the company in the market.

In their research [3], the authors proposed the implementation of e-learning with a personalized system based on competencies and employee training paths. That allows a company to organize training that addresses the missing skills of each employee. The authors also argued that personalization in e-learning systems aims to improve motivation and the quality of training in the company.

There are people who have the motivation to learn, but don't know where to start [16], in this sense, the authors recommended the personalization of the system for autonomous learning. They explain a personalized system to manage e-learning in companies can help an employee to find the right direction and where to start adequate training.

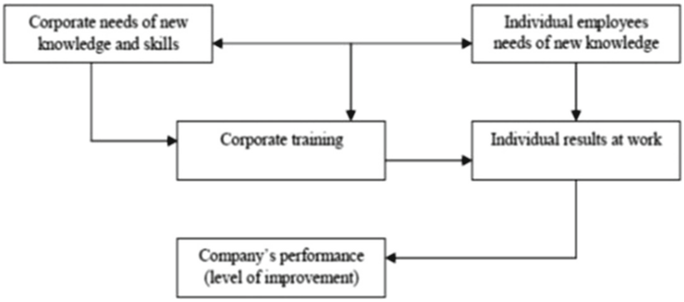

Fig. 6. Complex character of a corporate formation (Captured from [2])

After comparing five e-learning platforms, iSpring Online, WebTutor, Mirapolis, LMS Teachbase, and Moodle, the authors in [24] concluded that the platforms of e-learning have pros and cons. The ease of using the LMS platform leans on how it can be adapted easily to the need of its users.

Table 5 presents the reasons for personalizing the LMS in companies/organizations, based on 5 papers used to answer this research question.

Table 5. Reasons for personalizing the LMS in company/organization

Reasons	Source
Greater student involvement in their own learning and outcomes	[19]
Provide necessary training to improve performance in the current role of employees	[2, 3]
Possible to offer training, focused on each employee's missing skills; enables an employee to follow useful training for the current or new role; improve motivation and quality of training in the company	[3]
Autonomous learning; facilitates and guides an employee to select adequate training	[16]
Ease of use of the e-learning platform	[24]

3 Conclusion and Future Research

By executing a literature review, it was possible to verify the types of LMS. Moreover, lead to understanding on which aspect and element the adaptation and personalization of learning systems are based.

The literature demonstrates the existence of solutions to adapt and personalize an LMS that can be adopted and implemented in companies (or organizations). Any LMS used in organizational training allows the adaptation and personalization according to the demands of the company and its employees. Take into perspective that could be depended on the agreements between the companies and providers.

Most of the authors conclude that companies or organizations should consider the development of personalization in their training systems to benefit and achieve the best results. They also agreed that adapting and personalizing the LMS that focuses on individual needs can increase motivation and facilitate the uptake of training.

In our viewpoint, facilitating the selection of learning content oriented to employees' roles is crucial. Based on the literature, the ease of an employee to select the training content that adapts to his/her role can be achieved through personalization, as explained by the authors in these studies (e.g., through individual profiles, characteristics, and previous knowledge). Since most of the LMS available on the market offer features for personalization, organizations can use these vantages to obtain better results and return on investment from their learning area.

Additionally, based on this literature review, we have noticed the small number or lack within the personalization of LMS that facilitates employees to select adequate training content. We found that some organizations or companies already use the feature of LMS to enhance their training system. Even though that lack can become a problem in the training process, for example, demotivation to follow or complete the training, the employees must follow the training that is not related to their function or the training's contents not oriented to employees' role.

To understand this problem in a real enterprise context, in future work, we will conduct the survey research methodology. The survey aims to inquire about the existence of adaptation and personalization of learning management systems (LMS) in enterprise contexts that facilitate the selection of training content tailored to employees' roles.

For our survey, we are going to focus on a questionnaire survey. Through this methodology, we try to get answers to whether or not companies personalize their LMS for this purpose. In the execution of this methodology, the target audience is the employees of companies or organizations in general scope that use LMS in their online training system.

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Augmented Reality in Education: Exploring Greek Teachers' Views and Perceptions

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Abstract. This study investigated how teachers, who were familiar with AR and implemented AR-based instructional interventions, identify and perceive the factors that affect the integration of AR in educational practice. The research data were collected through online semi-structured interviews from teachers who had previously participated in a professional development program about AR in education. The findings indicated that the participant teachers considered that the use of AR in their instruction can provide many benefits for the students by harnessing a range of affordances that promote active learning. In addition, the findings revealed several factors that affect the integration of AR in primary and secondary classrooms.

Keywords: Augmented reality · Digital technologies · Primary and secondary education · Teachers' perceptions

1 Introduction

In recent years, the advanced features and capabilities of smart mobile devices and wearable technologies, combined with the diffusion of broad-band Internet connections, have contributed to an increased usage of emerging technologies in education. Among them, Augmented Reality (AR), defined as the technology that overlays virtual objects and information onto real settings, is receiving a growing interest from both students and teachers [1]. Compared to other technologies, the added value of AR is relied on the co-existence of digital and real objects, in the same space of a real-world setting, without "isolating" the user in a virtual environment as in the case of Virtual Reality [2, 3]. Real-time interaction, presence, autonomy, first-person view, and the visualization of invisible, complex and abstract concepts are the key affordances, upon which the use of AR in education is based and justified [1, 4].

Both earlier and recent studies, as well as literature reviews on the use of AR in education, support the idea that AR offers enhanced opportunities towards combining formal and informal learning environments and supporting ubiquitous learning [5–8]. Furthermore, the existing literature provides sufficient evidence that the use of AR affects

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students' motivation towards learning and promotes their active engagement in the process, thus enhancing their learning outcomes in various subjects, from Science and Mathematics to History, Arts and Project-based learning [1, 9–13, 22].

Nowadays, internet tools and applications supporting the utilization of AR in books and other printed material (e.g., leaflets, cards, maps) [14, 15] as well as in locations [16] of significant cultural, historical and educational value are more affordable and widely available. These applications, characterized by an easiness in use, enable teachers to become creators of their own augmented experiences (e.g., 3D, video, sound) through immersive and interactive activities in specific educational contexts [17, 18].

A large number of previous studies have focused mainly on the effects of AR on students' learning [10, 21, 22]. In addition, several studies have concentrated on the factors affecting the use of AR in teaching, using technology acceptance models [19]. However, very little empirical research has been conducted on teachers' experiences and perceptions regarding the use of AR in their instruction [20, 23].

The assumption that addressed the current study was that many teachers were willing to use AR applications in their emergency remote teaching practices, during school closure due to the COVID-19 pandemic. We, therefore, assumed that those teachers have explored AR-based ways to enhance students' motivation and learning engagement. The aim of this study was to investigate how teachers, who implemented AR in both emergency remote teaching and in-person instruction, perceive the factors that affect the integration of AR in the educational practice. The following research questions were addressed regarding teachers' beliefs and perceptions:

- What are the benefits and the affordances of AR in teaching and learning?
- What are the factors that affect the integration of AR in teaching and learning?

The remainder of this paper is organized as follows: Sect. 2 focuses on existing studies about the use of AR in teaching, and teacher-related factors. Section 3 presents the research methodology, while Sect. 4 presents the results. Finally, Sect. 5 summarizes and discusses the main results of the study, presenting both limitations and suggestions for future research.

2 Related Work

Previous studies in the literature have shown that teachers who used AR in their teaching were positive about those technologies, since they considered AR easy to use, fun for the students and useful for both, students and teachers [19, 23]. Furthermore, teachers believe that AR technology has a positive impact on students' learning outcomes [4, 24]. For example, teachers who utilized AR in an environmental program during a field trip to a local pond environment, stated that AR enhanced students' interaction, collaborative communication and problem-solving skills; moreover, it contributed to a student-driven learning approach and to a better understanding of scientific practices compared to traditional activities [5]. According to a recent qualitative study, concerning the affordances of augmented reality technology in science education, teachers believe that AR concretizes abstract knowledge, makes learning more understandable, and increases students' motivation [23].

Teachers' support is a crucial factor determining their decision to use AR in their instruction. This includes technology leadership, the school principal's support, collaboration with the other teachers at school, and opportunities for professional development [19]. Other factors that affect the implementation of AR in the classroom are related to school digital infrastructure and technical support. Specifically, previous studies have concluded that teachers find it difficult to implement AR-based interventions due to the insufficient number of tablets and/or limited internet connection in their classroom [23, 25]. In addition, the limited number of AR applications available for each learning subject and the fact that many of those applications are not open or free affect teachers' decision to use AR in their instructional designs [24].

Previous studies have also shown that teachers find it difficult to implement AR in their teaching when they have to solve issues related to the management of the digital equipment, for example, carrying devices to class, charging them, distributing them among student groups etc., or when organizing a field trip [5, 26]. A recent study on primary school teachers [20], has showed that the lack of AR learning materials (in accordance with the existing syllabus and context), the lack of time (i.e., students require more time to master AR applications) and the limited resources provided by the schools were the main teachers' concerns affecting the use of AR in their instruction.

Finally, a factor that plays an important role in teachers' successful integration of AR is the pedagogical approach they adopt in their teaching. A recent meta-analysis using 46 AR studies has shown that collaborative learning had the highest impact on the effectiveness of AR interventions [11]. In this meta-analysis, it appears that the cognitive theory of multimedia learning, inquiry-based learning and project-based learning were mostly used in these studies; however, Alalwan et al. [20] suggested that the effect of the various pedagogical approaches should be examined in relation to different educational settings (i.e., classroom, laboratory, field trips, and outdoor activities).

3 Research Method

3.1 Data Collection and Participants

The present study was qualitative and online semi-structured interviews were used for data collection regarding teachers' views, perceptions and experiences about AR in their teaching. The interview schedule was based on the research questions and consisted of 13 broad thematic questions aiming to help participants to express their thoughts, beliefs and challenges to use AR applications in their teaching. In addition to the fact that a certain interview schedule was available, the researchers also had the opportunity to spontaneously ask the participants new questions in an interactive way, with the aim of achieving a more comprehensive understanding of the topics under investigation [27].

All teachers were initially informed about the purpose of the study and were asked whether they agreed to be videorecorded while being interviewed through Webex. They were assured that their interviews, as well as their personal data, would remain confidential. The time duration of the interviews was between 43 and 60 min.

The sample included 10 in-service primary and secondary teachers participating in the current study on a voluntary basis. All the participants were familiar with AR technologies, since they were members of a group of 60 teachers who had attended a

20-h teacher training program about AR in education. The interviews were conducted after teachers had completed the training program. The teachers' age ranged from 28 to 50 years while their teaching experience ranged from 4 to 27 years. Six of them were primary school teachers, two were preschool teachers, and two were teaching the Greek Language and History in secondary schools.

3.2 The Teacher Training Program

The AR training program that the teachers of the present study attended was conducted online, in the midst of the COVID-19 pandemic, in the spring of 2021. It was organized by the Laboratory of Informatics, of the Department of Education, National and Kapodistrian University of Athens, Greece. A series of online sessions were conducted via the Webex platform. The aim of the program was for teachers to develop the necessary technological and pedagogical knowledge and skills in order to be able to (a) design and develop AR units related to the schoolbooks and (b) use AR artifacts in the context of the emergency remote teaching they were involved with their class.

The program lasted almost two months and consisted of five units as following:

- Features and affordances of AR in teaching and learning (3 h).
- Design principles for AR applications: (a) general issues, such as the connection with the school syllabus, the suitability regarding students' age and level, and the added value of AR use compared to other digital technologies; (b) technological design principles, such as the ease of using the augmented objects, the quantity and quality, and the connection to/arrangement into the augmented printed material; and (c) pedagogical design principles, such as the type of AR interaction that can be developed, the pedagogical strategies and the type of AR-based learning activities (3 h).
- Familiarization and use of AR development platforms and tools, specifically on books and other printed material. Four commercial AR tools (i.e., ZapWorks, 3DQR, Blippar, ROAR) and an open-source (i.e., ARIS) were used (7 h).
- AR creations: Teachers were asked to develop an indicative application for a specific course and school book using one or more AR tools/platforms (3 h).
- Presentation of AR creations: Teachers presented indicative examples of augmented pages they created; plenary discussion, feedback and commentaries from other participants (4 h).

3.3 Data Analysis

Teacher video recorded interview data were transcribed using word-processing software. Next, the transcribed data were analyzed using thematic content analysis, in order to reveal and capture the emergent categories from the teacher interviews. Inductive content analysis was applied, in which relevant categories were identified through a standard procedure including open coding, creating categories, reducing and connecting codes, reviewing and defining the major codes and themes [27].

4 Results

The results of the qualitative analysis of the interviews showed that 9 out of 10 teachers were using AR in their emergency remote teaching while all teachers reported that they are currently using AR during in-person teaching. However, AR-based instruction was occasional and not systematic. It was mainly supported by image-based augmented reality and some kind of material developed by the teachers themselves (e.g., using commercial AR applications) combined with schoolbooks. Additionally, some teachers reported that they have used commercial AR books in their instruction.

Table 1 presents the key factors, extracted from the qualitative data analysis, that determine teachers' beliefs and perceptions of AR. These factors were classified into three thematic categories: (a) teachers' perceived benefits of using AR in classroom practices; (b) affordances of AR technologies; and (c) teachers' challenges and concerns about of using AR in their instruction.

Table 1. Factors affecting teachers to use AR in their instructional decisions.

Categories	Factors
Educational Benefits of AR	Increased learning motivation and interest
	Better understanding of the subject content
	Knowledge comprehension and expansion
	Students' collaboration
	Interactive learning
	Personalized learning
	Creative learning
	Gamification
	Classroom climate
	Innovative technology
	Mobile learning
Categories	Factors
Affordances of AR	Combining printed and digital-virtual material
	Efficient visual representations
	Immediate access to AR material
	Interoperability with other digital technologies
Categories	Factors
Teachers' challenges and concerns	Digital infrastructure

(*continued*)

Table 1. (*continued*)

Categories	Factors
	AR platforms and material (cost, free)
	Increased workload
	Students' familiarization with AR
	Curriculum restrictions
	Classroom management
	Teachers' training
	Supportive educational-school environment

4.1 Benefits of AR in Teaching and Learning

All teachers believed that the use of AR provided many benefits for their students and for themselves as educators, along with specific affordances compared to other digital technologies. The factors related to AR benefits were divided into two sub-categories. The first includes factors clearly recognized as benefits for the students, like "*increased learning motivation and interest*", "*better understanding of the subject content*", "*knowledge comprehension and expansion*" and "*students' collaboration*". The following indicative quotes correspond to each of the aforementioned benefits:

> *Students have an increased motivation to engage attendance when a virtual object is integrated into a real-world setting. (T5)*
>
> *Essentially, my objective is to help students to expand their knowledge on Cycladic civilization. (T7)*
>
> *AR-based activities promote students' collaboration and participation … (T6)*

Teachers also considered "*interactive learning*" and "*personalized learning*" as important benefits of AR technologies for students.

> *This (AR) is an interactive way of learning which, I believe, is superior to the traditional methods of teaching. (T6)*
>
> *[AR] works much better because every student has his/her own learning pace. (T4)*
>
> *Students can become really self-active through AR technology. (T9)*

Furthermore, the teachers considered "*creative learning*" and "*gamification*" as important features of AR-based instruction for the students.

> *AR contributes to students' imagination and creativity… (T4)*
>
> *Students perceive learning [with AR] not as a dull procedure but as a fun activity. (T1)*
>
> *AR-based instruction is a gamification of the subject under study … (T5)*

Other teachers, as T1 and T8, noticed that AR can change the *"classroom climate"*.

AR can create a pleasant collaborative atmosphere in the classroom. (T1)

The classroom dynamics changed radically with AR since students worked as a team … (T8)

Finally, the analysis revealed that the teachers perceive AR as an *"innovative technology"* while they have the opportunity to engage students in *"mobile learning"* approaches. The following quotes are indicative of teachers' ideas and perceptions:

… AR offers increased motivation to do something new compared to what I used to do in my instruction … (T5)

It is an innovative method where teachers can be engaged into a process of creating their own educational material. (T6)

…AR allows teachers to use mobile devices as pedagogical tools … in students' hands. (T4)

4.2 Affordances of AR in Teaching and Learning

As demonstrated in Table 1, our analysis has revealed four factors related to the affordances of AR. Firstly, all teachers reported that AR applications can afford a *"connection of printed and digital-virtual material"*. This affordance is considered by the teachers as unique and not supported by any other digital technology used for educational purposes.

I believe that the added value of AR is relied on the connection, the coexistence of both printed and digital material. It is a combination. Clearly, there is no other technology that can facilitate this. (T1)

It is very interesting to combine the virtual and the physical. In addition, it is a combination of the traditional (sometimes dated) schoolbook with an emerging technology. (T4)

In addition, some teachers noticed that AR applications are very helpful for the teachers, since they incorporate enhanced features of *"visual representation"* of complex and abstract concepts:

… [with AR] I can explain difficult concepts and abstract ideas much better; I can present them live, on the spot. (T10)

With an augmented material representing, for example, the human organs the students can easily understand how the heart or the lungs are operate; it is more effective than reading two complex paragraphs in the schoolbook (T1).

With AR the students are able to visualize either abstract concepts or events to which they have no access… The invisible is becoming visible. (T2)

The third factor related to the AR affordances is *"immediacy"* in a sense that students have the opportunity to immediately access the AR educational material. Several teachers' statements, like the following, were identified:

…Students can have access to the AR material whenever they want, in the classroom and at home; this is very important. (T4)

The printed material may include a specific QR code. The students can, at any time, scan this code while studying the corresponding content. Thus, they can have an immediate access to the AR-material very easily. (T3)

The fourth feature pointed out by the participants is the *"interoperability"*, since augmented reality can be connected with other digital technologies to share specific material. Essentially, educational material and learning activities supported by other technologies can be integrated into AR.

I can incorporate several activities through various tools into an augmented reality platform. […] Thus, they are not detached or separate. (T4)

We (students and teacher) can use Padlet and a portable device… All material can be integrated [in AR]. (T6)

In reality, this is not your typical Web technology. It is a combination of many such things, like YouTube, Google images etc. […] that makes [AR] even more powerful. (T8)

4.3 Factors Affecting the Integration of AR in Teaching and Learning

As shown in Table 1, our findings revealed a range of factors that affect the integration of AR into the teaching and learning processes. Eight key factors were identified; namely: (a) "digital infrastructure"; (b) "AR platforms and material (cost, free)"; (c) "increased workload"; (d) "students' familiarization with AR"; (e) "classroom management"; (f) "curriculum restrictions"; (g) "teachers' training"; and (h) "supportive educational-school environment".

Under the term *"digital infrastructure"* were classified teachers' difficulties related to the technical equipment and internet connectivity at schools. Indicative quote examples are presented below:

There are not enough mobile devices in my classroom. (T6)

The main problems I faced are related to the Internet connection in my classroom. (T4)

Moreover, some teachers reported the problems concerning the availability and the features of "*AR platforms and material*" they use to develop their own augmentations, in terms of the ease of use, cost and free creations, restrictions in augmented objects (e.g., 3D), etc.

AR tools should be user-friendly, so that a teacher with basic ICT skills will be able to work easily with them. (T1)

The platform I used, in its free version, provides users with the opportunity to create only five AR projects/deliverables. (T2)

There is a lack of AR material, especially in 3D objects; there are enough on the Internet but not free of charge. (T6)

Perhaps the major difficulty is gathering material and then deciding what is more appropriate based on what I want to show to my students. (T8)

The participants also stressed the need that the students should become familiar with AR. As T7 noted:

Some students needed their parents' help to download or use the AR application at home.

Another factor affecting the integration of AR in teaching and learning is related to "teachers' workload" since they need more time and effort to prepare the augmented material. For instance, T6 stated that:

Certainly, designing AR material takes more time. This is a barrier for me, i.e., the time required for creating a lesson.

Aside from the extra time that teachers need to use AR, they noted difficulties regarding the *"Curriculum restrictions"* and *"Classroom management"* from the part of the teacher. The following responses are indicative of the teachers' perceptions regarding these difficulties:

Definitely (in an AR-based intervention) there will be time delay until all students concentrate on and attend a certain lesson flow. Of course, this will happen in any innovation, when applied for the first time. (T4)

Coming back to school [after the pandemic closure], there is time pressure to cover the content set by the curriculum… I was not able to use [AR] as frequently as I wanted to. (T2)

My greatest challenge is that the curriculum is not aligned to the goals and the affordances of AR technology. (T9)

Finally, it appears that *"teachers' training"* in both technological and pedagogical issues is necessary so that they can integrate AR in their teaching. In addition, they require a *"supportive environment"* at school regarding the use of digital and AR technologies. The following quotes are indicative and reveal some of the perceptions and views of the teachers regarding these two factors:

As a teacher I need concrete examples, e.g., a specific educational scenario, so that I will be able to learn more about the pedagogical design. (T4)

I have a hard time in designing and creating AR content. The pedagogical aspect is a major difficulty. New tools call for a different approach. (T6)

We certainly need a supportive educational framework… For instance, if I propose the use of mobile devices in the classroom. (T4)

5 Conclusions

The present qualitative study has explored teachers' views and perceptions on implementing AR interventions in their instruction and the critical factors that affect their decisions to integrate AR-based material and learning activities in educational practice.

Overall, the findings indicated that the participant teachers appeared to perceive the use of AR in education as beneficial for a wide range of reasons. More specifically, they believe that using AR has many benefits for their students, such as supporting their learning motivation and interest, facilitating interactive learning and personalized learning, and promoting students' collaboration and creativity.

From the teachers' point of view, all participants believe that using AR has a positive effect to their instructional work; e.g., improving the classroom climate, introducing an innovative technology in the class, and harnessing the advantages of mobile learning. The findings above seem to confirm the results of a recent study by Arici et al. [23], which has indicated that teachers perceive similar benefits for AR-based learning. As suggested by Arici et al. [23] the teachers who believe that AR is beneficial for their students, and for themselves as well, may be motivated to use AR in their teaching.

Regarding AR affordances, our findings have revealed a range of interrelated factors, namely, combining printed and digital-virtual material, efficient visual representations, immediate access to AR material, and interoperability of AR with other digital technologies in real educational settings. Our results are in-line with prior studies [1–4, 23], thus indicating that the above-mentioned factors related to affordances of AR technology are perceived by the teachers as important.

In addition to this, confirming previous studies, the present research provided similar results regarding the factors that affect the integration of AR in school teaching and learning [20, 23]. Teachers' difficulties to apply and integrate AR in their practices are due to inadequate digital infrastructure in the schools, the cost of AR applications, and the difficulties associated with appropriate AR material. Moreover, the teachers noticed that they need extra time and workload to prepare AR material and plan their AR-based interventions. They also reported as an important factor their difficulties in managing class time and students' engagement with AR materials and technologies. Other factors that affect the integration of AR in primary and secondary classrooms are related to students' familiarization with AR, teachers' training needs in order to design AR interventions and using proper pedagogical approaches, curriculum restrictions that they need to overcome as well as the need of a supportive educational-school environment that promotes innovative instructional choices like AR-supported learning.

To the best of our knowledge, this qualitative study is among the first to focus on the experiences and perceptions of teachers regarding the use of AR in education, after their experience of emergency remote teaching. Despite the fact that the results presented could be limited by the specific sample and the educational context in Greek primary schools, the findings are important since they are based on teachers who had already attended a professional development program regarding the creation and use of AR applications in teaching practice. Therefore, our results are expected to enrich the existing literature in the field and to shed light on new understandings of the key factors that affect the systematic use of AR in primary and secondary school settings [20, 23].

In conclusion, in order to design effective AR-based interventions in school practice, teachers need improved digital infrastructure in the schools, appropriate AR applications and material, a supportive educational environment, and specific training on the pedagogy that determines the design of AR-based learning scenarios. Our future research studies will be conducted by using quantitative methods and a larger sample size from different regions, as well as different groups of teachers (e.g., both experienced and beginner users of AR), with the aim to acquire more detailed views of teachers' challenges and concerns to apply AR in their educational design. Students' learning experiences with AR in specific subjects and topics will be also a future research project of ours.

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An Initial Framework for Adaptive Serious Games Based on a Systematic Literature Review

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Abstract. Serious Games have been used in professional training to increase employee engagement and improve the results of training initiatives. This work intends to investigate the influence of game elements, in adaptable Serious Games, according to the users' interactions, on the increase of engagement in the game itself and, as the main goal, on the learning results and the transfer of the acquired knowledge and practised skills to the daily work activities. Using the Design Science Research - DSR methodology, this study aims to develop a framework for the development and evaluation of Serious Games to improve the user experience, the learning outcomes, the transfer of knowledge to work situations, and the application of the skills practised in the game in real professional scenarios. This paper presents an initial Framework for Adaptive Serious Games derived from a systematic literature review. The next steps in this investigation are pointed out following the DSR methodology.

Keywords: Framework · Adaptive · Serious games · Professional training · Learning outcomes

1 Introduction

In professional training, Serious Games have been used in various contexts for more than two decades in various training courses, such as courses on compliance or related to specific procedures.

Among the different aspects considered relevant for the development of efficient Serious Games, fun, an inherent characteristic of games, is one of the most important, as cited by Ferreira de Almeida & dos Santos Machado [6]. Thus, to avoid Serious Games from becoming boring or stopping being fun is fundamental to maintaining the game characteristic.

Martin, Casey, & Kane [12] argue that dynamic game adjustment, to prevent tasks from being too easy or difficult, and thus maintain the player's focus on an in-game learning task, is important to provide both a challenging and fun experience and effective learning.

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As Lopes & Bidarra [11] pointed out, the lack of adaptability of games can result in two consequences. The first is the loss of efficiency in learning if users perceive the game's dynamics and evolve without achieving the learning objectives. And, also, the impossibility of repeating the application of the game for the same users, once they already know its content.

Among the biggest challenges for the efficient application of Serious Games are adaptating and evaluating the results. In this sense, Mayer [13] highlights that more empirical research is needed on the contribution of Serious Games to learning.

1.1 Framing

This research aims to propose a decision framework concerning the adaptation of Serious Game elements in the professional training context.

It is intended that this framework will improve:

- The player's experience and involvement in the game;
- The learning outcomes;
- The transfer of knowledge to work situations;
- Application of skills practised in the game in real-life scenarios during professional activities.

The following research questions were identified to achieve the proposed goal:

1. What is the influence of the game elements?
2. How should the game elements be adapted?
3. How to classify and organize the game elements to adapt and meet the previously established objectives?

In this way, it is intended to relate the game elements to player involvement, learning, and the transfer of knowledge gained and activities practised in the game to real work scenarios.

2 Methodology

Design Science Research - DSR proved to be more appropriate for this research because, as pointed out by Dresch, Lacerda, & José Antonio Valle Antunes Júnior [5], this methodology has the characteristic of investigating how things should be, while the other methodologies, such as case study or action research, are used to investigate how things are or behave.

This methodology is also suitable for the research in progress, as it has the design and development of an artefact (framework) as its main part.

To conduct this investigation, considering the questions formulated in the framing section of this paper, the process sequence of the model presented by Peffers, Tuunanen, Rothenberger, & Chatterjee [14] for DSR was adopted.

Concerning this model, this research started at the first entry point, identifying the problem: Verification of the efficiency of using Serious Games, as a learning initiative, in professional training, restricted to e-learning.

Following this methodology, initial exploratory research was conducted in the first stage, problem identification and motivation. Then a Systematic Literature Review was performed, according to the protocol provided by Kitchenham [9], on adaptive Serious Games applied to professional training.

In this literature review, 3 cycles of searches were performed, which, after applying the inclusion, exclusion, and classification criteria, resulted in 53 final publications.

Among the publications analyzed, there were 7 literature reviews, in distinct areas, complementary and relevant to the review in question: Effectiveness of instructional games [8]; Practices used in Serious Games research [16]; Engagement in games for entertainment [1]; Empirical studies on gamification [7]; Evaluation of Serious Games [3]; Empirical evidence of the impacts and outcomes of computer games and Serious Games [2]; Serious games and gamification in professional training [10].

After the Systematic Literature Review, it was possible, in the next stage, definition of the objectives of the solution, confirm the originally proposed objective of the investigation and define the purposes of the framework.

Continuing the investigation, in the design and development stage, an initial proposal for the framework was developed.

Following the investigation, in this stage, data were collected in focus groups and interviews with experts, so that the triangulation of data collection methods [4] could be done next, and thus perform the first evaluation of the framework, formative and artificial, according to the FEDS framework [15].

3 Proposed Framework

3.1 Purposes

The purposes determined for the framework were:

- Include learning outcomes as dimensions of the framework;
- Group the dimensions into learning and game;
- Consider the forms of adaptation in these two groups of dimensions;
- Be used for both development and evaluation of adaptive Serious Games;
- Be used to improve Serious Games by comparing framework 's application at the development stage (development team) and the evaluation stage (players).

3.2 Framework for Adaptive Serious Games (FA-SG)

From the systematic literature review and the analysis of the existing frameworks for Serious Games, a framework was developed, considering all the aspects found in this research, so that it would be possible to approximate the learning and engagement results in the game to the expected results, using the adaptation of the Serious Game.

Each dimension can be discretized into relevant aspects and each aspect into items to be analyzed according to the suitability of their application in the Serious Game.

Thus, the analysis can be performed at three levels of detail, from the most specific to the most general:

- Component items of each relevant aspect of the dimension;
- Relevant aspects of the dimension, if there are limitations to answering all the items of an aspect;
- Dimension as a whole.

According to the resources available (knowledge or time, for example), it is possible to mix the depth of analysis for each dimension.

3.3 Learning Dimensions

Concerning learning dimensions, each dimension, aspect and item are described in Table 1.

Table 1. Learning dimensions of the Framework for Adaptive Serious Games (FA-SG).

Content/context/framing	
Aspect	Items
Content clarity	Are the terms and expressions used clear and familiar (or have they been defined previously)? Is the flow of the text direct and unambiguous? When necessary, because the language is very specific, is there a glossary of terms?
Adequate context	Are the situations presented or exemplified possible situations in the reality of the student's work? Are the most common situations addressed as most relevant? Are exceptional situations presented as such?
Content level	Are the necessary explanations given for the student to absorb the content at each stage of the Serious Game? Throughout the content, the student can relate previous content to new content that is being presented?
Content coverage	Does the content reflect all the knowledge and/or skills that the student will need in his/her daily work? Does the content cover topics that are not related to the student's work only to relate them to the content, to provide external connections, highlighting them as non-essential?
Instructional elements	
Aspect	Items
Learning objectives approach	Are all instructional objectives addressed? Are there clear instructions for how students are to demonstrate achievement of each objective? Are the objectives ordered in increasing complexity concerning the knowledge and skills?

(*continued*)

Table 1. (*continued*)

Instructional elements	
Aspect	Items
Evaluation types	Do the evaluations cover all the learning objectives of the Serious Game? Do the evaluations clearly indicate the learning outcomes?
Cognitive load and memory usage	Are there situations that present players' previous experiences, which allow these to be related to the game situations?
Learning outcomes	
Aspect	Items
Objectives' compliance	Are all the enabling objectives for a learning objective clearly depicted and in a sequence that facilitates their achievement? Do the learning objectives have a clear relationship to the expected learning outcomes? Is there a relationship between the objectives and the results and goals of everyday work? Is the assessment of the results appropriate to the expected results, according to their level (Reaction, Learning, Behavior, Results)?
Challenges' alignment	Are the situations presented to the players related to the expected results? Is it possible to transfer a situation from the game to the work routine and associate learning with everyday tasks?
Level progression	Does the game provide for incremental learning outcomes? Can learning outcomes be built on previous experiences in the game? Does the game enable the relationship between the learning outcomes, favouring a holistic view of the topics covered?
Opportunities to redo tasks	Is it possible to redo tasks? How are the tasks redone, i.e., in the same way, with some kind of help/feedback? Are all attempts to execute a task displayed to the player?
Learning adaptation	
Aspect	Items
Learning curve	Is the pace of the game changed when a player makes a mistake? Does the number of tasks change according to the learning results? Is the type of task changed according to the learning outcomes? Is the content adapted according to the learning results?
Feedbacks	Are the game feedbacks fixed? Are the feedbacks adapted based on the player's characteristics? Are the feedbacks adapted according to the player's evolution in the game? Are the feedbacks adapted to motivate the player's evolution?
Evolution/goals	Are the game situations changed according to the player's evolution? Is the sequence of presentation of the situations/challenges variable according to the results obtained throughout the game?
Content change	Does the content adapt to provide better learning outcomes? Are learning outcomes used to adapt the game content?

3.4 Game Dimensions

Table 2 shows the dimensions, aspects and corresponding items related to game dimensions of the Framework for Adaptive Serious Games.

Table 2. Game dimensions of the Framework for Adaptive Serious Games (FA-SG).

Game mechanics	
Aspect	Items
Interaction types	Are the forms of interaction appropriate for the players? Are the forms of interaction explained initially to the players? Do the players receive the necessary instructions and have opportunities to practice before the game?
Game elements	Do the game components characterize the artefact as a game? Are the game components harmonious with each other? Do the game elements portray the context?
Reward structures	Are there reward structures in the game? Are the reward structures clear to the players? Are the reward structures appropriate for the players' evolutions?
Tasks	Are the tasks that the player must perform associated with the learning objectives? Are the tasks adapted according to the outcomes of the game? Do the tasks cover all learning objectives?
Game environment	
Aspect	Items
Aesthetics	Is the aesthetic appropriate to the theme? Is the aesthetic appropriate to the application context? Is the aesthetic appropriate for the target audience?
Audio	Do the sound effects correctly reflect the game states? Do the sound effects complement the environment, adding useful sensory information? Do the sound effects not distract the player at times when they should be focusing on some information?
Immersion	Do the game elements and mechanics provide the degree of immersion necessary to engage the player during key moments in the game? Do the forms of interaction help the player's immersion in the game context?
Narrative	Does the narrative aggregate the other elements of the game? Is the narrative appropriate to the game's context? Is the narrative appropriate to the target audience?
Challenges	At each level, are the challenges appropriate to the knowledge and skills of the players? Do the challenges highlight the learning objectives? Do the challenges present environments that motivate the player to solve them?

(*continued*)

Table 2. (*continued*)

Results	
Aspect	Items
Points	Are points recorded and displayed for the players? Are the scoring criteria variable, according to the player's performance and level, for example? Do the points influence the performance or evolution of the player, for example by assigning bonuses or burdens?
Choices	Can players make choices during the game? Are the choices variable, according to the player's level or score, for example? Are the available choices adapted to maintain the player's flow state, at each moment of the game? Are the available choices optimized to bring the learning outcomes closer to the expected values?
Levels	Is the game organized in levels according to the learning objectives? Are the levels adaptable according to player performance? Can the sequence of levels be changed according to the player's performance?
Rewards	Are there rewards for players' actions? Are the rewards tailored, according to the student's history of actions, for example?
Game adaptation	
Aspect	Items
Adaptation decisions	Is it possible to adjust the difficulty of the game? Does the game provide for interpretation and adaptation from player interactions, such as an intelligent tutoring system?
Game elements change	Do the game elements adapt from information such as the player's activity history? Do the game elements adapt according to the player's progress in the game?

4 Conclusions and Future Work

The proposed framework for adaptive Serious Games was designed to approximate the game's learning and engagement results to the expected results, using the adaptation of the Serious Game.

The next steps, following the DSR, are:

- Data analysis and triangulation, from the systematic literature review, the focus groups, and the expert interviews, to identify confirmations, divergences, and complements, serving as an evaluation of the proposed framework, still in the design and development stage;
- Application of the initial framework to existing Serious Games - Framework for evaluation;
- Applying the framework to a prototype:

  ○ Conceptual - Framework for development;
  ○ Practical - Framework for evaluation and development;

- Evaluation of the framework; and
- Iteration for the improvement of the framework, i.e. changing the framework based on the results of its evaluation, refining the sets of dimensions, and investigating the relationship between them and their application options.

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Student Engagement Detection Using Emotion Analysis, Eye Tracking and Head Movement with Machine Learning

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Abstract. With the increase of distance learning, in general, and e-learning, in particular, having a system capable of determining the engagement of students is of primordial importance, and one of the biggest challenges, both for teachers, researchers and policy makers. Here, we present a system to detect the engagement level of the students. It uses only information provided by the typical built-in web-camera present in a laptop computer, and was designed to work in real time. We combine information about the movements of the eyes and head, and facial emotions to produce a concentration index with three classes of engagement: "very engaged", "nominally engaged" and "not engaged at all". The system was tested in a typical e-learning scenario, and the results show that it correctly identifies each period of time where students were "very engaged", "nominally engaged" and "not engaged at all". Additionally, the results also show that the students with best scores also have higher concentration indexes.

Keywords: E-learning · Student engagement detection · Facial emotion · Eye-head movement · Machine learning

1 Introduction

Students of the 21st century are moving to a Digital Education, focusing on teachers and students' relations to achieve the goal of meaningful, high quality and dynamic education. The advent of digitization in education has brought drastic changes in education system. However, there are still some challenges that teachers/instructors are facing. As

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mentioned by [1], one of the challenges that the teachers/instructors are facing is to examine how well the students/learner are receiving the content delivered from the lecture. Student engagement, which occurs when the student involves meaningfully through the learning environment, is a topic of paramount importance and should be taken carefully in order to improve the educational system. As defined by [2], student engagement is the psychological investment of student in learning and understanding the knowledge, skills or crafts that academic work is trying to encourage. Engagement is directly proportional to student's achievement [3].

The concept of Virtual Classroom was implemented for the first time in mid 1990s [4]. At the same time, the World Wide Web has become a popular way to deliver the content to students. As a natural consequence, virtual classroom systems have been adapted in many schools. However, one of the most important problems of virtual classroom systems is the dropout rate of students.

The problem of disengagement of students is being raising attention every day. Low achievement of the student is a relative minor problem when compared to disengagement of students (and is a direct consequence of disengagement). Reyes et al. [5] have collected data from 63 fifth- and sixth grade classrooms (N = 1,399 students) and they have found that good emotional climate and grade are mediated by engagement. As stated by Stanley and Hanse [6], students not paying attention in class is one of the main indicators of disengagement. Their degree of attention and curiosity reflects their engagement in class. Psychological effect and socio-cultural orientation that students bring to school can be the external factors that lead to the declination in degree of attention. Bradbury [7] concluded that the way of teaching is also a reason behind engagement of students; they reported that between 25% to 60% of the students were bored for a long period of time and disengaged in the classroom environment [8]. Ekman, Friesen, and Ellsworth, [9], state that the fast way to understand emotion is with the help of facial expression that people express. Emotions of students during their learning period (in the classroom or any other learning environment) can be used as a useful information to evaluate their concentration towards the "delivered" content. In particular, eye and head movements can be used to determine the engagement of students when using a computer (e.g., in virtually classes). These movements can be used to estimate how much students are concerned with the delivered contents. For example, eye tracking is being used to evaluate human behaviors and predict the degree of attention [10]. As stated by Poole and Ball [11], eye tracking is the system in which a person's eyes movements are measured, letting the researcher know where the person is looking, at any given time, and the sequence in which the person's eyes are moving from one position to another. Both eye tracking hardware and software algorithms can be used to extract the information from the movement of eyes (or only one eye) [12, 13]. Other authors suggest the use of other data, such as pupil dilation, because it occurs when the students see emotional arousal pictures [14], or eye closure duration [1], to identify the engagement of students.

In a typical e-learning environment, students have a laptop computer with a built-in camera. Here, we propose the use of the laptop built-in web-cam to grab real time information about the eye's movements (eye tracking) and facial emotions of the students. This information will be used to determine a concentration level, hence helping the instructor to see how engaged (or not) the students are. We believe that this information will help the teacher in making the learning environment affordable. To produce the concentration index presented here, in real-time, Python and Keras for the facial emotion analysis, the Haar-cascade algorithm for the eye tracking, and a Convolution Neural Network (CNN) are used.

2 Related Works

The problem of finding indexes to determine the concentration and engagement of students is being gaining attention in the recent years. These indexes can be of particular usefulness when the students are using autonomous e-learning systems, where no teacher/instructor is present and so the feedback about the reactions, emotions, etc., of the students are not easy to grab. The number of researches addressing these problems is being growing every day.

The research conducted by Divjak and Bischof [15] analysed and evaluated three variables (eye tracking, head movement and eye close duration) to produce an alert when they find the user having "computer vision syndrome". They used Open CV to localize the head and eye and set the threshold value for both movements, if the movement crosses the minimum threshold value, the alert will be generated to notify the user.

A research work done by Turabzadeh et al. [16] was based on facial emotion recognition in real-time, using the Local Binary Point (LBP) algorithm, in which LBP features were extracted from the video captured, which was then used as input for a K-Nearest Neighbour (K-NN) regression with dimensional labels. The system's accuracy, using MATLAB Simulink, reached 51.28% and in the Xilinx simulation was 47.44%.

Bidwell and Fuchs [17] measured students' engagement with an automated gaze system. They designed a student engagement classifier by using recorded video in classes. They used a face tracking system to extract students' gaze. The resulting automated gaze pattern was correlated with the pattern produced by a panel of experts' observations, for the training of a Hidden Markov Model (HMM). However, HMM resulted in a poor classification; they proposed to produce 8 discrete behaviours categories, but only were able to classify weather a student is "engaged" or "not engaged".

Krithika [18] uses eye and head movements for checking the concentration of students and generate a low concentration alert. The video was divided into frames and then taken into analysis. The implementation was done in MATLAB, using different functions for face detection and the ViolasJones features detection. The system is efficient enough to detect the negative emotions of the student in e- learning environments.

Kamath, Biswas, and Balasubramania [19] use the VilolaJones face detection algorithm for the analysis of the input images, and then Histogram of Oriented Gradients (HOG), for the facial representation for the patch to get the final vector of features. Those features were used to train the instance-weighted Multiple Kernel Learning-Support-Vector Machine (MKL-SVM) to build a model and then the performance of the system was measured. They reached an average accuracy of 43.98%, and a maximum accuracy of 50.77%.

Sharma et al. [20] proposed a real time system, based on expressed facial emotions during a lesson, to check the students' concentration in an e-learning context, automatically adapting the contents according to the student's concentration level, by analyzing the student's emotions. The emotions are processed to find the final concentration index. The results have proved that the emotions expressed were correlated with the concentration of the students, and devised three distinct levels of concentration (high, medium, and low).

Deep learning was utilized by Omid [21] to train a face expression identification model using pre-existing image data, and they used the models weight to initialize a new engagement recognition model based to recognize engagement. 4627 engaged and disengaged image datasets were used to train the new model. When they used deep learning architectures to engagement recognition for the first time, they discovered that the engagement model outperformed them.

Sheng [22] suggested a novel paradigm for measuring learning engagement that uses facial expression recognition to quickly track learners' changing emotional states. Additionally, a brand-new facial expression detection technique based on domain adaptation is put forth that is appropriate for the MOOC scenario. The results of the experiments demonstrate effectiveness of their suggested framework to measure students' participation in their learning. They compared their framework with the state-of-art methods which showed superiority of their proposed framework.

Islam [23] designed a methodology for measuring students' levels of participation in traditional classroom settings as well as online learning environments. The suggested framework records the user's video and follows the user's face as it moves through the frame of the video. From the user's face, several features are extracted, including learnt features, learned facial fiducial points, head attitude, eye stare, etc. The Facial Action Coding System (FACS), which breaks down facial expressions into the basic movements of certain muscles or groups of muscles, is then utilized to detect these aspects (i.e., action units). The student's willingness to participate in the learning process (also known as behavioral engagement) and his or her emotional attitude toward learning are subsequently measured using the decoded action units (AUs) (i.e., emotional engagement). This system will enable the professor to get immediate feedback from body kinesics such facial expressions and gaze.

3 System Architecture

Figure 1 presents the main blocks of the system proposed for student's engagement evaluation. The system can be used during the real time lecture session, whether in a virtual class or remote learning scenario, or in any other learning environment using a laptop computer with a built-in web camera.

In the learning environment there are two participants: the instructor and the learner. When the student is interacting with the learning material, the image data of learner (captured by the web-camera) are automatically analyzed by the system to evaluate the student's concentration level. If the resulting concentration index falls below a predefined threshold value, an alert will be issued (e.g., to the instructor/teacher or to the learner itself).

The detector engagement system comprises three modules, as shown in Fig. 1:

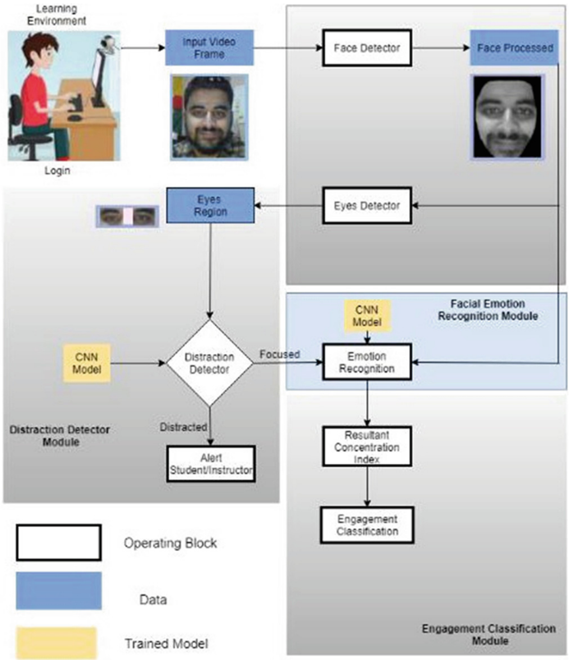

Fig. 1. Proposed system for student's engagement evaluation.

3.1 Distraction Detector

In each video frame the student's face is detected using the Viola & Jones algorithm. Next, within the detected face, the eyes region is located. The eyes region feeds a Convolutional Neural Network (CNN), used as a binary classifier, to predict the student's attention state in the two categories "Distracted" or "Focused".

3.2 Facial Emotion Recognition

Only when the student is "Focused", further facial emotions analysis will take place. For this purpose, another CNN model recognizes the dominant emotion expressed by the student's face at each moment. The classification is based on the emotion shown in the facial expression which can be one of the seven categories: Angry, Disgust, Fear, Happy, Sad, Surprise or Neutral.

3.3 Engagement Classification

The concentration index is calculated using the confidence score of dominant emotion and emotion weights. The resultant concentration index, a score between 0% and 100%, is used to classify the student's level of engagement in one of three categories: Very Engaged, Nominally Engaged and Not Engaged.

The system operates according to the following main steps:

Step 1: The student logs into the learning environment and the camera starts image acquisition.

Step 2: The face is detected and processed.

Step 3: The eyes region is detected and cropped.

Step 4: The student's attention state is classified in "Distracted" or "Focused";

Step 5: If the student is focused, dominant facial emotion is recognized.

Step 6: The resultant concentration index is calculated based on the confidence value and respective concentration index of dominant emotion.

Step 7: Finally, the student's engagement level is determined.

Two relevant algorithms are used in the detector engagement system: the Haar Cascade Algorithm; and a Convolution Neural Network.

3.4 Haar Cascade Algorithm

The Viola & Jones object detection algorithm uses the so-called Haar Cascade algorithm to extract features from images in a rapid and efficient way, and it had become one of the most popular methods currently being used to this end [21]. It needs a lot of positive and negative images to be trained for the cascade function to work properly. After getting trained, it can detect other images according to the previous training.

In this work we use this algorithm to detect the student's frontal face in the image and locate the eyes region within the face.

3.5 Convolution Neural Network (CNN)

CNN are distinct from traditional Artificial Neural Networks because they have the ability to encode relevant image features directly from the raw input images, making them more efficient to implement and reducing the number of parameters in the network [22].

In this work a CNN was trained on eye images to detect if the student is facing the webcam ("Focused") or not ("Distracted"), performing a binary classification in these two categories.

The CNN architecture comprises the following layers:

- Input layer 64x64 to hold the raw pixel values of the image;
- Convolutional layers with a set of 3×3 filters, to compute the output of neurons connected to local regions in the image.
- Pooling layer of 2×2 to reduce the spatial size of data representation.
- Fully connected layer to compute the two classes scores.

A second CNN, based on Arriaga, Valdenegro-Toro, and Ploger [23] work, was trained with grayscale images to ¨ classify facial emotions belonging to one of the following classes "angry", "disgust", "fear", "happy", "sad", "surprise", "neutral". This classification CNN model architecture, named mini-Xception which was inspired by Xception, developed by Franc¸ois Chollet [24], is a fully-convolutional neural network that contains Conv2D, residual depth-wise and separable Conv2D layer, each one followed by a batch normalization operation and a ReLU activation function. Finally, the output layer predicts the probabilities of seven emotions. The emotion with the highest probability score is considered the dominant emotion. When tested in the FER2013 dataset this architecture obtained an accuracy of 66% in emotion classification.

To train this CNN, we used the data-set from Kaggle challenge, which consists of 48×48 pixels gray scale images of faces and 35,887 examples. Figure 2 presents the achieved accuracy, depending on the limited data-set and computational power. As can be seen, the accuracy increment is directly proportional to the number of epochs (one epoch means one pass through the full training set), but the accuracy remains constant after the 81st epoch, which means that the accuracy does not increase after that period or change insignificantly.

3.6 Concentration Index

Initially, for the eye/head movement, we used the Haar cascade algorithm, which gives the result as a binary classifier ("Distracted" or "Focused"). Only when the student is "Focused", further facial emotions analysis will take place. CNN classifies the facial emotions data, generating the Dominant Emotion Probability (DEP) score. We have used the seven emotions that basically a person expresses: Neutral, Happy, Surprise, Sad, Disgust, Anger, and Scare. Table 1 represents Dominant Emotions and their corresponding Weights. The resulting Concentration Index (CI) is determined by multiplying the Dominant Emotion Probability (DEP) value by the corresponding Emotion Weight (EW), according to Table 1, expressed by Eq. 1:

$$\mathrm{CI} = \mathrm{DEP} \times \mathrm{EW} \tag{1}$$

Table 1. Dominant Emotions and their corresponding Weights

Dominant Emotion	Emotion Weight
Neutral	0.9
Happy	0.6
Surprised	0.6
Sad	0.3
Disgust	0.2
Anger	0.25
Scared	0.3

Emotion weight is defined as the value that describes how much a specific emotion state reflects the concentration of a student at that point of time. The value ranges from 0 to 1. To get the weights corresponding to each emotion, an informative video was shown to 30 students followed by a quiz with 10 questions. Data of facial emotion was recorded for all the students. Students were grouped on the basis of their major emotion expressed; for example, if a student expressed the majority of time (more than 50% of the

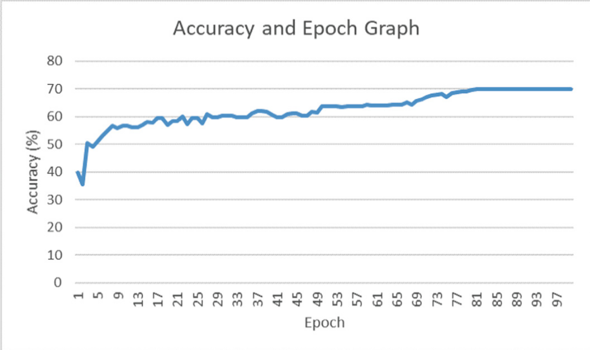

Fig. 2. Evolution of the accuracy as a function of epoch.

time video duration) a neutral expression, he/she was included in the neutral emotional group. The students were distributed among the seven emotional groups according to the facial expressions obtained during the video. The mean score achieved in the quiz for each group was calculated and is presented in Table 1. Hence, the score of each group at some extent reflects the relation between the concentration of a student and its emotional state. Figure 2. Represents the evolution of the accuracy as a function of epoch.

3.7 Categories of Engagement

We will have two outputs, one resulting from the analysis of the movements of the eyes and head, and one resulting from the facial emotions analysis. By analyzing both components, presented in the results section, we decided to divide the engagement level into three different categories: very engaged; nominally engaged; and not engaged at all, as described below.

- Very engaged: a student engagement is under this category when its concentration index value from the facial emotion is in between 50% - 100%, and he/she is also focused.
- Nominally engaged: a student engagement is under this category when the student is focused and the concentration index value from the facial emotion is below 50%.
- Not engaged at all (alert stage): a student engagement is under this category when the student is distracted, i.e., when the output from eye-head movement analysis is 0.

Figure 3 presents a general view of the system working in real time, and it presents the information data to the instructor/teacher. These data, which includes the facial emotions of the learner/student and eye-head movements, can be used to monitor the student/learner in real time while a teacher/instructor/e-learning system is delivering the content.

4 Experimental Results and Discussion

The system was tested with 15 students, from different teaching institutions, and ages in the range between 20- 30 years old. Students were requested to see an informative video lecture, which is 1 min and 56 s long, on one general topic on germs and diseases in a normal/traditional class environment. Figure 3. Demonstrates the general view of the system working in real time. The starting frames (0–50) consists of an informative and attractive colorful diagram of a pyramid. In the middle of the video, as illustrated with the question mark ('?') in Fig. 4, the tutor/teacher gives specific instructions about which component will fit in the missing part of the pyramid (the tutor changed this information accordingly).

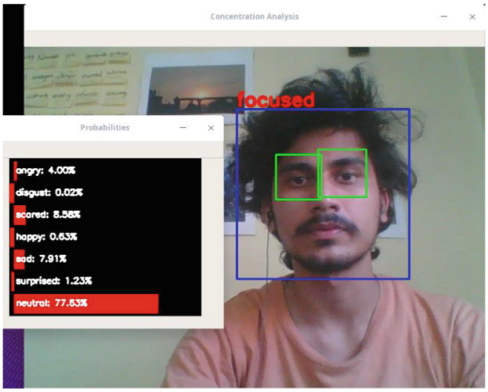

Fig. 3. General view of the system working in real time.

The last section of the video consists of almost only verbal information, with this section being shorter than the other sections of video. We have recorded individual videos capturing the facial emotions for each student. At the end of the video presentation, a very simple quiz (3 min long) was given to each student. The questions in the quiz have a direct answer in the presented video (i.e., the questions can be easily answered if the student watches the video lecture attentively). Figure 4 represents a figure which was asked to complete by students. The quiz consisted of the following questions:

i) Which topic did you studied?

   a) Bacteria and Insect
   b) Bacteria Only
   c) Virus Only
   d) Bacteria and Virus

ii) Who is host?

   a) Human

b) Bacteria
c) Virus
d) All

iii) What is the missing part in the Fig. 4?

a) Host
b) Virus
c) Bacteria
d) None

iv) Bacteria like when the respiratory track is…

a) Cold
b) Hot
c) Mild
d) None

v) What makes the host vulnerable?

a) When the host has more microbes
b) When the virus has more microbes
c) a and b
d) None

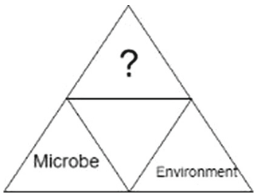

Fig. 4. Figure for the quiz.

Table 2 presents the global results of this quiz, along with the partial concentration indexes, for each subject and question. Before we proceed with the analysis of these results, we will explain the procedure used to find the values in this table.

Figure 5 shows examples of students watching the video, and the corresponding concentration index plots over the time for the full video.

As can be seen from these plots, some students have some intervals with a constant concentration index, while others have fluctuating plots. These fluctuations are due to eye/head movements and negative emotions.

Figure 6 plots the evolution of the concentration of a student, based solely on the movements of the eyes and head. Since we have used a binary classifier, the concentration index will be either 0 or 100, in percentage. The value 0 signifies that the student is "Distracted", whereas the value 100 signifies that the student is "Focused" (e.g., we can see that, in Fig. 6, a student is "Focused" during the interval between 10th to 70th frames, and from frame 70th to frame 105th the student is "Distracted"). Using algorithmic language, this can be represented as:

if c > 0.5 then

a = 100 (i.e., Focused)

else a = 0 (i.e., Distracted),

where c represents the value given by the Distraction Detector and the concentration in percentage. Note that the value of c is determined as explained in the beginning of subsection III-B above.

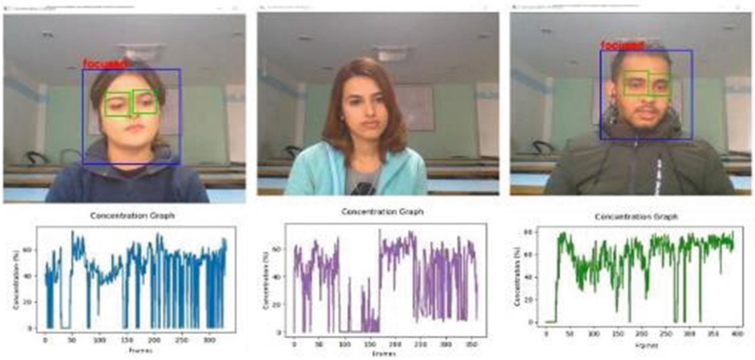

Fig. 5. Examples of students watching the video and the corresponding concentration index plots over the complete video.

Figure 7 plots the evolution of the concentration of a student, based solely on the facial emotions. The concentration index depends upon the seven basic emotions presented above. Each emotion contributes with its own value to the presented concentration index, to extrapolate the concentration value. To determine the concentration in percentage, a, based only on the facial emotion detected, we used the following rules:

if 'neutral' then CI = (DEP × 0.9) × 100

else if 'happy' then CI = (DEP × 0.6) × 100

else if 'surprised' then CI = (DEP × 0.5) × 100

else if 'sad' then CI = (DEP × 0.3) × 100

else if 'scared' then CI = (DEP × 0.3) × 100

else if 'angry' then CI = (DEP × 0.25) × 100

else if 'disgust' then CI = (DEP × 0.2) × 100

else CI = 0 (i.e., Distracted),

The weight values (0.9, 0.6, 0.5, 0.3, 0.3, 0.25, 0.2) have been found experimentally, and presented in Table 1. The DEP score is determined using the machine learning algorithm presented above in section III, then the concentration in percentage, CI, is calculated based on the dominant emotion, explained in subsection III-C. Figure 7 shows an example where we can be seen that between frames 90 and 120, the student reveals

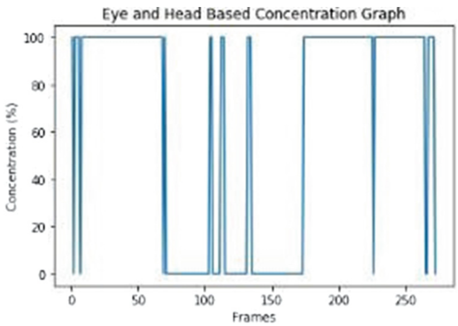

Fig. 6. Concentration index based only in the movements of the eyes and head.

a high concentration level, and between frames 150 and 190 the student shows a low concentration level.

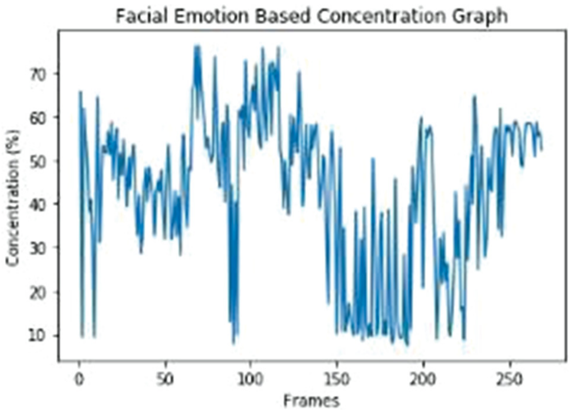

Fig. 7. Concentration index based only on the facial emotion's prediction.

Finally, Fig. 8 plots the evolution of the concentration of a student, based on both the facial emotions, and eye and head movements. First, the eye and head movements are analyzed. If this first analysis results in "Focused" state, then facial emotions are predicted to determine the concentration value, using the same rules and weights as presented and explained above. As can be seen in Fig. 8, from frame 12 to frame 47 the student is "Focused", having a concentration index value greater than 45 (in average). Between frames 109 and 140, the student is totally distracted, resulting in a concentration index of 0. Once again, note that if $c < 0.5$, then the student is "Distracted" and an alert can be issued (e.g., the instructor can be notified).

From Table 2, we can see that, out of the 15 students who performed the quiz, all of them have correctly answered question number 3 (which asks the student to find the missing part of the pyramid that was shown in the video) and the resultant mean concentration of the respective question is 60%, which is in "Highly engaged" category.

From this result we can conclude that the figure in the e-learning material helps the students to score better, as they have high concentration.

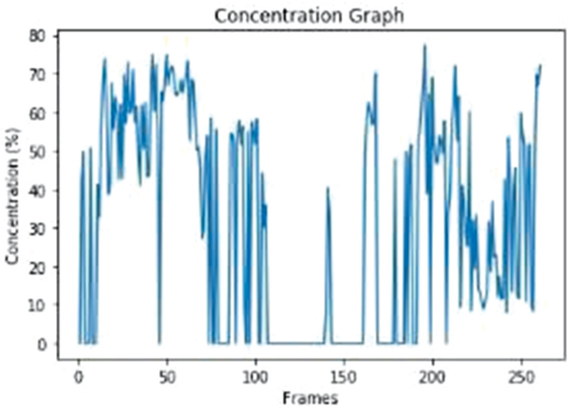

Fig. 8. Concentration index including eye, head movements and facial emotions prediction.

Levels during that learning period. Additionally, we can see that 92% of the students who scored 3 and above are also in the "Highly engaged" category (between 50–100%), which signifies that the score is correlated with their respective concentration value. Another finding reveals that the majority of students were not able to answer question number 5 (which is in the last section of video lecture). This might have happened due to the stress they feel with lots of new information, and the relatively short period of time they had have to absorb all the contents, and at the end they get saturated.

While the majority of the results are aligned with the concentration index values determined by the system presented here, this is not the case for the scored values for students 2, 6 and 8.

A detailed analysis of the entire videos of these students revealed that our system was unable to deal with the problem of "face occlusion". In our case, face occlusion is a state in which the face of the student is partially covered by his/her hand/s or any other object (such as glasses). As mentioned by [25], one of the major face occlusion is "hand to face gesture in which face is covered by hand". In the particular case of face recognition systems, this problem results in a lowering of the performance rate of these systems [26]. Figure 9 shows examples of student 2 and 6 partially covering their faces with their hands. As can be seen from the images, the students are focused because their eye-head movement is positive, i.e., they are effectively watching the content in the screen. However, the system is unable to extract their facial emotions completely, which results in a low concentration index. As a consequence, the system regards them as students with low concentration level, even if they are watching the content with high attention. In some particular cases, although the system gives a relative high value for the concentration, contrasting with the low marks they achieved in the quiz, these results, as explained by the students, could be because of the stress of their approaching board exams. Concerning the results of student 8, our system was unable to correctly find the concentration index due to the fact that this student wore glasses, and the concentration

Table 2. Global Results of the Quiz, along with the partial concentration indexes, for each student and questions

	Question 1		Question 2		Question 3		Question 4		Question 5		Total	
Student	Score	CI	Score	CI	Score	CI	Score	CI	Score	CI	Score	CI
1	0	46.4	0	34.8	1	37.6	1	35.9	0	28.3	2	36.6
2	1	54.4	0	56.8	1	27.1	0	61.6	0	56.0	2	51.2
3	1	68.6	0	64.4	1	74.1	1	71.8	0	68.7	3	69.5
4	1	57.5	1	46.3	1	49.7	0	61.3	0	49.0	3	52.8
5	1	62.1	1	60.6	1	60.3	1	66.7	1	60.5	5	62.0
6	0	62.2	1	52.2	1	68.1	0	66.9	0	54.8	2	60.8
7	0	63.8	1	71.3	1	52.9	1	58.5	0	56.8	3	60.7
8	1	46.0	1	1.1	1	53.9	1	50.6	0	27.5	4	35.8
9	1	72.6	1	71.0	1	77.1	1	73.4	0	61.1	4	71.0
10	1	57.6	0	47.6	1	58.0	1	51.3	0	47.0	3	52.3
11	0	74.2	1	69.8	1	73.2	1	74.1	1	72.6	4	72.8
12	0	71.1	1	68.1	1	68.9	1	65.5	1	74.3	4	69.6
13	1	64.3	1	49.2	1	62.5	0	63.5	0	63.7	3	60.6
14	1	68,8	1	70.1	1	66.5	1	69.1	1	65.1	5	67.9
15	1	67.6	1	61.8	1	72.4	0	61.3	1	63.1	4	65.2
Mean	0.7	62.5	0.7	55.0	1	60.2	0.7	62.1	0.3	56.6	3.4	59,3
Mode	1	---	1	---	1	---	1	---	0	---	3	---
StD	0.5	8.4	0.4	17.9	0	13.7	0.5	9.7	0.5	13.5	1.0	11.2

values given by the system were fluctuating. It is our aim to correct this effect in the future versions of the system presented here.

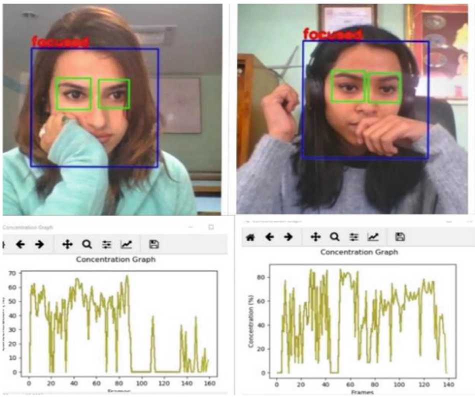

Fig. 9. Facial recognition error due to hand gesture.

5 Conclusion and Future Work

With the increase of distance learning, and e-learning environments in particular, having a system capable of determining students' engagement is of primordial importance and one of the biggest challenges both for teachers, researchers and policy makers.

Here, we presented a new approach of a system to detect the engagement level of the students. The system uses only the information provided by the built-in web-camera present in typical laptop computer. Our system uses the images grabbed by the camera to extract information about the movements of the eyes and head, and combines this information with the facial emotions, also retrieved from these images, to produce a concentration index. The presented system produces three classes of engagement: "very engaged", "nominally engaged" and "not engaged at all". The system proposed here was designed to work in real time.

By including the facial emotions information reflected by students about the learning topic, which includes the seven typical emotions, a teacher/instructor/learning management system will have live feedback, hence helping the system/teacher/instructor to automatically adapt the learning contents to the needs of the students. This will definitively contribute to dynamically enrich the learning environment and, hence, improve the performance of the students.

We have tested our system with fifteen students in a typical e-learning scenario, and the results show that the system correctly identifies each period of time where students were "very engaged", "nominally engaged" and "not engaged at all". Additionally, the results also show that the students with best scores also have higher resultant concentration index. In the future, we want to merge the information currently provided by our system with the information retrieved with the help of other sensors, such as heart rate, EEG signals, and oxygen level, among other. We are also working to change to 3D facial expressions detection, because they better facilitate an examination of the fine structural changes inherent to spontaneous expressions. However, this will pose additional difficulties and the need to use other capturing cameras, besides the laptop typical built- in web-camera.

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Online Learning and Blended Learning

Teacher Readiness to Adopt the Flipped Learning Model: Exploring Greek Teachers' Views and Perceptions

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Abstract. This paper reports on a study exploring the key factors that determine Greek teachers' perceptions about flipped learning and their readiness to adopt and use the flipped classroom model in educational practice. The research data were recorded from a total of 283 primary and secondary education teachers who participated in an online survey. The preliminary findings of qualitative data analysis, gathered from teachers' written responses to the open questions of the online questionnaire, indicated that the majority of participants were positive towards adopting and using flipped learning approaches in their instruction. They recognised the key pedagogical features that determine effective implementations of flipped classrooms. The findings also revealed a range of factors related to teachers' chal-lenges, concerns, barriers and difficulties to effectively design and implement flipped class-room interventions.

Keywords: Flipped classroom · Flipped learning · K-12 teachers · e-learning

1 Introduction

Over the last decade, the flipped classroom model has become a very popular technology-enhanced learning approach among educators in both, K-12 and higher education contexts. Inverting the lecturing-learning sequence is the core difference of the flipped classrooms compared to the traditional classroom instruction approach [10]. In flipped learning (FL) contexts, students are expected to acquire the basic content knowledge before the classroom by using online technologies to access lecture material and other educational resources. The in-class time, on the other hand, is not spent to teachers' lecturing; thus, the students can have increased opportunities for applying the basic knowledge learned at home, peer collaboration in problem solving activities and interaction with the teacher.

The flipped classroom (FC) approach has been widely used in higher education [2]. With regards to primary and secondary education, FC designs and implementation have been reported in various core subjects; for example, mathematics [16, 19], science [9, 29], English [31], humanities and social sciences [14, 25]. A variety of empirical research studies worldwide supported the idea that the flipped classroom approach provides a

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more flexible and active learning environment with positive effects on students' engagement, motivation, autonomous learning, interaction with classmates, collaboration and satisfaction [4, 23]. Many studies have also reported that the flipped classroom approach can increase students' learning engagement in the in-class activities, as well as their communication, interaction and problem-solving skills, thus enhancing their learning outcomes and achievements [16, 18, 22, 30, 32].

Literature review indicated that the majority of research studies have mainly focused on students' adoption, learning performance and satisfaction of the flipped learning model [8]. In general, students appear positive about the FC approach and recognize many benefits of FC with regards to their learning achievements [4, 23, 27].

On the other hand, research on teachers' perceptions and readiness to adopt the FC model, as well as their abilities to design and support flipped learning in their class, is rather limited [6, 12]. In this paper, we present initial findings and insights from a recent study investigating Greek primary and secondary teachers' perceptions about the flipped classroom approach and their abilities, concerns and difficulties to use this model in educational practice.

2 Rationale for the Present Study

Teachers' views and perceptions of the effectiveness of FC and the challenges faced to integrate flipped learning in their instruction remains an open research problem worldwide [2, 17]. Literature review showed that teachers face difficulties in organizing flipped classroom instruction, since this task is time consuming [3, 20, 26, 28, 31] while they lack appropriate learning resources and open educational material for their FC interventions; e.g., video lessons and digital material required for students' preparation in the entry phase (before-class) of the flipped classroom [18, 31]. Moreover, other commonly stated factors, related to the students, concern their effective preparation and use of the educational material provided prior to class [20, 28] as well as their limited access to online technologies at home [1, 11, 15, 26, 28].

Undoubtedly, teachers may encounter many barriers to the effective implementation of flipped classroom since this approach is opposed to their current traditional way of teaching and their experience. Thus, teachers may be reluctant to adopt FC approach and resist to changes due to their beliefs, attitudes and lack of self-confidence towards ICT [28]. As noted by Chou et al. (2019) the implementation of FC requires supportive school environment which provides the facilities needed but also training opportunities for teachers to improve their abilities to plan FC interventions. In the same vein, according to Wang [28], successful flipped classrooms require motivated and confident teachers who also need appropriate levels of time, resources, and support to develop FC designs in practice.

Our motivation to investigate teachers' views and perceptions of flipped learning was based on the emerging adoption of e-learning tools and online practices in K-12 education, observed over the last couple of years in Greek schools. The hypothesis that directed the present study had two related dimensions:

a) The rapid transition to Emergency Remote Teaching, when schools were closed because of the COVID-19 pandemic, forced many educators to use a variety of online technologies (e.g., Learning Management Systems, video conferencing platforms, YouTube, Web 2.0 tools), to use open educational resources (OER), to create their own digital materials, and to experiment with new pedagogical ideas like the flipped learning approach [19, 24].

b) Considering the findings of a previous investigation, flipped classroom was an attractive approach among Greek educators who provided online remote teaching during the COVID-19 pandemic [13]. We hypothesized therefore that, after their experience with online remote teaching, many teachers will be aware and/or interested about flipped learning approaches in their instruction.

2.1 Research Context and Research Questions

Currently, the prominent educational policy by the Greek Ministry of Education concerns curriculum reform and teacher development programs, both focused on a) cultivating novel pedagogical approaches in the schools; and b) students' development of 21st century skills. Since limited research has been conducted on the impact of the flipped classroom in the Greek educational context, the assumption that addressed the present study was that many teachers will be aware of the FC model and willing to participate in an investigation exploring their readiness to adopt and apply the flipped learning approach in their educational practices. In addition, they were expected to provide valuable information with regards to the application of the flipped learning model in practice, since they have developed a coherent network of perceptions and pedagogical ideas.

The aim of the present study was to reveal critical factors related to the flipped learning that could be of value, beyond the Greek educational context. Two research questions were explored:

- How do the participant teachers perceive the advantages/potential of FCs in relation to their pedagogical features and students' learning outcomes?
- What are the main concerns and difficulties teachers face in order to effectively design and implement flipped classroom interventions?

3 Research Method

The main body of this research project was quantitative in nature; however, we did add a qualitative component, described in the instrument section below. Our decision was to adopt a mixed research method by integrating both, quantitative and qualitative procedures, with the aim to enhance the significance of the present investigation. In this paper we present the qualitative findings that concern teachers' views about the pedagogical features of FC, their challenges and difficulties to design and support flipped learning practices in their classes.

3.1 The Sample

The survey conducted in January 2022 and data collection period lasted for three weeks. A total of 283 completely responded questionnaires were received for analysis. All participant teachers were serving in public primary and secondary schools from various district areas across the country. In the sample, 71 (25.1%) were males and 212 (74.9%) females. In addition, 161 teachers (56.9%) were teaching in secondary schools and 122 (43.1%) in primary schools. About 6 out of 10 teachers (58.3%) reported that they have used, at least once, the flipped classroom approach in their instruction. In addition, 113 teachers (39.9%) attended a 36-h teacher professional development program regarding students' development of 21st century skills. The program was delivered by the Institute of Educational Policy, Greek Ministry of Education and the flipped classroom approach was included as one of the thematic units.

3.2 The Instrument

We used an online questionnaire through Google forms with the objective to collect both quantitative and qualitative data regarding teachers' perceptions about flipped learning. The development of the questionnaire was relied on the existing literature and our research experience regarding teachers' adoption of learning technologies in K-12 educational contexts. Firstly, an initial pool of items created from previous related studies [1, 5, 6, 11, 15, 26, 28]. Then the various items were organized based on the research questions and were presented as phrases. The research instrument consisted of four open questions and a series of Likert-type statements (1 = strongly disagree, 5 = strongly agree) representing teachers' perceptions in the following dimensions: a) abilities to design and implement flipped classroom interventions; b) pedagogical features of the flipped learning approach; c) benefits and weaknesses of the flipped classroom model; and d) concerns and difficulties to design and implement flipped classroom interventions.

3.3 Data Analysis

Teachers' detailed written responses to the open questions of the questionnaire were thematically analysed. We systematically used a procedure including open coding, identification and creation of categories, reduction and connection of codes, reviewing and defining the major codes and themes [7]. A constant comparison method was used to achieve consensus, consistent description and interpretation of the findings. The data set was examined as a whole and a total of 917 units of meaning were identified. The two researchers independently classified codes into separate thematic categories and sub-categories. Intra-rater percent agreement was 97.8%. The discrepancy data were re-coded by agreement of the two authors, one week later.

4 Results

The qualitative data analysis revealed a range of critical parameters and factors which were organised and classified into three main thematic categories reflecting the overall view of teachers' perceptions regarding flipped learning: a) perceived pedagogical features of the flipped classrooms; b) challenges and concerns about the flipped classroom approach; and c) difficulties in designing flipped learning interventions. Quantitative data were also recorded and provided here, in relation to the specific factors identified (N = number of the independent teacher responses).

4.1 Pedagogical Features of Flipped Learning

Table 1 presents the results regarding the pedagogical features of the flipped learning approach which were spontaneously reported by the teachers. The majority of the participants appeared positive and recognized a range of important pedagogical features in flipped learning However, it was pointed out by 13 teachers that the FC model lacks the features of students' interaction and immediacy of support. In relation to the features of the flipped classrooms, our analysis identified 9 broad thematic categories, labelled and ordered as following: a) active learning; b) better use of in-class time; c) students' interaction and collaboration; d) development of high-level learning skills; e) deepening and applying new knowledge; f) creative learning; g) development of 21st century skills; h) personalized/differentiated learning; i) lack of interaction and immediacy. The quotes in Table 1 are representative of many similar statements that reflect teachers' views and perceptions regarding flipped classrooms.

Table 1. Main pedagogical features of flipped learning

Factor	Indicative quote examples
Active learning (N = 45)	T25: Flipped classroom is a student-centered approach; the students are actively involved in learning T238: Students are more engaged …. I can use new methods that keep students' interest for learning
Better use of in-class time (N = 36)	T63: There is more productive time available in the classroom … T146: There is more in-class time available for discussion and feedback
Students' collaboration (N = 32)	T205: There is time for students' collaboration in the classroom T214:… There are more opportunities for collaborative learning
High-order learning skills (N = 31)	T16: Students are able to self-regulate their learning T146: Students are actively engaged in a process of "learning how to learn"
Deepening, applying new knowledge (N = 27)	T218: There is more time available for solving questions and deepening knowledge T269: There is more time saved for students to practice and apply new knowledge

(*continued*)

Table 1. (*continued*)

Factor	Indicative quote examples
Creative learning (N = 24)	T34: You can save time from lesson delivery and use it in creative learning activities T163: …there is more time for consolidation and creative activities
Development of 21st century skills (N = 24)	T79: Students can develop 21st century skills, like self-motivation, freedom of expression, creativity, and collaboration T138: Students can develop critical thinking skills
Personalized/differentiated learning (N = 17)	E69: The great advantage of FC … is personalized learning E161: There are opportunities for differentiated instruction
Limited interaction and immediacy of support (N = 13)	T6: There is lack of teacher-student interaction in FC… T206: (Flipped classrooms) lack the feature of personal contact; i.e. students' communication and immediacy of teacher support

4.2 Challenges and Concerns About the Flipped Learning Model

Table 2 presents the results, as well as representative quotes, regarding the main challenges and concerns recognized by the participant teachers with regards to applying the FL approach in their classrooms. The factors identified constitute nine broad thematic categories as following: a) students' accessibility to digital technologies; b) students' preparation before class; c) learning effectiveness and students' inclusion; d) parents' role and bias; e) teachers' negative attitudes about flipped learning; f) students' readiness for flipped learning; g) school digital facilities; h) students' digital skills; i) students' negative attitudes about FC.

Table 2. Challenges and concerns about the flipped learning approach

Factor	Indicative quote examples
Students' accessibility to digital technologies (N = 104)	T11: Some students may face technological difficulties (e.g., Internet connection, digital equipment) T15: Some students may not have support and/or access to digital technologies, in order to be prepared for the in-class phase

(*continued*)

Table 2. (*continued*)

Factor	Indicative quote examples
Students' preparation and engagement into pre-class activities (N = 95)	T26: I had occasionally applied the FC model … I noticed that some students were not prepared and did not use the material provided before in-class instruction T120: …many students are not engaged into the pre-class activities; so, they are not able to actively participate in the in-class activities
Learning effectiveness and student inclusion (N = 38)	T32: I am not sure if all students can cope with the (FC) requirements. My concern is related to the inclusion of all students T76: I am concerned about the effectiveness of the flipped classroom approach, i.e. in terms of students' acquiring the new knowledge
Parents' role (36)	T176: Many parents lack the time and the digital skills (to support their children) T226: Parents' beliefs is a critical factor. Many of them prefer the traditional model instead of novel instructional approaches
Teachers' negative attitudes about FC (N = 35)	T83: Unfortunately, I cannot see any advantage (of FC). The "bad" students will be "bad" anyway… The "good" students are wasting their time and they lack the quality of teaching T200: I think that the implementation of flipped classrooms induces new problems that create barriers to students' learning
Students' readiness for flipped learning (28)	T74: The students are not familiar with the flipped classroom approach where collaboration and teamwork are presupposed T209: The majority of students are not prepared to actively participate in inquiry and problem-based activities
School digital facilities (N = 26)	T58: Many schools, especially in non-urban areas, are not equipped with the appropriate ICT facilities
Students' digital skills (N = 14)	T38: Many students will not be able to respond to flipped learning because they lack the digital skills needed T160: Some students are not familiar with digital technologies

(*continued*)

Table 2. (*continued*)

Factor	Indicative quote examples
Students' negative attitudes about FC (N = 8)	T50: Many students are not willing to adopt a new way of learning that requires more working time at home T195: Many students prefer the traditional model instead of the flipped classroom approach

4.3 Teachers' Difficulties in Designing Flipped Learning Interventions

Table 3 presents the results regarding the factors that represent teachers' difficulties to design FC interventions and integrate flipped learning in their instructional practices. The corresponding quotes are representative of many similar statements that reflect teachers' views and perceptions. Six main categories of difficulty factors were identified and classified in this dimension, namely: a) increased workload for the teachers to prepare and support FC approaches; b) teachers' development of flipped learning design abilities; c) lack of proper digital educational resources; d) curriculum related restrictions; e) teachers' specific digital skills; f) school culture.

Table 3. Factors affecting the integration of flipped learning in school practice.

Factor	Indicative quote examples
Teacher workload (N = 122)	T248: Flipped classroom requires considerable time for the teacher … it is not easy to be used on a daily basis T76: I lack the time required to design and organize the educational material needed for the pre-class phase T146: The main disadvantage of the flipped classroom is that it requires excessive workload for the teacher
Flipped learning design abilities (N = 77)	T101: I need to learn more about the flipped learning approach T105: The flipped classroom model demands that the teachers have specific pedagogical and digital skills T130: I lack the knowledge, in both theory and practice, to adopt the flipped classroom model

(*continued*)

Table 3. (*continued*)

Factor	Indicative quote examples
Educational resources (N = 29)	T66: There are not enough digital educational resources available in Greek T238: Sometimes it is difficult to find suitable material for my lessons
Curriculum related restrictions (N = 20)	T79: The curriculum should be modified and rationalized in order to integrate the flipped learning approach T212: The curriculum is not in line with the principles of flipped learning
Teachers' specific digital skills (N = 20)	T24: I am not familiar with specific digital tools needed to implement the flipped classroom approach T36: I faced problems in creating my videos; in particular, to integrate sound in my presentations
School culture (N = 16)	T84: The flipped classroom approach should be integrated at the school level (not just to be used in one class) … many teachers are resistant to any change T163: The existing school culture does not support the implementation of the flipped classroom model

5 Final Considerations

The present study reported upon Greek K-12 teachers' perceptions, challenges and concerns about the implementation of flipped learning interventions in the schools. The preliminary findings, based on the analysis of qualitative data from teachers' written responses to the open questionnaire, offer a detailed description of many intervening factors. Overall, the findings clearly indicated that the majority of the participants recognised the pedagogical features of the flipped classroom approach and they were positive to adopt this model. However, they noted a series of factors that determine their concerns and difficulties in relation to applying flipped learning approaches in their classes. They also highlighted the need for further training and enhancing their pedagogical skills and abilities in order to effectively design and support students' learning in flipped classrooms.

Confirming the results of previous studies, the majority of the participant teachers agreed that the FC approach promotes active learning, and allows students to carry out creative and collaborative activities, to interact with their peers in order to solve problems and apply new knowledge [15]. In addition, the teachers believe that, in the FC model, the students have increased opportunities to develop a range of higher-order skills, such as critical thinking, creativity, communication and collaboration skills [11, 25, 33].

Moreover, the Greek teachers in the sample appear aware and recognise the key pedagogical features of the FC approach; i.e., that they can make better use of the in-class time through student-centred, creative and collaborative activities that help students to deepen and apply new knowledge. In this flexible and creative learning environment, teachers perceive their role as facilitator of students' learning while they support students' personalized and differentiated learning.

Participants also highlighted several challenges related to the implementation of the FC model in school practice. In line with previous studies [11, 28, 31], they pointed out that the effective implementation of flipped learning requires students' suitable preparation and access to digital resources (before in-class instruction). Students' disengagement into pre-class activities and lack of digital skills were also indicated as main barriers to implement effective flipped classrooms.

In addition, confirming existing research findings [28, 31], the design of flipped learning interventions requires teachers to devote considerable efforts and more time, compared to traditional instruction, in order to prepare suitable educational material (e.g., video-lectures, in-class activities, assessment tools) and communicate with their students through asynchronous discussion tools out of classroom. Similarly, Lo et al. [20] identified two major challenges: a) considerable start-up efforts for teachers to prepare FC material; and b) students' lack of pre-class motivation.

Our findings revealed also factors related to the educational context (i.e., school culture and support, parents' role and perceptions, the existing K-12 curriculum) which affect teachers' adoption of FC and their decision to apply the flipped learning model in practice. Nevertheless, the transition to flipped learning in the education context of K-12 schools is not necessarily a new concept, in terms of teachers' readiness, pedagogical framework, digital technologies and teachers' learning design abilities [21]. To successfully apply flipped learning, teachers need to put extra effort by harnessing specific pedagogical ideas to design and support an educational process aiming to integrate students' pre-class and in-class learning activities. In this perspective, cooperation with other teachers in the school is critically vital to maximise the benefits of the flipped learning approach.

Despite that this study could be limited by the specific sample and the educational context in the Greek schools, particularly after the pandemic of COVID-19, the findings are of value for designing teacher professional development programs and supporting teachers to overcome their difficulties in designing and implementing FC interventions.

Further investigations on teachers' perceptions and readiness to integrate the FC model in educational practice are necessary. In addition, combining both qualitative and quantitative studies could provide insight into teachers' adoption of the flipped classroom method. This research project is currently directed to a comparative analysis of the qualitative and quantitative data extracted from teachers' responses to the online questionnaire. We expect thus to shed light into the multiple aspects of flipped classroom approach as perceived by the teachers in the Greek K-12 schools and beyond.

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Designing, Deploying and Evaluating an Undergraduate Course on the "Didactics of Informatics"

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Abstract. This paper presents the design, deployment and evaluation of an undergraduate course on the Didactics of Informatics. The course was designed taking into account relevant literature and aims at preparing undergraduate students of Informatics for teaching the subject at schools. Specifically, the course aims at educating students, who are potential pre-service teachers, for teaching Informatics utilizing contemporary learning and digital technologies, educational environments and games, as well as students' difficulties and representations mainly for programming and Computational Thinking. The course was offered for the first time as an elective course at an Informatics department during the academic year 2020–21, while 265 students attended and participated in the exams of the course. Students' performance in the assignments and the exams, as well as in an anonymous questionnaire administered by the Quality Assurance unit of the University show that the course was well perceived by students. Students evaluated positively the quality and organization of the course, considered its content interesting for their studies and the educational material sufficient. Although the results are promising, it is clear that refinements are necessary in order for the course to accomplish its learning objectives.

Keywords: Didactics of informatics · Undergraduate course · Curriculum

1 Introduction

Teaching any scientific subject to students is not an easy task. As Gal-Ezer and Harel [1] (p.77) note "*while the work of a practitioner or researcher requires extensive knowledge and skills in the field itself, the educator must have the additional ability to convey this knowledge to others correctly and reliably, to teach the said skills, to provide perspective, and to infuse the students with interest, curiosity, and enthusiasm*". Computer Science (CS) in specific is a rather challenging field to teach since it is constantly evolving [2]. In order to properly teach CS, both pre-service and in-service CS teachers have to be appropriately trained [3] through specially designed courses and programs respectively [4]. Such training programs or courses should focus on subject matter, pedagogical content and curricular knowledge [5].

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Preparing a training program for in-service Informatics teachers or a course on the Didactics of Informatics for undergraduate students is not an easy task. Teachers of Informatics tend to give more emphasis in practice and not in theory in comparison with teachers of other disciplines, while as technology experts they do not get easily as enthusiastic as teachers in other disciplines with the use of ICT in the educational practice [4]. A key concept that has to be conveyed either at training programs or undergraduate courses on Didactics of Informatics is that of the didactic transposition from the scientific knowledge to what is actually taught in the subject of Informatics at schools [6].

Although, designing and deploying a Didactics of Informatics course is of great importance the literature is sparse. Lapidot and Hazzan [7] report a "Methods of Teaching Computer Science in the High School" course that aims to prepare future teachers for teaching programming without focusing on a specific language, programming paradigm, level of students, or curriculum. Brinda and Hubwieser [8] focus on the requirements and the organizational settings of a "Didactics of Informatics I" course for future Informatics teachers and potentially for training in-service teachers. The lack of literature on designing and teaching a course on the Didactics of Informatics constitutes the offering of such a course rather challenging. This paper aims to contribute to the field by presenting a holistic overview of an undergraduate course on the "Didactics of Informatics", including: its learning objectives, syllabus, and assignments; its deployment; and the first evaluation results based on students' achievements in the course and the evaluation of the course by students through an anonymous questionnaire.

The rest of the paper is structured as follows. In Sect. 2 the learning objectives and the syllabus of the course are presented and analyzed in the context of the literature that guided its design. In Sect. 3, brief information for the deployment of the course is presented, while in Sect. 4 the first results of its evaluation are analyzed. Conclusions are drawn in Sect. 5.

2 Course Design

In this section the learning objectives, the course syllabus, as well as the rationale of the assignments are presented. Emphasis is given on analyzing the rationale of the course structure and the literature it was based on.

2.1 Learning Objectives

Upon the successful completion of the course, students will be able to:

- Distinguish and describe fundamental concepts of the theoretical framework of didactics.
- Apply contemporary learning approaches and design lesson plans and didactical scenarios and activities for the subjects of the Informatics Curriculum in Primary and Secondary Education.
- Distinguish common difficulties and misconceptions of students during their introduction to programming (computational thinking, procedural and object-oriented programming) and ways for dealing with them.

- Distinguish between available didactical approaches and educational programming environments/games and select the most appropriate one according to the age of the students and the goals of the analytical program of studies.
- Evaluate existing educational games for the field of Informatics and design new ones.

2.2 Course Syllabus

The content of the course is organized in six units, with each one of them serving specific goals of the course. It is clear that these units are not independent to one another and the ultimate goal is to synthesize the underlying concepts, research findings, teaching approaches and tools and create a holistic and contemporary view of the field. The course aims to help students exploit their learning experiences (good and bad ones) from their school and University life and their knowledge on ICT, to educate them on contemporary teaching approaches and tools, and finally to motivate them to use their creativity for advancing the teaching of Informatics as future teachers.

The six units of the course and their content are summarized in Table 1 and analyzed in the following subsections.

National Educational System. A brief introduction to the program of studies on Informatics in the Greek primary and secondary schools is presented. Although all the attendants of the course have prior knowledge of the content of the Informatics and Information and Communication (ICT) courses taught in Greek schools, this part of the course aims: to make clear what the goals of the Informatics and ICT courses are; to highlight from the beginning that the relevant courses rely heavily on a constructivist approach, active learning and a spiral approach for revisiting and comprehending more deeply various concepts; cultivating Computational Thinking (CT) and problem solving skills; and utilizing ICT in the entire program of studies and not only the ICT courses. The role, the learning goals, the syllabus and indicative educational tools and activities for teaching problem solving and computer programming throughout the program of studies are presented and critically discussed.

Students are asked to: recall their own experiences as students in primary and secondary education; comment on the degree that the goals and objectives of the Informatics courses as presented in the program of studies were met; and critically discuss their ideas for a more successful teaching of Informatics at schools. This is followed by presenting students with initiatives around the world for enhancing the teaching and learning of Informatics and motivating them to actively participate towards this goal.

Foundations of Didactics of Informatics. The module of the course on the foundations of Didactics of Informatics focuses on the underlying theoretical framework, typical didactical techniques and contemporary learning approaches. Emphasis is given on the didactic transposition of scientific concepts [6], which is necessary when teaching Informatics in schools.

Students are asked to recall their experience from Informatics and ICT courses attended in school, but also courses in tertiary education, and discuss positive and

Table 1. Course syllabus.

Course Unity	Contents
Unit 1: National educational system	
Program of studies on Informatics	Outline and goals of the program of studies on Informatics for the Greek Primary and Secondary School (Gymnasium & Lyceum); The role of problem solving and computer programming
Unit 2: Foundations of Didactics of Informatics	
Theoretical framework	Phases of incorporating Informatics and Information and Communication Technologies (ICT) in education (Educational technology, the didactical machines of B.F Skinner; Computer Science Education as a discipline) Behaviorism; constructivism; scaffolding; activity theory The didactical triangle (students, instructor, knowledge); didactical contract; didactic transposition of scientific concepts; social practices of reference (digital games, Internet etc.); students' perceptions and representations; mental models; mistakes and misconceptions; Technological pedagogical content knowledge (TPACK)
Didactic techniques	Advantages, disadvantages and prerequisites for the successful application of established didactic techniques: lecturing; discussion/dialogue; Q&As; snowballing; brainstorming; demonstration; practical activities; group work; interdisciplinary projects; role playing games; case studies; conceptual mapping
Contemporary learning approaches	Exploratory learning; cooperative learning; the project approach; game-based learning; concept mapping
Unit 3: Lesson plans and didactical scenarios	
Lesson plans and didactical scenarios	Distinction between lesson plans (usually refer to one didactical hour) and didactical scenarios (can span to several didactical hours) The constituent elements of lesson plans and didactical scenarios Design, application and evaluation of lesson plans and didactical scenarios with the use of contemporary teaching approaches and educational tools

(*continued*)

Table 1. (*continued*)

Course Unity	Contents
Unit 4: Didactics of Programming	
Difficulties and misconceptions	General difficulties and misconceptions of teaching and learning programming Difficulties and misconceptions of novices during their introduction to the procedural (control structures, functions) and object-oriented techniques of programming (objects, classes, inheritance, polymorphism, overriding)
Teaching approaches	The classic teaching approach and its didactical problems Alternative teaching approaches and their advantages
Educational programming environments	Educational programming environments for teaching algorithms, procedural and object-oriented programming Practical examples and didactical scenarios for their exploitation
Unit 5: Computational Thinking	
Computational Thinking	Computational thinking (CT) skills and their importance for the citizens of the 21st century Approaches (e.g. CS-unplugged, educational robotics) and environments (microworlds, educational games) for cultivating CT skills Empirical studies on the use of educational games for cultivating CT skills
Unit 6: Educational Games for Computer Science Education	
Educational games	The role of digital games in the teaching of Informatics; categories of games; designing and evaluating educational games with the use of specialized conceptual frameworks and questionnaires respectively; applying educational games in the didactical practice; practical examples and empirical studies

negative experiences in terms of the didactical techniques and contemporary learning approaches used, but also their vision on the teaching and learning of Informatics. Students express their opinion on the advantages and disadvantages of various known teaching approaches based on their experience. This is followed by the presentation of guidelines for a more successful implementation of these approaches, as well as new ones. Finally, it is stressed that it is important to organize the teaching and learning process taking into account students' perceptions and representations [6].

Lesson Plans and Didactical Scenarios. This module of the course focuses mainly on acquiring the ability to design, deploy and evaluate lesson plans and didactical scenarios for various fields of Informatics included in the program of studies. Lesson plans refer mainly to the teaching of a subject for one didactical hour, while a didactical scenario can span to several didactical hours. In Table 2 the constituent elements of a lesson plan and a didactical scenario are presented. Emphasis is given on clearly defining learning/didactical goals based on the program of studies and designing effective activities utilizing contemporary learning approaches and educational tools. Action verbs are used for expressing learning goals according to Bloom's taxonomy.

Students are presented with ready-made examples of lesson plans and are asked to characterize them as "good" or "bad" and indicate what their strengths and weaknesses are and finally propose improvements, or even propose a different lesson plan for achieving the predefined learning goals.

Didactics of Programming. The first part of this module examines students' difficulties and misconceptions with programming in general, as well as the procedural and object-oriented programming techniques, which are taught in Greek schools. The general difficulties and misconceptions that are intrinsic to learning programming, but also attributed to specific programming techniques have been studied for decades. Students' are presented with the results of archival studies in the field, such as:

Table 2. Constituent elements of lesson plans and didactical scenarios.

Lesson plan	Didactical scenario
Title, Class, Duration, Placement in the program of studies, Learning goals, Required resources and materials, Outline of student activities, Brief description of the organization of teaching, Assessment, Debriefing	Title, Class, Duration, Placement in the program of studies, Learning goals, Brief description of the organization of teaching, Scientific approach to teaching and analysis of concepts, Extensions and interactions of the underlying concepts or the activities, Multiple representations of concepts and approaches for comprehending them, Expected difficulties, Use of computers, Didactical "noise", References and sources, Underlying learning theory, Didactical contract, Orchestration of the class and feasibility of the designed scenario, Description and analysis of worksheets & evaluation sheets

- *General difficulties*, which are related to the orientation of learning programming, the notional machine, notation, structures, pragmatics, as well as *common errors* that stem from them, such as misapplication of analogies, overgeneralization and bad manipulation of complexity and interactions [9].

- *Programming constructs-based problems*, such as the natural-language and the human interpreter problem; *plan composition problems*, such as the summarization problem, the optimization problem, the inappropriate previous experience problem, the natural language problem and the unexpected cases problem [10].
- Difficulties and misconceptions for *fundamental programming concepts/constructs* [11–13]: variables; data input; selection structures; repetition structures/loops.
- Difficulties and misconceptions for the main *object-oriented programming concepts* [14, 15], such as the ones reviewed in [16]: object/class conflation; object/variable conflation; class/collection conflation; class-object as set-subset; class-object as whole-part; forming a static view of OO; difficulties with multiple classes, composed classes, and modelling.

Having knowledge of such difficulties and misconceptions can help an instructor to appropriately organize a course [17]. Specifically, having knowledge of the anticipated difficulties and misconceptions can help instructors in designing tests for diagnosing the existence of such difficulties and misconceptions, as well as effective examples and activities that can reduce students' difficulties and misconceptions or even eliminate them from the very beginning. This is one of the main goals of this part of the module and emphasis is given on presenting students with examples of indicative activities that aim both to investigate the existence of and deal with widely known difficulties and misconceptions. Moreover, emphasis is given on the fact that empirical studies on students' difficulties and misconceptions with fundamental programming concepts and constructs that refer to specific programming languages, such as Basic and Pascal, are still valid and can be utilized for designing appropriate didactical activities in other languages as well. As a case study, students are presented with examples of activities for diagnosing well-known misconceptions recorded in studies with Basic and Pascal in the context of a pseudo language called Glossa utilized in Greek schools for an introduction to fundamental programming concepts.

The second part of the module on the didactics of programming focuses on the available *approaches to teaching programming*. Specifically, the classic teaching approach that is often used is presented along with its didactical problems. The classic approach to teaching programming is based on the use of [18]: a general purpose programming language; a professional integrated development environment (IDE); and number and symbol processing problems. The classic approach to teaching programming is accompanied with several difficulties.

This is followed by the presentation of alternative teaching approaches [19]: microworlds; compilers with improved diagnostic capabilities; syntax editors either with the form of structure editors or iconic programming languages or flowchart-based environments; software visualization and program animation; and educational games. Emphasis is placed on the problems of the classic approach that each one of these alternative approaches deals with, as presented in Table 3. The ultimate goal of this part of the unit is to help students that will become future Informatics instructors to appropriately select and combine the appropriate teaching approaches for a more successful teaching of programming based on the age of the students and their background, as well as the goals of the course.

Table 3. Difficulties of the classic teaching approach dealt with by alternative approaches.

	Microworlds	Student-friendly Compilers	Syntax editors	Software visualization & program animation	Educational games
Extended and complex instruction set	✓		✓		✓
Attention is focused on learning the syntax of the language and not on problem-solving	✓		✓		✓
The dynamic nature of program execution and the semantics of control structures are a black box	✓			✓	✓
Compilers report abstract error messages that are targeted to expert programmers	✓	✓			✓
It is cognitively complex to transfer an algorithm to a programming language	✓		✓		✓
Number and symbol processing problems do not attract students' attention	✓				✓

This is followed by specific examples of *educational programming environments* that apply and in several cases combine the aforementioned teaching approaches:

- Programming microworlds [18]: Karel the robot [20] and various implementations
- Tools for designing and executing flowchart diagrams [21]: Raptor [22]

- Environments for writing pseudocode with a syntax editor and executing it through program animation: Glossomatheia (in greek)
- Environments with visualization of concepts and direct manipulation techniques: BlueJ [23]
- Environments with features of programming microworlds that approach the learning of programming through game development: Scratch [24], ScratchJr [25], Greenfoot [26]
- Educational games: LightBot, RunMarco

Practical examples and didactical scenarios for effectively exploiting the special features of educational programming environments and dealing with the didactical problems of the classic approach and the difficulties that are specific to the underlying programming techniques are presented.

Computational Thinking. Computational thinking (CT) skills are considered important for any citizen of the 21st century [27]. CT skills, such as abstraction, decomposition, generalization, algorithmic thinking, analysis, and pattern recognition, are important for everyone nowadays no matter what his/her field of studies or profession is. Acquiring CT skills is an important goal of the program of studies for Informatics. Several initiatives have appeared worldwide for CT and one of the goals for this module of the course is to inform students about important initiatives, such as the "EU Code Week" (https://codeweek.eu/), the "Hour of Code" (https://code.org/learn) [28], the "Scratch Day" (https://day.scratch.mit.edu/) and the "Bebras" competition (https://www.bebras.org/) [29] as well as ways for applying them in the classroom [30]. Another goal of this module is to briefly present various approaches for cultivating CT skills, including: CS-unplugged activities [31]; educational environments such as microworlds and educational games [32] that are targeted even at preschoolers [25]; and educational robotics [33]. Empirical studies on the use of educational games for cultivating CT skills [34] are analysed and critically discussed.

Educational Games. Educational games [35, 36] are considered to offer many advantages in the learning process, with motivation, engagement and entertainment being some of the most referenced ones. The role of digital games in the teaching of Informatics is the main goal of this unit. It is stressed that using an educational game does not necessarily lead to better results, since several conditions have to be met [37]. It is necessary to select an appropriate educational game depending on the underlying learning goals, to plan carefully the teaching intervention, evaluate its impact and make the necessary adjustments. In order to accomplish it, students are presented with: specialized design frameworks, such as the Four-dimensional framework by De Freitas and Jarvis [38] that focuses on the context of using the game, the features of the learner, the pedagogical dimension of the game and issues that concern its representation and aim at achieving a high level of interactivity and immersion, among others; the MEEGA + model for evaluating educational games for CSE and the relevant questionnaire [39], as well as the key criteria of game design and application of a game in the educational process proposed by Sanchez [40]; and finally, practical examples and empirical studies. This is expected to prepare students in selecting the most appropriate game for a specific topic, but even to start designing their own educational games with a focus on using them in the educational practice [41].

2.3 Assignments

The assignments of the course account for 30% of the final grade. The two main assignments refer to designing a lesson plan and a didactical scenario for a topic included in the program of studies in primary and secondary education in Greece.

During the first year of teaching the course students were also asked to play test an educational programming game and evaluate it through an online questionnaire based on the MEEGA + model analyzed in the course, as well as an Eclipse plugin for supporting novices in designing the solution to a problem using the object-oriented programming technique.

3 Course Deployment

The course on the "Didactics of Informatics" was offered as an elective course for the first time during the spring semester of the academic year 2020–21. The course was taught for 3 h per week for a total duration of 13 weeks. Due to the Covid-19 pandemic lockdown the course was taught exclusively online using Zoom. During the lectures the instructor utilized presentations, as well as websites with learning objects, educational material and online proceedings of relevant conferences. Whenever an educational tool was used, students were informed in advance in order to install it in their computers. The chat tool incorporated in Zoom was used during lectures and also the instructor shared google forms for collecting students' perceptions, representations and ideas for specific topics under consideration and presenting and discussing the results in real time in the virtual classroom. The educational material, links to the approved programs of studies for primary and secondary education, repositories with learning objects, educational tools, and relevant conferences were shared through a learning management system (LMS). The assignments were also announced and uploaded to the LMS. Discussion forums for general topics and the assignments were created in the LMS, while all the announcements were posted to a dedicated area of the LMS and sent through emails to registered students.

4 Course Evaluation

The course was evaluated in terms of students' performance in the assignments and the exams (Sect. 4.1), as well as students' evaluation of the course through an anonymous questionnaire (Sect. 4.2).

4.1 Student Performance

Students' achievements in the assignments and the final written exams are presented in Table 4. The exams were carried online due to the Covid-19 pandemic lockdown and consisted of 30 multiple choice questions (50% of the grade) and two short open-ended questions (20% of the grade) asking students to propose the overall didactic techniques, potential educational tools and types of activities for teaching specific programming or CT concepts at a group of students with specific characteristics (age, prior knowledge). All the questions were based on the educational material of the course, which was available during the exams from the official Learning Management System of the Institution, and required critical thinking and not solely memorization.

Table 4. Results on student performance.

	N	Max value	Mean	Std. Dev	Median
Assignments	206	3	2.35	0.78	2.8
Exams	265	7	5	0.88	5.2
Final grade	265	10	6.83	1.63	7

In Table 5 the percentage of correct/wrong answers in the closed type questions of the exams are presented. Due to space limitations students' difficulties cannot be further analyzed. However, we must note that based on the assignments it seems that some students: find it difficult to articulate the learning goals in a lesson plan/didactical scenario using appropriate action verbs; propose several learning goals that cannot be achieved in the available didactical hours; do not take into account the results of relevant literature when designing their lesson plans or didactical scenarios; do not adequately describe the overall organization of their scenario and just present the learning activities; do not define the teaching approaches and techniques that are going to be used in the proposed lesson plan/scenario.

Table 5. Results on the closed-type questions of the exams.

	Question context	Correct	Wrong
Foundations of Didactics of Informatics			
Q1	Areas of interest for Didactics of Informatics	67.9%	32.1%
Q2	Introduction of Informatics and ICT in education	93.2%	6.8%
Q3	Use of Informatics and ICT in the program of studies	90.9%	9.1%

(*continued*)

Table 5. (*continued*)

	Question context	Correct	Wrong
Q4	The relation of behaviorism and constructivism with personal and group activities	91.3%	8.7%
Q5	The scientific knowledge and the knowledge taught in schools for the various fields of Informatics	87.9%	12.1%
Q6	The relation of the didactical transformation and the exploitation of ICT in the didactical practice	84.5%	15.5%
Q7	The way that an instructor should treat students' prior knowledge	97.7%	2.3%
Q8	Techniques that promote interaction and cooperation among students	10.9%	89.1%
Q9	Usage of concepts maps for investigating prior knowledge	71.7%	28.3%
Q10	Usage of concepts maps as a tool for retrieving and representing students' prior knowledge	89.1%	10.9%
Q11	The relation of CS unplugged activities and computers	76.6%	23.4%
Q12	Tools for identifying knowledge and misconceptions for any concept	27.2%	72.8%
Lesson plans and didactical scenarios			
Q13	The concepts of a lesson plan and a didactical scenario	96.6%	3.4%
Q14	The verbs used for expressing learning goals	88.3%	11.7%
Q15	The desired features of a learning goal	26.8%	73.2%
Q16	Potential activities for evaluating students' prior knowledge	80.4%	19.6%
Q17	Potential causes of students' difficulties with a concept related to Informatics	87.5%	12.5%
Q18	Potential relation of didactical "noise" with wrong or insufficient students' prior representations	91.3%	8.7%
Didactics of programming			

(*continued*)

Table 5. (*continued*)

	Question context	Correct	Wrong
Q19	The difficulties and mistakes of novice programmers and their sources, i.e. plan composition problems	69.4%	30.6%
Q20	The difficulties of the classic approach to teaching programming	22.3%	77.7%
Q21	The features of programming microworlds	67.2%	32.8%
Q22	The similarity/difference of student difficulties with basic algorithmic structures in different programming (pseudo) languages	51.7%	48.3%
Q23	The importance of having knowledge of the literature on students' difficulties and misconceptions on programming	76.6%	23.4%
Q24	Common misconceptions with OOP concepts	75.8%	24.2%
Q25	The role of examples on specific misconceptions with OOP	57%	43%
Q26	Effective approaches for comprehending OOP concepts	90.9%	9.1%
Computational thinking			
Q27	CT skills	93.6%	6.4%
Q28	The relation of CT skills and programming	92.5%	7.5%
Educational games			
Q29	The role of conceptual frameworks on designing educational games	70.6%	29.4%
Q30	Evaluation of educational games	70.2%	29.8%

4.2 Course Evaluation by Students

In Table 6 the results of the anonymous questionnaire (including closed-type 5-point Likert scale questions) administered by the Quality Assurance Unit of the University are presented. The whole evaluation process is managed by the Quality Assurance Unit, while the data collected are analyzed by the Department of Statistics, Computerization and Informatics of the University and are afterwards made available to instructors. The majority of the students evaluated positively the quality, the organization and presentation of the course, as well as the available educational material. It is also important that students perceived the topic of the course interesting and useful for their studies and consequently it is important to include relevant courses in an undergraduate program of studies dedicated to Informatics. Finally, the frequency of attending the course and the hours of study per week follow the same pattern as the other courses. Unfortunately, nearly one out of ten students that participated in the exams answered the questionnaire, but it is a widely known problem with this type of evaluation since it is not compulsory for students.

Table 6. Results of anonymous student course evaluation.

	N	Course Mean	Mean for all courses
1. Was the quality of the course high? 1 = not at all, 2 = slightly, 3 = averagely, 4 = much, 5 = very much	25	4.20	3.79
2. Was the organization and presentation of the course flawless? 1 = not at all, 2 = slightly, 3 = averagely, 4 = much, 5 = very much	25	4.32	3.84
3. Was the topic of the course interesting and useful for your studies? 1 = not at all, 2 = slightly, 3 = averagely, 4 = much, 5 = very much	25	4.08	3.93
4. Was the educational material (textbooks, notes, exercises, articles etc.) sufficient for the needs of the course? 1 = not at all, 2 = slightly, 3 = averagely, 4 = much, 5 = very much	25	4.40	3.89
5. Do you attend the lectures regularly? 1 = not at all, 2 = slightly, 3 = regularly, 4 = very regularly, 5 = always	25	4.12	4.31
6. Besides the lectures, how many hours do you devote in this course per week? 1 = $<$ 2 h, 2 = 2–4 h, 3 = 4–6 h, 4 = 6–8 h, 5 = $>$ 8 h	25	1.80	1.81

5 Conclusions

Preparing undergraduate students of Informatics for teaching the subject at schools is necessary. Utilizing learning and teaching technologies in combination with contemporary tools can promote the teaching and learning of Informatics. However, students must have both a theoretical background (i.e. the transposition of scientific concepts to the "teaching subject"), and practical knowledge on designing their teaching utilizing contemporary teaching approaches, technologies and tools. Having this goal a "Didactics of Informatics" course was designed and deployed during the academic year 2020–21 in an Informatics department.

The aim of the study presented in this paper was to reflect on the learning goals and the syllabus of the course, its first deployment and the initial evaluation results. Based on students' performance on the assignments and the exams, as well as an anonymous evaluation of the course based on a questionnaire it turned out that the course was positively perceived by students. Students considered the course to be interesting for their studies and evaluated positively the quality, presentation, organization and the educational material of the course. Moreover, the results of the assignments and the exams showed that the learning goals of the course were achieved at a satisfactory degree, while specific topics that caused difficulties and need to be addressed were recorded. We must note that the course was taught exclusively online due to the Covid-19 pandemic lockdown, while it is being taught face-to-face for the first time at the time of writing this paper.

It is clear that the study presented has some limitations, with the most important ones being: the small number of students (25) that evaluated the course in comparison with the number of students (265) that participated in the exams; the fact that the questionnaire administered by the Quality Assurance Unit of the University for course evaluation, although validated does not offer possibilities for a qualitative analysis. Consequently, the course has to be further evaluated and refined, but it is also clear that the proposed design of the course is solid enough.

The main problems, or else challenges faced so far, that have to be further researched are the following: there is a lack of literature on similar courses to rely on, and this makes studying the syllabus of existing courses and exchanging experiences with instructors necessary; there is a lack of contemporary textbooks with a balance between theoretical and practical aspects that have to be presented in the course (at least in Greek); there is an abundance of important topics, teaching approaches and tools that could be presented in the course, but the time is limited (3 h *13 weeks) and an informed selection of topics has to be made.

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On Enhancing the Conversation Skills: The Dealogos Prototype

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Abstract. Communication skills are very crucial in everyday life and they can be learned. Focusing in conversation skills, problematic organization of turn-taking in any talking dyad may lead to the overlap of their speech. In this vein, this work proposes a prototype, namely DEtect Avoid and LOG Overlap eventS (Dealogos), a tangible kit including micro-electronics that is used towards avoiding conversation overlap. Initially, a theoretical background is presented that exemplifies the trajectory of phases, i.e., prior, during and after the overlap in talk. Unlike other approaches that focused on the mechanics of these phases, the presented work focuses only in the overlap phase in order to inform the speakers about its occurrence. In particular, through two microphones, raw audio data are collected upon which feedback on the overlap (mode one) and/or modeling of each speaker's behaviour (mode two) can be provided. This approach leaves room for a more reflective approach to the enhancement of the conversation skills through self-adjustment and avoidance of the overlapping from the speakers. The design of the prototype was based on elements of the Tangible Learning Design Taxonomy. Pilot experimental use with primary school students proved positive feedback on the usability and the performance of the proposed prototype and encourage its further refinement.

Keywords: Communication skills · The Dealogos prototype · Turn-taking in talk

1 Introduction

There is a plethora of approaches to the term skills e.g., hard skills, soft skills, 21st century skills, key competences or skills and a much more variety of their relevant definitions. Unlike the hard skills that are considered mostly technical and specific to a particular occupation [1], the rest examples of skills refer to more horizontal and intangible personal dimensions. In particular, within the framework of the knowledge society, 21st century skills constitute a concept that is not clearly defined although it is considered as very important. In most cases however, from the society perspective it focuses at skills connected to the workforce whereas from the educational one at training youth for future careers and jobs. According to [2, p.16], the term '21st century skills' is an 'overarching concept for the knowledge, skills and dispositions that citizens need to be

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able to contribute to the knowledge society'. The authors in [3] provided bibliographical evidence of various approaches to the definition the 21st century skills along with efforts of its categorization. Among these it is evident that in the broad category of social skills, the communication skills are included in all the presented categorizations. On the other hand, [4] referred to key competences that can contribute to a successful life in a knowledge society, among which communication is also included. Even further, according to [1] soft skills refer to "a set of intangible personal qualities, traits, attributes, habits and attitudes that can be used in many different types of jobs". However, [5] expanded the use of the soft skills across important areas of one's lives, beyond workforce. Upon the aforementioned it is evident that despite the different terminology and definitions, communication skills constitute a cross cutting category of skills for a lifetime.

Putting oral communication skills as the focus of interest, [6] regarded conversation as an elemental piece of social interaction with specific properties as made explicit through the conversation turn-taking, i.e., one speaker at a time but allowing also open participation. In particular, [7] provided an empirically grounded account of overlapping talk (i.e., when "more than one people talk" at one time in a conversation) and proposed the conception of "overlap resolution device". More specifically, [7] supported that the case of "more than one people talk" in fact is reduced to discussion of pairs' or one speaker and the others listening. Configurations of the overlapping talk of A, B, C speakers that show how their talk is reduced in two of them are: i) A talks to B and B talks to C, ii) A talks to B and C talks to B, iii) A and B talk each other and C listens [7, p.8].

Moreover, [7] focused on the characteristics of the overlap and the way it is resolved through a turn in the talk. By modeling the characteristics and phases of the overlap he defined that the 'overlap resolution device' is composed of: a) a set of resources of turn production that are used by the speaker, i.e., hitches and perturbations (e.g., louder in volume, higher in pitch, faster in pace) that may e.g., cut off the talk-in-progress, or stretch out the next sound in order to keep the turn. The distribution of the hitches and perturbations reflects the effort that the speakers deploy towards the resolution of the overlap and their position within it. Furthermore, [7] proposed phases of the overlap trajectory, stating that the overlap does not begin with the onset of the simultaneous talk. In particular, there exists a pre-onset phase (before overlap) where the running speaker may detect e.g., body behavioral displays, hearable inbreaths, which signal that another speaker is about to launch a turn and either s/he will not allow the turn (e.g., through hitches and perturbations) or the other will withdraw. The onset of the overlap, initiates the post-onset phase where the simultaneous talk takes place. During this phase, hitches and perturbations are used by one or both parties towards a competitive effort to keep the turn, while overlap takes place. In the post-resolution phase, the overlap is resolved, either because the other speaker withdraws or the running speaker completes the utterance and there is no meaning in the 'solo' use of the hitches and perturbations thus s/he lowers his/her voice to the level before the overlap onset.

Turn-taking organization efforts may be based upon formal mechanics as [6] proposed: a) the current speaker selects the next one, b) the current speaker does not select the next one and someone else self-selects, c) if the current speaker does not select and someone else also does not self-selects then the current speaker may, but not need, to continue unless another self-selects. Yet, [7] considered that the aforementioned rules may lead to underspecification of the overlap resolution problem when the focus is only at the mechanics of the overlap analysis. With the conceptualization of the ‘overlap resolution device’, he manages to reveal the practices across the trajectory of the overlap in talk that are employed by participants in relation to overlap and consequently to the turn-taking organization. In this way, any two parties that are employed in the discussion may adapt their stance to the turn-taking organization as their talk unfolds. Hence the procedure is adaptive to the overlap situation per se, according to each speaker’s talking behavior and leaves room for their possible adjustment beyond the competitive stance of keeping the locus of talk.

Considering the fact that there is not a consensus concerning the definitions of the aforementioned categories of skills there is also a lack in the approaches concerning their teaching and assessment. In particular, [8] proposed the idea of developing learning progressions towards the acquisition of the skills of reference. Towards this direction a descriptive analysis of such progressions of turn-taking strategies (overlaps, interruptions, and pauses) was proposed [9]. Through a conversation analytic approach, [10] explored the relationship between turn-taking and silences in classroom and showed that a formal turn-taking structure influences the silences and minimizes the overlap. Through conversation analysis techniques [11] focused on overlapping talk in order to identify phonetic differences that discriminate turn-competitive (competing to take the turn) from non-competitive overlaps (supportive to the speaker to continue). An algorithmic approach with linear and non-linear Neural Networks was adopted by [12] towards the classification of speech overlaps. Apart from approaches towards the analysis of the turn-taking organization and overlap, [13] focused on teaching primary school students the turn-taking procedure. Towards this direction, they proposed a series of tangible objects (e.g., Turn Talk for group and Class Talk for the class) in order to sustain children’s learning and reflection upon their behaviors concerning social norms for conversations. Moreover, their design supports gamification, i.e., using game elements in a non-game context to influence behaviour [14]. In particular, Turn Talk is a pentagon-shaped tangible equipped with Arduino IoT MKR1000 micro-electronics. Turn-taking is organized upon the rule that each time only one speaks and the rest speakers reserve their turn using tangible cards. LED pins visualize the turn-taking order, i.e., green for the current speaker, yellow for the next speaker and red for the rest. According to the number of turns and the amount of time taken to talk by each student, LED strips depict the progression feedback to the participants. From the aforementioned, it is evident that there are approaches towards the analysis of the mechanics of turn-taking and overlap employing different research methods and analysis tools [e.g., 8–10]. Moreover, some of them analyze data from a free conversation setup without imposing any restrictions to it thus, overlap may occur at any time [e.g., 11], whereas others employ norms of turn-taking that restrict it and minimize overlap [e.g., 13]. Moreover, the approaches may be classified according to the existence of feedback to the participants [e.g., 13] and the mediation of face-to-face conversation by tangible physical objects [e.g., 14].

Considering the overlap as the main concept to be taught in a speakers’ training framework, this paper does not impose any restrictions to any of the turn-taking phases [7] as speaking unfolds. In particular, it proposes a more reflective approach by making explicit only the overlap phase whenever it occurs and allows the speakers to self-adjust by metacognitively realizing the turn-taking norms through sessions of training. In particular, this work presents a prototype namely DEtect Avoid and LOG Overlap eventS (Dealogos) that lays at the case of tangible objects with embedded micro-electronic components to provide to any pair of speakers a multi-sensory gamified experience towards reflective realization/resolution of overlap in talk. In this sense they become learners of the conversational skills.

2 The Proposed Dealogos Prototype

2.1 Methodology

Within the broad area of developing tangible user interfaces, the Tangible Learning Design Taxonomy (TLDT) approach was deployed [15] towards the Dealogos prototyping. TLDT offers five interrelated elements upon which the designer conceptualizes and controls the design space, i.e., physical objects, digital objects, actions on objects, informational relations and learning activities. Although the elements are described as discrete, decision making during the design process is based on their interrelations, thus the development of the prototype is an iterative and not linear procedure. Upon the TLDT taxonomy, the five elements of the Dealogos prototype are as follows [15].

Physical objects are material objects with shape, textile, visual (color) and/or auditory attributes and spatial properties.

Digital objects are virtual entities with dynamic attributes that may also include particular attributes like visual (color) and/or auditory. The learner may or may not interact with them depending on the design decisions.

Actions on objects (sensed by them), are actions that couple the physical and digital objects, either as controls or as informational relations. The design of the learner's control on the objects might foresee also manipulations that may be discovered or enacted by the learner intentionally for some learning purpose.

Information relations refer to the semantic mapping of the coupling of the physical and digital objects to a meaning that might be conceptual (e.g., the red LED means stop) or behavioral (e.g., when the LED is green, start talking). The informational relations are connected to learner's actions that are either predefined and foreseen in the tangible's design or be performed by the learner while s/he interacts with the tangible.

Learning activities refer to the activities that frame the use of the tangible in a context of reference, might that be the classroom or other, the working mode (individually, collaboratively) etc. The consideration of the context, early in the design phase of the tangible, clarifies its learning goals and puts its use in the right place of the learning procedure within the context of reference.

2.2 Design and Development of the Dealogos Prototype

The function of the proposed Dealogos prototype is presented in Fig. 1. In particular, any dyad is involved in a conversation using speech capture via directional microphones. On the basis of this audio data, the Dealogos produces feedback concerning the occurrences of overlap at the end of a discussion session. This feedback is expected to evoke self-reflection procedures so as the dyad may realize the phenomenon of the overlap in their talk and start to self-adjust to a better turn-taking organization. This is expected to be a metacognitive approach to the enhancement of the conversation skills. As this reflective approach matures, the dyad might turn off the feedback and try to avoid the overlap. Thus, using the Dealogos repetitively, a progression in the conversation skills is expected to be detected between an initial stage (overlapping in talk) to a more skilled (turn-taking organization with no overlaps). Data post processing may refine the feedback upon the speaker's profile. In this vein, the type of the feedback defines the function of the Dealogos prototype in two modes, i.e., informing about the occurrence of overlap at the end of each discussion session and/or about the speaker's longitudinal conversation behaviour upon longer periods of time, respectively.

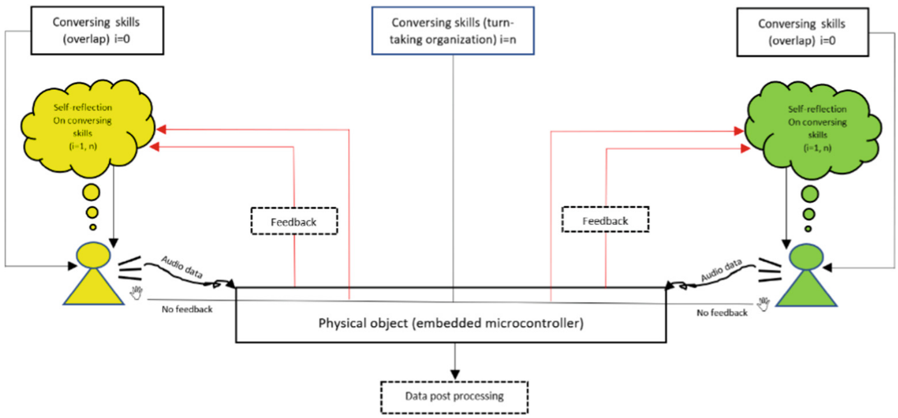

Fig. 1. A schematic representation of the Dealogos concept, acting as a feedback interface to converge to turn-taking organization and minimization of the conversation overlap.

In particular, based on the TLDT approach the following decisions were made concerning the design and development of the Dealogos prototype.

Physical objects. Part of the physical objects of the Dealogos prototype are presented in Fig. 2. In particular, Fig. 2 depicts the internal part, i.e., the micro-controller that is embedded in the Dealogos and an external part with LEDs and switches to activate or deactivate each LED's operation. The hardware embeds the Arduino Nano 33 BLE microcontroller development board which has an onboard BLE controller and a serial communication port for wired connection to a USB port. Moreover, two microphones are attached to the learners' clothes which means that there are two independent audio channels. This allows for real time logging of audio data that are produced by the two speakers, while they talk to each other. The Dealogos prototype is also independent of WiFi which many times is unavailable e.g., in school classrooms. Finally, the physical part also contains ON/OFF buttons for activation/deactivation of relevant functions.

Digital objects. The Dealogos prototype can operate in two modes towards the realization of the overlap in talk of any talking dyad. The first mode of operation allows for visual information to be given as feedback (e.g., times of overlap occurrences, their

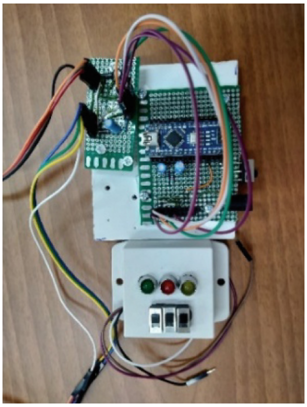

Fig. 2. Parts of the *physical objects* of the Dealogos prototype.

durations and the percentage of the duration of overlaps to the whole duration of the talk). The second mode is only for logging raw data for post processing which may give elaborated information to the interested e.g., to the teacher and the learners in a school setting on a more longitudinal basis (e.g., the speaker's behaviour profile). The *digital objects* function according to the learners' performance yet, they cannot manipulate them tangibly.

Actions on objects. The speakers act on the *physical objects* of the Dealogos prototype through the following ways. They provide audio input while they talk. They control the function of the tangible through the main on/off button by which they initialize/finalize the talking session. Moreover, they can disconnect the function of the three LEDs at the external part of the *physical objects* at their will (see Fig. 2).

Information relations. Two of the LEDs on the external part of the *physical objects* map the current speaker (green and yellow LEDs, respectively) and the other one (red LED) the situation when they overlap. The control of the three LED buttons maps the will and/or either the need to use them, independently.

Learning activities. The Dealogos prototype is a tangible with a gamified character to support the reflection on the overlapping talk. It supports the speakers towards the realization of the overlap in talk and the meaning of the turn-taking while talking with others. The Dealogos prototype can be used in a setting of a pair discussion with less as possible background noise depending on the quality of the microphones to be used. Thus, e.g., in a classroom setting, the teacher can either isolate in a way the speakers from the classroom in a separate training area or ask the classroom to be silent (providing in the second case chances for the class training on listening skills). As the learners try to minimize the overlap occurrences (gamifying characteristic) in iterations of talking sessions, it is expected to reflect on the overlap and self-adjust by enhancing their turn-taking organization and hence further on their communication skills.

Basic design considerations towards the aforementioned elements of the TLDT approach, were made so as the Dealogos prototype as a whole would be very simple, and not intrusive. Moreover, it should make explicit the overlap per se and leave room for the reflective part to take place. Finally, the feedback would have flexibility as far as the information to project to the interested, e.g., either to the students and/or to the teacher, synchronously and/or asynchronously. Finally, the way it could be embedded in the context should also provide flexibility and be adjusted according to the interested parties in formal and/informal settings.

2.3 Pilot Evaluation of the Dealogos Prototype

A pilot evaluation of the Dealogos prototype was performed through its use from 5 pairs (N = 5) of primary school students aged from 11–12 years old. In particular, they were involved in 10 sessions of 5 min talk using the Dealogos prototype. Different discussion themes were selected per session, in order to provoke overlapping occurrences. The pilot evaluation took place at different informal settings upon the consensus of the parents. The pilot study tested the function of the Dealogos prototype in the first mode. Figure 3 and 4 depict the results of the pilot use of the Dealogos prototype from a dyad of the aforementioned sample.

In particular, Fig. 3 presents the envelope of the speech signals from the microphones of the third conversating dyad at the first use of the Dealogos prototype for 5min. Using a threshold upon tweaking, it is evident that speech overlap took place with the speakers raising their voice amplitude to sustain the turn.

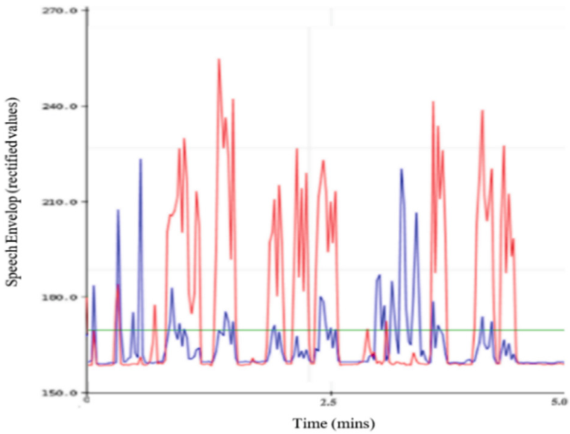

Fig. 3. Depiction of the envelope of the speech signals from the microphones of the third conversating dyad (speaker A: blue; speaker B: red) at the first use of the Dealogos prototype for 5 min.

Figure 4 depicts the results from the same third dyad after 10 iterations of the use of the Dealogos prototype for 5 min. Based on the overlap of the speech envelops from the two speakers, and comparing them with the ones at Fig. 3, it is evident that the dyad reached an organized turn-taking so as to avoid overlapping talk.

Moreover, though this evaluation it was revealed that it was very easy for the students to realize the function of the physical element of the prototype. In particular, they tested different actions upon it and they understood the information relations that were

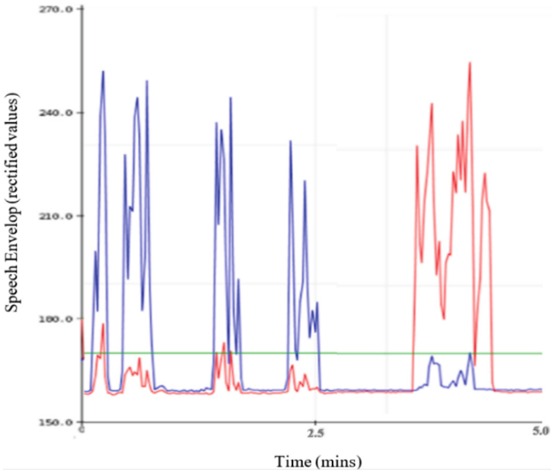

Fig. 4. Depiction of the envelope of the speech signals from the microphones of the third conversating dyad (speaker A: blue; speaker B: red) after 10 iterations of the use of the Dealogos prototype for 5 min.

embedded in the prototype along with the feedback information that was provided to them in the form of digital object.

In overall, the prototype was very well welcomed. It is evident that the pilot evaluation provided very promising results as far as its contribution to the communication skills (mode 1). For a more enhanced feedback (mode 2) more longitudinal data are needed. However, a first acquaintance with the concept overlap in talk was achieved.

3 Discussion

In this work, the Dealogos prototype is presented. It constitutes a tangible that aims to make explicit the overlap in a dyad's talk and evoke implicit reflective realization of the phenomenon to the speakers. Based on the work of [7], i.e., the 'overlap resolution device', it foresees a dyad of speakers, as the case of "more than one people talk" is reduced to a discussion of pairs. Moreover, it detects the post-onset phase [7] where the simultaneous talk takes place and provides relevant feedback (visual notification) to the speakers. With this approach, it leaves the speakers room to practice no only their conversation skills but their learning skills as well, towards self-reflection, self-assessment and finally self-improvement as far as the overlap minimalization is concerned [16] and thus become learners.

From the aesthetics point of view, a gamified character is introduced in the Dealogos prototype through the overlap scoring. So, by using game elements in a non-game context, it is expected to motivate the learners to reuse the tangible towards talking sessions with no overlap, thus it influences their behaviour [14]. This gamified character is further enhanced by the control that is provided to the learners to manipulate the physical part of the tangible, according to their overlap realization and resolution strategy. For instance, as a challenge, they can tun off the LED visual signaling at their will if they feel that they have mastered the turn-taking organization, and realize at the end if they were indeed successful to it. In this way, it is expected to cultivate a metacognitive perspective that can help the learners to realize the turn-taking organization rules.

Thus, the Dealogos prototype deviates from a strict approach to the overlap in talk upon formal mechanics [13] that put the focus on the turn-taking organization (like 'traffic' controllers), and redirects it to the overlap phase. From this perspective, it draws upon [7] proposal for a more reflective approach, that is adaptive to the context of the talk and the personality of each learner, and aims at cultivating communication skills through changing the stance of the learners when talking to each another, rather than competing for the locus of talk. From the technical point of view, the Dealogos prototype is constructed using simple materials and a few electronics. This makes the whole construction compact, easy to replicate, light to carry and very quick to deploy. Moreover, due to the two discrete audio channels there is no need for diarization, i.e., 'who spoke when' [17].

The Dealogos prototype can be embedded in different context settings according to the learning goal that is defined each time and the profile of the participants. For example, it could be used in an informal setting by adults that are preparing for a job interview, or in formal school setting when students are practicing their communication skills, provided that they use reflective approaches to their learning. In the latter case, the teacher may also scaffold such efforts and even use the Dealogos prototype as a tool to exemplify the overlap in talk. Depending on the technology that is used and the raw data elaboration algorithms, a restriction may be put concerning the background noise of the setting (e.g., classroom). Yet, even under such restriction the cultivation of being good listeners and/or reflective observers might be the focus of the teacher to organize the classroom while e.g., a pair uses the Dealogos prototype. Successful pilot experimental uses with primary school students have revealed the potentiality of the Dealogos prototype towards triggering the aforementioned reflective approach and detected improved communication skills in relation to the overlap.

4 Conclusions

In this work the Dealogos prototype that is proposed offers ideas of teaching and assessing the communication skills of a talking dyad in any context either formal and/or informal. Successfully pilot experimental uses with primary school students has revealed this potentiality. Its further elaboration is expected to contribute to the enhancement of these cross-cutting skills.

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Learning Analytics Framework Applied to Training Context

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Abstract. Currently, business organizations are struggling with the increasing demand for learning needs to address their knowledge gaps. They must have a structure that can reach all employees in terms of training and extract all the important data which is collected by Learning Management Systems during the instruction or learning process. This data will be of extreme importance for better business decisions. In this paper, it is presented a Systematic Literature Review with their respective phases duly explained and framed in the topic. It allowed us to understand the benefits, challenges, enablers, and inhibitors of the deployment and usage of a specified Teaching-Learning Analytics Framework. Finally, it is concluded, that the development of a reference model, could fulfill this gap in knowledge and help business organizations to allocate resources better and improve the decision-making process as well as an instructional and learning process. To achieve the final goal of this research, future work about the development of a Survey Research methodology will be started to fulfill this gap of knowledge.

Keywords: Learning analytics · Framework · Learning management systems · Learning organization

1 Introduction

Currently, business organizations are struggling with the increasing demand for learning needs to address their knowledge gaps.

According to Alavi [1], knowledge is the organizational asset that allows a sustainable competitive advantage in hypercompetitive environments. In this sense, many organizations are developing information systems specifically designed to facilitate the sharing and integration of this knowledge. However, organizations are faced with reduced use of existing knowledge in these Learning Management Systems (LMS), and the great challenge in managing this knowledge is less its creation and more its capture and integration, and this knowledge has limited organizational value if not is shared [2]. The lack of a specific method of data analysis in these LMS, combined with inadequate and insufficient means and a poorly organized structure, leads to an increasing difficulty in

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managing and using this knowledge, generating a deficit in the perception of the value existing in this information.

As such, organizations make the use of Learning Analytics field to analyze learning data, which, according to Brown [3], refers to the entire process of systematically collecting and analyzing large sets of data from online sources to improve learning processes, and in this way generating value and feedback from the processed information. Al-Hunaiyyan [4] refers that it appears the technological management processes to support this knowledge in LMS, have difficulty in finding adequate support for the analysis of content applied in the organization, to make it an effective process for the collection and evaluation of this knowledge and a huge amount of data. This difficulty is transposed to the teacher or instructor of the LMS system, as a misuse of the LMS presupposes an inadequate collection and management of data and behavior patterns obtained for later analysis to address better management for benefit of organizations. Furthermore, it is shown in some cases where instructors have access to a variety of student data, there may not be organized efforts to support students across multiple courses [5]. The management difficulty by system users is also evidenced by Blackmon [5] when refers that is difficult to access learning analytics and ways to leverage learning analytics data across instructors and, in some cases, administrators, to create cross-disciplinary opportunities for comprehensive student support.

This paper starts with some research background with the overview of the most related subjects to this topic. Then, it is discussed the definition of one of the research methods that are going to be implemented: the Systematic Literature Review. We start by defining the research questions and presenting the systematic literature review related to the theme. The focus of the research is on the benefits and challenges of having a learning analytics framework applied to a learning management system and the enablers and inhibitors of its deployment. The proposed approach chosen to solve the research problem will be focused on developing a teaching-learning analytics framework that will address the challenges and the problems appointed with the existing frameworks to improve the support and the process of teaching and learning, which will be planned and developed in future research. Finally, it is presented the future objectives that we pretend to achieve with this research.

2 Research Background

The following section presents a more in-depth overview of the topics that are essential to understanding the research. Consequently, a description of E-Learning, Learning Organization, Learning Analytics, Learning Management System, and Framework is given.

2.1 E-Learning

In the 21st century, the information and communication technology explosion increases the use of digital devices for many purposes in the world of work and in formal and non-formal education. E-learning (electronic learning) has become part of these educational purposes and the alternative of traditional education and also a complementary to it

[6] Technologies can provide the means and tools for e-learning to take place in its preferred way and be distinguished from conventional learning because of its flexibility and adaptative strategies in teaching and learning to achieve the effectiveness of learning [7] According to Noesgaard [8], a structured search of library databases revealed that research examining the effectiveness of e-Learning has heavily increased within the last five years. At the same time, learning and development professionals within the public and private organizations are increasingly being asked to prove the effectiveness of their learning and development initiatives. The effectiveness of learning has become an important part of the Learning Analytics role when applied in Learning Management Systems.

2.2 Learning Organization (LO)

With the uncertainty and constant change of the environment, organizations and individuals need to have the flexibility and responsiveness to learn new skills and new abilities to thrive and have success or else their knowledge will become obsolete. Resistance to change appears to be personalized in organizations and members when it comes to the creation of new organizational knowledge mindsets [9]. Having that in mind we can understand that it may exists some confusion when it comes to organizational learning and its multitude of different levels of analysis which range from individuals to organizations and the diffusion of information within the organization and how individuals interpret and manage it to create a knowledge adaptive organization. So, we can perceive the organizational learning as an outcome brought through intervention [9] and can be seen with multiple constructs and dimensions which go from organizations as whole systems that that can adapt or change, according to their cognitive structures and policies, and as individuals that can develop, adapt or update their cognitive models becoming a whole process where an organization expands its range of action and focus on how the knowledge is attained and disseminated [9]. So, the main objective of an organization is to increase the capacity of individuals and organizational knowledge enhancers, giving the maximum attention to the change and the way in which it occurs, the flexibility and openness to innovative ways that are engaged to the organization goals and culture [10]. Therefore, we can consider a Learning Organization as an organization that is continuously increasing the skills and knowledge of its members, promoting collective learning conditioning organizational learning, and building organizational memory along the path [10].

2.3 Learning Management System (LMS)

According to Shurygin et al. [11], e-learning and distance technologies are being actively introduced into both academic and corporate education, as complementary to traditional forms. The efforts of teachers are aimed at finding effective models of learning. Education in an online environment is famous for its interactivity and opportunities to combine several teachings and learning strategies, so the Learning Management System (LMS) has been at the forefront in education, enabling the training process both online and offline. The top famous e-learning platforms include Moodle, Blackboard, Canvas, etc.

Organizations, on the other hand, use LMSs to make sure that new and old employees have the necessary skills and competencies. They have also perceived that their training platforms can be used as a tool for continuous learning improvement beyond compatibility and adaptability.

2.4 Learning Analytics (LA)

Fahri Yilmaz [12] refers that the education model has changed over time. This change has created new situations such as individualized learning, determination of student behavior, and the use of alternative assessment tools. Learning Analytics (LA) is defined as measuring, collecting, and reporting data related to learners and learning environments to understand and improve learning and the surrounding environment. Its use creates opportunities for individualized learning, to determine the student behaviors associated with success by examining the student behaviors affecting success and serving as an alternative assessment tool. The main goal of learning analytics is to obtain meaningful results from the virtual learning environments to improve student outcomes in online learning environments by providing early warnings of students at risk of dropping out and better recommendations to tailor the learning path.

2.5 Framework

Defining Framework or a Reference Model, in line with Yosef Jabareen [13], it is stated that for a better understanding of complex phenomena linked to multiple bodies of knowledge that belong to different disciplines we require a multidisciplinary approach. Qualitative methods serve as adequate tools for investigating these complex phenomena. Following that we can define Framework or Conceptual Framework as a network, or “a plane,” of interlinked concepts that together provide a comprehensive understanding of a phenomenon or phenomena. The concepts that constitute a conceptual framework support one another, articulate their respective phenomena, and establish a framework-specific philosophy. Conceptual frameworks are not merely collections of concepts but, rather, constructs in which each concept plays an integral role. They provide not a causal/analytical setting but, rather, an interpretative approach to social reality.

3 Systematic Literature Review

In this section of the paper, it is presented one of the research methodologies used in this research: the Systematic Literature Review (SLR).

3.1 Systematic Literature Review

A Systematic Literature Review (SLR) is a way of identifying, evaluating, and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest. The main goal of a Systematic Review is to synthesize existing work in a manner that is thorough, fair, and seen to be fair to be scientifically valuable [14]. This Systematic Literature Review was conducted following Kitchenham’s Procedures for Performing Systematic Reviews [14]. Therefore, the process was divided into three main steps:

- Planning – Identifies the need and motivation for a systematic review of a particular phenomenon to summarize all information in a thorough and unbiased manner.
- Conducting – involves the identification and selection of primary studies and their quality assessment using the review protocol developed in the first step. Finally, data is extracted and synthesized from these studies.
- Reporting – The extracted data is summarized and the results of the SLR are communicated effectively.

The chosen Research Methodology for this work was SLR, (see Fig. 1), since our main goal was to collect and summarize all the existing information concerning Learning Analytics Frameworks and their efficient deployment within an organizational context.

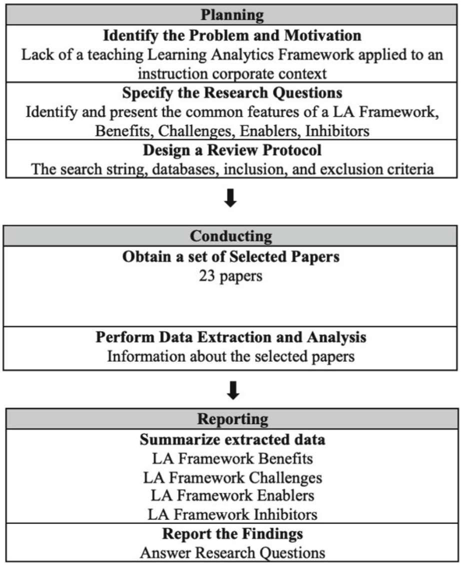


Fig. 1. Represents the three steps of an SLR explained above and adapted to our research.

Planning the Review

In this section, we present the motivation for our research, and then we will present the Research Questions aimed at this research. We finish with the presentation of data sources and data strategies.

Motivation

Nowadays the evolution of technology and the need for learning is increasing in its complexity. Business Organizations and teaching staff require greater and better analytical tools to address these needs and understand learners' difficulties and gaps to be more informed in their decision-making process and increase the effectiveness of learning and teaching. The adding value of an efficient and easy-to-use learning analytical tool is of great importance to all stakeholders.

So, to address the current challenges and gaps of the existing teaching analytical tools we aim to develop a reference model that could easily be adapted to most of all Learning Management Systems to help teaching staff in their supervision and teaching role and maybe improve businesses with a solid scientific approach to make better instructional decisions. That why we first start with this SLR comparing to other SLR that exist about this topic.

The adding value of this SLR is present in the aggregation of several topics related to the implementation of AL tools in training contexts that are dispersed in other publications, allowing us to have a clearer and more understandable view of this topic and thus start for an in-depth debate on what we can do to improve what already exists.

Research Questions

This research intends to make it clearer the status of Learning Analytics applied to a training organizational context. It targets the search for answers that fulfill the understanding of how we can efficiently implement a Learning Analytics Framework, what benefits come from this, what challenges we need to overcome, and what enablers and inhibitors we will face when implementing it.

As a result, the following research questions were developed to achieve that goal:

- **RQ1** – What are the benefits of implementing a Learning Analytics Framework in Learning Management Systems?
- **RQ2** – What are the challenges of a Learning Analytics Framework when applied in training contexts?
- **RQ3** – Which are the enablers of the deployment of a Teaching-Learning Analytics Framework?
- **RQ4** – Which are the inhibitors of the deployment of a Teaching-Learning Analytics Framework?

Data Sources and Search Strategy

After the need for a review was identified, and the review protocol determined, was selected literature that was based on search criteria (presented in Table 1) which resulted in a total of 67 articles.

Conducting the Review

In this section, we conduct the review (second phase of SLR), where we go through a selection of articles based on inclusion and exclusion criteria. The search was made with EBSCO and SCOPUS electronic library, ending with the final choice of SCOPUS as the selected library for the research.

Table 1. Search criteria

Element	Research details
Source	SCOPUS
Final search string	AB ((Learning or "E-learning") and ("Learning Management System" or LMS or "Knowledge Management System" or KMS or "Learning Content Management System" or LCMS or "Content Management System" or CMS) and "Learning Analytics" and (Framework or Reference or Model))
Search strategy	Abstract\Resume search of scientific articles from conference materials and academic journals with a date range limit (2016 to 2022) and a subject area limit (computer science)
Results	67

To obtain the final set of articles, a process of selection, data extraction, monitoring, and synthesis of the articles occurred (Fig. 2).

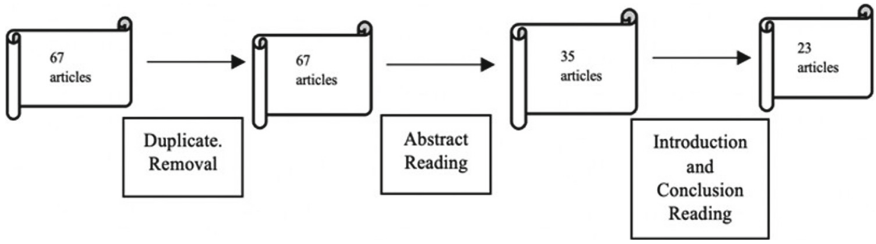


Fig. 2. Papers filtering process

Inclusion and Exclusion Criteria

After selecting the articles related to the topic in the literature, we proceeded to the removal duplicates with the use of the Rayyan tool. Then, the titles and abstracts were read, and each paper was categorized into three different categories: "accepted", "rejected" and "maybe" which led to a sum of 35 articles accepted.

The final set of 23 articles was obtained through the reading of the introduction and conclusion.

The inclusion and exclusion criteria are shown below in Table 2.

Table 2. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Papers from scientific journals and conference	Different subject

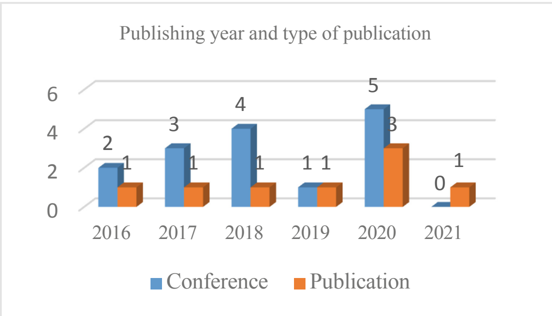
(*continued*)

Table 2. (*continued*)

Inclusion criteria	Exclusion criteria
Full-text access	Before 2016
Only after 2016	Articles of Paid access
Articles of the related subject (e-learning, knowledge management systems, le- arning analytics, framework)	No duplicates
Limited to the subject area (computer science)	

The next table (Table 3) will present the year and type of publication of the selected articles for the research analysis. 2020 was the year with the most published articles related to the topic.

Table 3. Publishing year and type of publication



The following table (Table 4) shows the number of publications of each specified conference, with LAK conference with most of the published articles.

Table 4. Conferences

Conference	Nº. of publications
International Conference on Innovation, Practices, and Research in the Use of Educational Technologies in Tertiary Education (ASCILITE)	1
International Conference on Science, Engineering & Te-chnology (ICSET)	1
IEEE Frontiers in Education Conference (FIE)	1

(*continued*)

Table 4. (*continued*)

Conference	Nº. of publications
International Conference on Data Science, Technology and Applications (DATA)	1
Panhellenic Conference on Informatics (PCI)	1
International Conference on Computers in Education Workshop Proceedings (APSCE)	1
Technological Ecosystems for Enhancing Multiculturality Conference (TEEM)	1
International *Conference* on Learning Analytics & Knowledge (*LAK*)	5
IEEE International Conference Information Visualization (IV)	1
International Conference on Frontiers of Educational Technologies (ICFET)	1

Reporting the Review

In this section, it is presented the last phase of SLR methodology, where the results from the analysis of each selected paper and the collected information are given to answer the research questions that were previously defined (see Table 5).

Table 5. Academic Journals

Journal	Nº. of publications
Journal of the World Engineering Education Forum (Procedia)	1
IEEE Transactions on Learning Technologies (TLT)	1
Education Sciences Journal (MDPI)	1
International Journal of Engineering & Technology (IJET)	1
Journal of Computer Systems, Science & Engineering (Tech Science and Press)	1
Journal of Internet and Higher Education (IHEDUC)	1
Journal of E-Learning and Knowledge Society (JELKS)	1
Journal of Technology, Knowledge, and Learning	1
Journal of Learning Analytics (JLA)	1

Benefits of a Learning Analytics Framework Implementation

After a careful read of the literature we can check that the implementation of a Learning Analytics Framework in Learning Management Systems can have several benefits for learners, teaching staff, or even organizations. This list of benefits found in the literature is shown below in Table 6.

Table 6. Benefits of implementing a learning analytics framework

Benefits	Sources
Provides the analysis and collection of students´ learning process data to improve early warning and personalized recommendations to avoid retention and knowledge gaps	[15–31]
Introduce new ways to improve the effectiveness of instruction	[15, 19, 20, 24, 27–31]
Drive senior management decisions to support organizational capacity and improve the learning process	[16, 22, 28, 29, 31, 32]
Integration of interactive technologies improve learning efficiency	[15, 19, 21, 22, 30]
Improve the student´s positive attitude towards an individualized analysis of their lear-ning path	[21, 27–29, 33]
Different levels of granularity improve knowledge discovery and teaching management	[25, 29, 34]
Allow intervening when inappropriate dispositions for the instructional design are present	[30]

As the context of learning has been changing over time and its importance is rising amongst learners, teaching staff and specially in organizations, the implementation of a specific Learning Analytics Framework in Learning Management Systems can bring the most mentioned benefit across the literature. It provides the analyses and collection of data from multiple sources which can predict learning outcomes and student retention by improving early warning and recommendation systems that provide personalized guidance, feedback, and support to learners while enabling teachers and instructors to better understand the needs and potential of their learners and intervene in the middle of their learning process [15, 21]. Another important benefit is that the introduction of new ways to systematically refine assess and improve the effectiveness of instruction to improve teaching and learning [15], can be done by integrating interactive technologies which can make the educational process more efficient and eliminate knowledge gaps [15, 21], promoting a positive attitude amongst students by the personalized analysis of their learning path and behavior patterns which can lead them to be aware of the changes on the approach they can make to their study progress [27]. The data extracted from these tools can be of great importance to an organization as it may act as an impetus to drive senior management to make decisions that support organizational capacity development in Learning Analytics and increase the power of LMS, improving teaching and learning [32]. Other less benefits but still important to mention, comes with the different levels of granularity which may improve knowledge discovery allowing a better teaching management [34]. We may also mention the allowance to intervene when inappropriate dispositions for the instructional design are present [30] and improve the learning track making the best corrective measures that are possible, to achieve the desired success. Having all these benefits in mind we can understand that a proper Learning Analytics framework can provide learners with a personalized experience and improve future e-learning courses by helping instructors understand the learner´s path and helping them reach their learning goals.

Challenges of a Learning Analytics Framework when applied in training contexts
Understanding the evolution of online learning and learning analytics within specific contexts when it is applied, we can also report several challenges that need to be addressed when developing and implementing an LA Framework to a learning environment. The list of challenges reported in the literature is below in Table 7.

Table 7. Challenges of a LA framework applied to a training context

Challenges	Sources
Challenge to prepare a proper personalized instructional design to guarantee proficiency of the learning process	[15, 21, 26, 27, 30, 35]
Need to identify and integrate advanced instructional methods and evaluation techniques to increase student´s engagement	[15, 22, 23, 28, 33]
Lack of regular supervision and feedback to provide support to the learning process more effectively to adjust the learning path	[16, 24, 27, 28, 35]
Integrated L.A. solutions and predefined types of L.O. and rules related to users learning styles are required to provide actionable information	[21, 29, 30, 32]
Adaptable and intuitive analytic tools are required to meet the needs of stakeholders and course-specific contexts	[21, 24, 26, 32]
Need to revise the intervention process to sharpen its effectiveness	[23, 30, 35]
The course should be designed with a variety of interactive activities and implemented regularly to be evaluated periodically	[24, 35]
Difficulty in assisting learners to understand the acquired knowledge in-depth	[15, 27]
Requires careful data manipulation and correct analytical models to avoid misinformation or invalid inferences	[18, 24]
Challenge in articulating the nuanced dimensions of SRL due to inaccurate data	[29, 36]
Diversification of traditional learning to online learning can pose a challenge	[22]
A design for teaching is required to encourage students to think critically and use creative skills in problem-solving	[20]
Lack of access to high-quality data, professional development in using data, and collaboration around its use	[18]
The need for evaluation protocols and digital competencies training should be consolidated	[37]

(*continued*)

Table 7. (*continued*)

Challenges	Sources
Traditional reporting included in LMS should be improved to satisfy the growing need	[25]
Need to present simple and powerful visualizations and suggestions of pedagogical actions to provide better feedback	[28]
Need for a shift in institutional culture leading to a management change that focuses on the value-adding role of L.A	[31]

Some of the challenges come from the increasing development of the technology and the raise of the different stakeholder's needs and should be addressed accordingly to their importance and specific context where they are implemented. We can observe that one major challenge to overcome is the need to prepare a proper instructional design that guarantees the proficiency of newly trained learners as it heavily influences learner behavior [15, 21, 35]. For that purpose, it is necessary to critically identify and integrate advanced instructional methods and proper evaluation techniques to increase student´s engagement and the success of the learning path [15, 21]. This situation may imply a lack of regular supervision and create some difficulty in assisting learners to understand and support the learning process more effectively in a manner that better feedback is given so the learning paths can be adjusted adequately [16, 27]. So, it is important to have in mind when developing this type of LA frameworks, the integration of predefined Learning Object types, rules related to user learning styles, and adaptable intuitive analytical tools, such as simple and power visualizations and suggestions of pedagogical actions, so the needs of all stakeholders are addressed to provide actionable information to ensure an effective learning environment, so students keep engaged [21, 28, 30, 32] and the needs of stakeholders are met and course-specific contexts. An important aspect to be mentioned is the need to have identified and integrated evaluation protocols and advanced instructional methods to increase student engagement and critical thinking [15, 20, 37]. One aspect that´s important to avoid misinformation or invalid inferences on prediction models is to handle carefully with data manipulation and analysis [18], so teaching staff should be better trained in digital competencies to improve the decision-making process and feedback [37]. One obstacle to mention is the difficulty in assisting learners to understand the acquired knowledge in depth [15]. Also, traditional reporting included in LMS must be improved to satisfy the growing need to understand the extracted data [25]. The change of traditional diversified learning to online learning can pose a serious challenge [22] which may imply some concerns in organizations as they must shift their institutional culture leading to a change in management model and focus the message on the value-adding role of Learning Analytics [31].

Enablers of the deployment of a Teaching-Learning Analytics Framework
In this section, it is provided an answer to which are the enablers that help and address the implementation of a Teaching LA Framework, according to the literature. The list of enablers is shown below in Table 8.

Table 8. Teaching analytics framework deployment enablers

Enablers	Sources
Appropriateness of the medium used, the learning activities, and tend to interact with tools that are recommended	[15, 26, 28, 29]
Enables teachers to identify and contact students at-risk of dropping out	[28, 30, 32]
Enables picture of learning outcomes so teaching staff can issue alerts to students and personalize the learning content	[16, 21, 27]
Allows consistent analysis of data which improves the decision-making process	[19, 27, 34]
Provides a set of evaluation metrics to test prediction models accuracy and student engagement	[17, 22, 28]
The use of the L.A. tools develops a student en-gagement model that supports effective teaching	[22, 28, 35]
Increasing investment and development in online learning and support	[16, 30]
Rise of teaching analytics to support the learning process	[25, 31]
Promotes an increasing focus on extraction and analysis of learner data to provide insights into patterns of SLR	[36]
Easy to reuse, allowing tutors with limited Machine Learning knowledge to predict student outcomes	[18]

The most common characteristic to enable the implementation of such framework mentioned in literature is the appropriateness of the medium used to deliver feedback and reminders, the learning activities, and the tendency to interact with tools that are directly recommended for use according to instructional conditions of the course [15, 26, 28]. Among the most important factors to enable the implementation, we have the consistency of data analysis which collaborates with the educational process, sending a clear picture of the learning outcomes to the teaching staff so they can identify and contact students at risk of dropping out and issue alerts and personalized recommendations to their learning path [16, 27, 32, 34]. The use of Learning Analytics tools also enables student engagement and provides a set of evaluation metrics to test the prediction model's accuracy [22, 28]. As the growing needs come to life with this kind of tools, its use is being promoted by organizations with the increasing investment and development and support in online learning [16] by the stimulation of an increasing focus on extraction and analysis of learner´s data to provide insights into learning patterns [36]. The easy to reuse of some of these tools also allow tutors with limited machine learning knowledge to predict student outcomes [18] and support effective teaching [22].

Inhibitors of the deployment of a Teaching-Learning Analytics Framework
Understanding the perpetual change of technology, it´s common to have impediments to the deployment of this type of framework. The list of these inhibitors is shown below in Table 9.

Table 9. Teaching analytics framework deployment inhibitors

Inhibitors	Sources
Cannot be replicated in different scenarios which cause restricted usage	[22, 30, 34]
Lack of specific framework design to capture the technology-enhanced learning process	[19, 30, 33]
Limited integration of L.A. in the context of immersive technologies	[15, 30]
Lack of rigor and few systematic efforts in some studies when L.A. practices are discussed	[15, 23]
Lack of leadership of a unified approach and inclusion of students to L.A. decision making	[29, 32]
Excessive intrusion in student´s learning routines leads to discomfort due to excess control	[28, 29]
Requires sufficient computer power to run	[17]
Increasing complexity of e-learning over time	[21]
Lack of predefined learning object types negatively affects the work of adaptive I.S	[21]
Lack of attention to instructional conditions leading to over or underestimation of predictions	[26]
Elaboration of deep learning analytics is difficult and expensive	[27]
LMS is seen as a problematic platform for sending messages or using as a mobile application	[28]
Poor usability of LMS can lead to poor accessibility of information by students and teaching staff	[28]

Restrictions to the deployment of Teaching Learning Analytics Frameworks have various sources and can be found in the literature about this topic. To start, one major inhibitor regarding the deployment of this tool is the lack of a specific design framework to capture technology-enhanced learning process [30, 33] due to the increasing complexity of e-learning systems overtime which causes difficulty to know which learning style aspects are worth modeling in the new Information Systems with the lack of predefined LO types or other analytic tools that affect directly the work of adaptive IS [21]. Another important aspect related to inhibitors is that the integration of LA in the context of immersive technologies may be limited which can require sufficient computer power to run and elaborating deep analysis can be quite difficult and expensive [15, 17, 27]. Another major inhibitor is that these frameworks may not be generalized or replicated in different scenarios which restrict their usage making it impracticable to manage new knowledge [22, 34]. LMS is seen as a problematic platform for sending messages or use it as a mobile application which may cause poor usability and lead to poor accessibility of information by students and staff [28]. Also, one major drawback to implement these tools is a lack of leadership of unified approach where inclusion of students to Learning Analytics decision making is poor and insufficient [32]. Finally, the lack of attention in designing the instructional conditions can be a major inhibitor of the framework deployment because it can lead to over or underestimation of certain predictors, causing misinformation on the analysis [26].

4 Discussion

In this section it is discussed the obtained results of the systematic literature review. As a result, this systematic literature review, provides additional implementation features to improve the instructional and learning process.

The benefits of applying a Learning Analytics Framework are well mentioned in the existing literature pinpointing the major one when it refers that it provides the analyses and collection of data from multiple sources which can predict learning outcomes and student retention by improving early warning and recommendation systems that provide personalized guidance, feedback, and support to learners while enabling teachers and instructors to better understand the needs and potential of their learners and intervene in the middle of their learning process. Although approaching some of the mentioned benefits, this SLR contributes with an improvement of the existing ones and introduce others to better reshape and refine the learning and teaching path and impact in student´s positive attitude towards these new educational models and knowledge learning achievement.

Reviewing the challenges presented to the existing models we can see there is still a lot of work and research to be made to address them and this SLR will try to contribute to that knowledge path by presenting a proposal of a framework that will try to fulfill the gaps and be successfully deployed in any organization and business and give proper feedback with actionable information that can lead to an improvement of better business decisions and support. Instructional and appropriateness of the design are mentioned and should be a priority to address and a set of specific guidelines should be made to improve the supervision throughout all the learning process.

To conduct this research, a SLR was made, and a summary of results were gathered within a table of sources for each concept. The main information extracted from the selected papers are:

- Analysis and impact of the benefits of a LA framework implementation.
- Raising awareness to the major challenges of a LA framework implementation that need to be overcome.
- Analysis of a set of enablers that will impact the deployment of a LA teaching framework.
- Analysis of a set of inhibitors that will impact the deployment of a LA teaching framework.

5 Research Problem

Often, businesses and institutions come across with some difficulties in managing the existing knowledge in LMS. It becomes of most importance to work it and make accessible to generate value other else it becomes useless and not shareable. It then becomes an impediment to generating strategic information that allows organizations to make better decisions about their human resources, business processes, and training management. This difficulty is transposed to the teacher or instructor of the LMS system, as a misuse of the LMS presupposes an inadequate collection and management of data and behavior patterns obtained for later analysis and treatment to show them in better management for benefit of organizations.

The adding value of an efficient and easy-to-use learning analytical tool is of great importance to all stakeholders and essential to address the current challenges and gaps of the existing learning analytical tools.

Objective of the Research

The main objective of this research is to focus on the deep analysis of Learning Analytic Models found on literature when applied in Learning Management Systems (LMS), evaluating the respective impact for learners, teaching staff, and organizations.

This analysis should highlight the respective benefits, challenges, enablers, and inhibitors that users with the profile of teachers or instructors encounter, in a relevant use of these LMS models, demonstrating the impact or not that this use has on the Learning Analytics models of the organizations themselves.

Based on the previous analysis, the result of this research will try to end up with the development of a new Reference Model of a Teaching-Learning Analytics Framework that can be deployed in almost every organization and help in the better decision-making process and teaching effectiveness.

6 Methodology to be Applied in Future Work

Following our Systematic Literature Review we will try to address our research problem by adopting the Survey Research methodology to analyze, evaluate and develop the reference model we propose. We have selected this methodology because it can be used to answer questions that have been raised, to solve problems that have been posed or observed, to assess needs and set goals, to describe what exists, in what amount and context and finally to determine whether specific objectives have been met or not and establish baselines for future comparisons and trends [38].

With the questions and problems that have been raised in SLR, we will try to develop a first draft of a new Learning Analytics Framework to answer the Research questions previously defined and explained.

For this research and development of a new LA framework we will depart from one of the most used Learning Management platforms which is Moodle. From there, we will apply Survey Research methodology to evaluate our framework proposed draft with the selected professionals from our field of study. To perform that task, we first need to understand how this methodology is prepared for better efficiency and to obtain the best results from data analysis and management.

Therefore, we can divide the methodology into four phases [38]:

- Survey design – sample selection and determination of sample size.
- Survey instrument development – define the objective and focus of the study.

- Survey execution – testing the instrument and procedures, conduction of the survey, data collection and process.
- Data analysis and reporting of results – analysis of data and reporting of the results

Below it is presented the survey research process flow [39]:

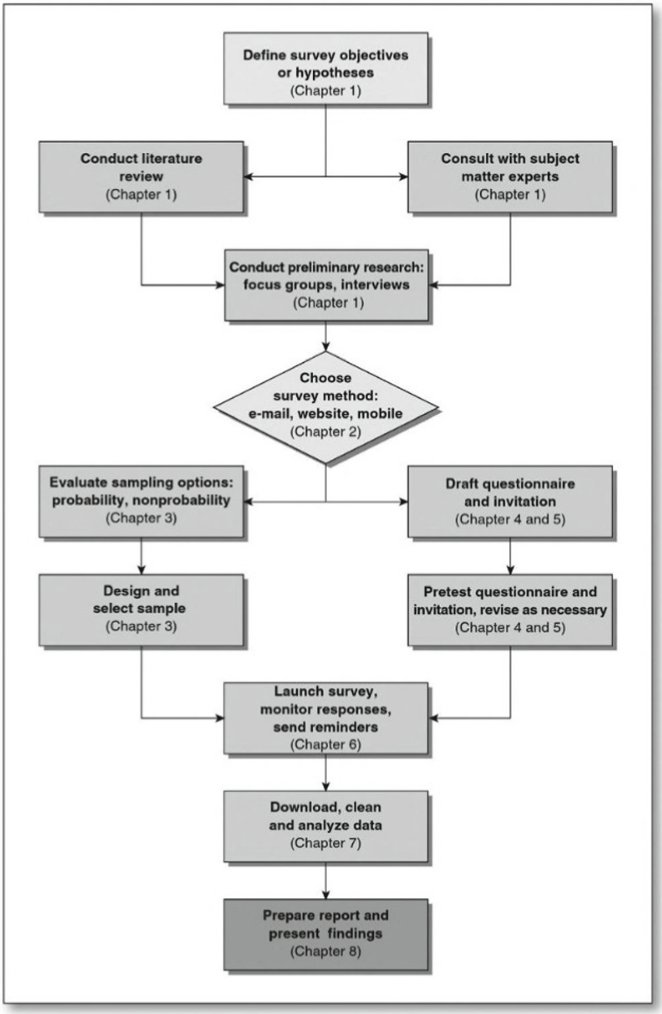


Fig. 3. Survey research process flow

According to the main objective of our research we will choose the questionnaire survey as the most appropriated method to obtain data and draw some conclusions about our proposed model. This method will consist of questioning a group of respondents which are representative of a population (selected professionals of our field of study), regarding their opinions related to any point that interests researchers (e.g., problem, event, or knowledge level) [40].

For our research, the questionnaire will be designed following a set of specific guidelines and according to the context of the study (organizational training context), regarding our Learning Analytics framework proposed draft. To proceed with this method, we will select an audience of business sector or general training professionals within public or private organizations.

After collecting data from the questionnaires, we will proceed to statistical analysis of it (e.g., SPSS) and draw some conclusions about the findings. The main goal to choose this methodology is that we can analyze the extracted data from the survey and identify patterns in the questionnaires which may be of great importance to evaluate and validate our proposed framework and implement corrective measures that can lead us to an important breakthrough in Learning Analytics frameworks.

7 Conclusion and Future Work

In this report, we conducted a Systematic Literature Review. With the Systematic Literature Review, it was possible to identify relevant articles related to Learning Analytics reference models and their intrinsic characteristics which led us to understand the important role of this type of tools to improve teaching and learning process and how we can go from an "as is" architecture to a "to be" architecture" of the model concerning its benefits, challenges, deployment enablers, and deployment inhibitors.

With that research, we believe it was possible to compile and summarize important information related to this topic which didn´t exist only in a single document.

One major limitation to the topic research was the context, as most of the studies in literature do not approach specifically instructional learning analytics applied in corporate context but mostly in educational organizations or other related institutions. This may imply that probably most of the business organizations use the existing LMS that are applied in educational institutions.

From the research, the lack of proper framework design without predefined learning object types or proper analytical tools with clear rules and better instructional design can lead to misinformation and inferences on predictors which can impact learning decisions. Lack of regular supervision and specific training to deal with data is also mentioned.

For the future, we expect to develop a new model that can try to solve this issue among other problems previously identified in the SLR and be used and implemented by business or vocational organizations to address their learning capabilities and processes. For that purpose, we will follow the Survey Research methodology (briefly explained above, see Fig. 3) to gather valuable data from rigorously selected specialist professionals working in the field of study to statistically analyze the data and reach meaningful research conclusions to evaluate, improve and develop the reference model that we propose.

Despite all this research about the topic, further research is needed to address the challenges that arise with the evolution of Learning Analytics.

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Towards an Accessibility Evaluation of eLearning Tools in Emerging 3D Virtual Environments Like Metaverse: Taking Advantage of Acquired Knowledge in Moodle and Second Life

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Abstract. Second Life (SL), a widely used Three-Dimensional Virtual World (3DVW), is being used as a tool for eLearning because of its interaction capabilities. On the other hand, accessibility is growing as a requirement for eLearning software tools, mainly because it can be an important factor for the learning process success by the impaired. In this paper we evaluate the accessibility of SL under WCAG 2.0/2.1 principles, and compare it with Moodle, which is a widely used web-based eLearning tool. We found that neither Moodle nor SL complies with accessibility under WCAG 2.0/2.1 rules, but SL does present itself as more accessible than Moodle. Moreover, WCAG 2.0/2.1 has several requirements specific for web pages, although they do not apply to 3DVWs. In this study, we intent to give a step forward towards evaluating emerging 3D virtual environments, like Metaverse, in the context of accessibility in the eLearning tools.

Keywords: WCAG · Accessibility · Virtual reality · eLearning · Multimedia · Interaction design · User experience (UX) design

1 Introduction

It is commonly known that impairments can affect people due to several reasons, such as congenital deformations, diseases, accidents, or aging. With the increase of life expectancy and, thus, a growth of people with age-related impairments, accessibility concerns of software tools become ever more important and relevant.

In the case of eLearning software tools, accessibility probably is a major factor in the impaired students' success, because it intervenes in the students' ability to take advantage of the contents and/or activities presented by the tools themselves. In this

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work, we intent to know how accessible Three-Dimensional Virtual Worlds (3DVWs) are with the notion that they have been used as an eLearning tool.

Indeed, 3DVWs are software tools that present interesting means of interaction that can be used for eLearning. In previous work [3, 4, 7–9, 11], several examples about the use of the virtual world Second Life (SL) as an eLearning tool were presented. Here, the question rises for 3DVW accessibility for students with impairments. Although there are many 3DVWs, we will use SL as our target, since it is widely used, and it has the 3DVWs typical interaction features.

To benchmark SL accessibility, we will compare it with Moodle. Moodle is a well-known and widely used eLearning environment, of which accessibility has already been extensively studied [10]. To evaluate the accessibility of both tools, we will use Web Content Accessibility Guidelines (WCAG) [12].

We conclude the paper with some reflexions that can be considered in how this acquired knowledge with these accessibility evaluations, in terms of eLearning tools in Moodle and Second Life, could be taken in mind for software developers in emerging 3D virtual environments like Metaverse [6].

The paper is organized as follows: we present the W3C-WCAG 2.0/2.1 principles and summarize the process of evaluation of contents under this recommendation; then, we present our methodology, and evaluate Moodle's virtual learning environment and the SL's under WCAG 2.0/2.1; finally, we present the analysis of results and our conclusions.

2 Web Content Accessibility Guidelines

WCAG are recommendations of World Wide Web Consortium (W3C) [13] to improve web content accessibility [12]. WCAG 2.1 is the latest version, and extends the WCAG 2.0.

The guidelines of WCAG 2.0/2.1 state that, in order to achieve accessibility, content should comply with four principles:

- Perceivable – content must be accessible to the senses the user has.
- Operable – the interaction must be developed to meet users' limitations.
- Understandable – content and interaction must be in reach of users' comprehension.
- Robust – accessibility must be maintained despite of technological advances.

To achieve these principles, WCAG 2.0/2.1 defines guidelines. The guidelines establish the requirements that should be implemented by developers, to comply with the respective principle. Then, to achieve conformity with the principle, a success criterion is also established for each guideline. Based on those criteria, three levels of conformity are established, from the lowest to the highest: "A", "AA", and "AAA". Each success criterion is classified in one of these levels. For content to be classified in one level, all the criteria of that level, and all criteria of the lowest levels if applied, must be met.

To help developers achieve success, WCAG 2.0/2.1 also includes techniques and descriptive examples of content following the criteria. These techniques are divided into two categories: the sufficient techniques are those which must be met to achieve success criterion; the advisory techniques are those which allow content to better address the guideline. Besides the techniques, examples of common failures in the techniques are also presented by the recommendation.

3 Accessibility Evaluation

Our main objective is to find out how well 3DVWs are in terms of accessibility for impaired students. To achieve that, we will use SL as our sample, and use WCAG 2.0/2.1 to evaluate its accessibility capabilities. Moreover, we will compare that evaluation with Moodle. Thus, we can summarize our objectives in two research questions:

RQ1: How accessible is SL for those impaired?
RQ2: How does SL compare to Moodle in terms of accessibility?

We will start by evaluating Moodle' accessibility, and then evaluate SL in a similar way. After that, we will analyze the results and answer the research questions.

We based our Moodle assessment on two previous evaluations [1, 2]. These include a total of four experts in content evaluation, which use WCAG 2.0 to assess Moodle. Table 1 is a compilation of the experts' evaluations including all the WCAG 2.0/2.1 principles, focused on the guidelines and success criteria that the authors considered relevant, i.e., some success criteria are not considered: the first column presents the guidelines for each principle; the second column the respective success criterion; the next four columns are the opinions of the experts for each criteria ("yes" if Moodle complies with the criteria, or otherwise "no"); the column "Agreement" presents the global evaluations of the criteria each time the experts agree; and the "Majority" column

Table 1. Evaluation of Moodle

Principle	Success criterion	[2]			[1]	Agreement	Majority
Perceivable							
1.1 Text Alternatives							
	1.1.1 Non-text Content (A)	Yes	Yes	Yes		Yes	Yes
1.2 Time-based Media							
	1.2.1 Audio-only and Video-only (Pre-recorded) (A)		No				No
	1.2.2 Captions (Pre-recorded) (A)	Yes	Yes	Yes		Yes	Yes

(*continued*)

Table 1. (*continued*)

Principle	Success criterion	[2]			[1]	Agreement	Majority
	1.2.3 Audio Description or Media Alternative (Pre-recorded) (A)		Yes				Yes
1.3 Adaptable							
	1.3.1 Info and Relationships (A)	Yes	Yes	Yes		Yes	Yes
	1.3.3 Sensory Characteristics (A)	Yes	Yes	Yes		Yes	Yes
1.4 Distinguishable							
	1.4.1 Use of Colour (A)	Yes	Yes	Yes	No		Yes
	1.4.4 Resize text (AA)	Yes	No	No	No		No
	1.4.5 Images of Text (AA)				No		No
	1.4.8 Visual Presentation (AAA)	No	No	No	No	No	No
	1.4.9 Images of Text (No Exception) (AAA)		Yes	No	No		No
Operable							
2.1 Keyboard Accessible	2.1.1 Keyboard (A)	Yes		No	No		No
	2.1.2 No Keyboard Trap (A)			No			No
	2.1.3 Keyboard (No Exception) (AAA)				No		No
2.2 Enough Time							
	2.2.1 Timing Adjustable (A)						

(*continued*)

Table 1. (*continued*)

Principle	Success criterion	[2]			[1]	Agreement	Majority
	2.2.2 Pause, Stop, Hide (A)				No		No
2.4 Navigable							
	2.4.2 Page Titled (A)	Yes	Yes	Yes	No		Yes
	2.4.5 Multiple Ways (AA)	Yes	Yes	No	No		Yes
	2.4.6 Headings and Labels (AA)				No		No
	2.4.7 Focus Visible (AA)		No	No			No
	2.4.8 Location (AAA)	Yes	Yes	Yes		Yes	Yes
	2.4.9 Link Purpose (Link Only) (AAA)		Yes	Yes		Yes	Yes
	2.4.10 Section Headings (AAA)				No		No
Understandable							
3.1 Readable							
	3.1.1 Language of Page (A)				No		No
	3.1.2 Language of Parts (AA)				No		No
3.2 Predictable							
	3.2.1 On Focus (A)		Yes	Yes	No		Yes
	3.2.3 Consistent Navigation (AA)				No		No
	3.2.5 Change on Request (AAA)				No		No
3.3 Input Assistance							
	3.3.2 Labels or Instructions (A)				No		No
Robust							
4.1 Compatible							

(*continued*)

Table 1. (*continued*)

Principle	Success criterion	[2]			[1]	Agreement	Majority
	4.1.2 Name, Role, Value (A)				No		No

presents the global evaluations of the criteria as result of the majority of the opinions of the experts.

Table 2 presents the results of our SL evaluation. The first column presents the guidelines for each principle; the second column the respective success criterion; the third column the evaluation; and fourty column some additional comments.

Table 2. Evaluation of Second Life

Principle	Success criterion	Evaluation	Comment
Perceivable			
1.1 Text Alternatives			
	1.1.1 Non-text Content (A)	Yes	
1.2 Time-based Media			
	1.2.1 Audio-only and Video-only (A)	No	Users are free to create content
	1.2.2 Captions (Pre-recorded) (A)	No	Users are free to create content
	1.2.3 Audio Description or Media Alternative (A)	No	Users are free to create content
	1.2.4 Captions (Live) (AA)	No	Users are free to create content
	1.2.5 Audio Description (AA)	No	Users are free to create content
	1.2.6 Sign Language (AAA)	No	Users are free to create content
	1.2.7 Extended Audio Description (AAA)	No	Users are free to create content
	1.2.8 Media Alternative (AAA)	No	Users are free to create content
	1.2.9 Audio-only (Live) (AAA)	No	Users are free to create content

(*continued*)

Table 2. (*continued*)

Principle	Success criterion	Evaluation	Comment
1.3 Adaptable			
	1.3.1. Info and Relationships (A)	Yes	
	1.3.2. Meaningful Sequence (A)	No	
	1.3.3. Sensory Characteristics (A)	No	
	1.3.4. Orientation (AA)	Yes	
	1.3.5. Identify Input Purpose (AA)	Yes	
	1.3.6. Identify Purpose (AAA)		Applicable only to web pages
1.4 Distinguishable			Applicable to media content
	1.4.1 Use of Colour (A)	Yes	
	1.4.2. Audio Control (A)	Yes	
	1.4.3. Contrast (Minimum) (AA)		Applicable only to text content
	1.4.4 Resize text (AA)		Applicable only to text content
	1.4.5 Images of Text (AA)		Applicable only to text content
	1.4.6. Contrast (Enhanced) (AAA)		Applicable only to text content
	1.4.7. Low or no Background Audio (AAA)	Yes	
	1.4.8 Visual Presentation (AAA)		Applicable only to text content
	1.4.9 Images of Text (No Exception) (AAA)		Applicable only to text content

(*continued*)

Table 2. (*continued*)

Principle	Success criterion	Evaluation	Comment
	1.4.10. Reflow (AA)		Applicable only to web pages
	1.4.11. Non-Text Contrast (AA)	No	Users are free to create content with their chosen contrast
	1.4.12. Text Spacing (AA)		Applicable only to text content
	1.4.13. Content on Hover or Focus (AA)	Yes	
Operable			
2.1 Keyboard Accessible			
	2.1.1 Keyboard (A)	Yes	
	2.1.2 No Keyboard Trap (A)	Yes	
	2.1.3 Keyboard (No Exception) (AAA)	Yes	
	2.1.4 Character Key Shortcuts (A)	Yes	
2.2 Enough Time			
	2.2.1. Timing Adjustable (A)	No	Users are free to create content
	2.2.2. Pause, Stop, Hide (A)	Yes	
	2.2.3 No Timing (AAA)	Yes	
	2.2.4 Interruptions (AAA)	Yes	
	2.2.5 Re-authenticating (AAA)	Yes	
	2.2.6. Timeouts (AAA)	Yes	Virtual Worlds are persistent
2.3 Seizures or Physical Reactions			
	2.3.1 Three Flashes or Below Threshold (A)	No	
	2.3.2 Three Flashes (AAA)	No	

(*continued*)

Table 2. (*continued*)

Principle	Success criterion	Evaluation	Comment
	2.3.3 Animation From Interactions (AAA)	Yes	
2.4 Navigable			
	2.4.1 Bypass Blocks (A)		Applicable only to web pages
	2.4.2 Page Titled (A)		Applicable only to web pages
	2.4.3 Focus Order (A)		Applicable only to web pages
	2.4.4 Link Purpose (In Context) (A)		Applicable only to web pages
	2.4.5 Multiple Ways (AA)		Applicable only to web pages
	2.4.6 Headings and Labels (AA)		Applicable only to web pages
	2.4.7 Focus Visible (AA)	Yes	
	2.4.8 Location (AAA)		Applicable only to web pages
	2.4.9 Link Purpose (Link Only) (AAA)		Applicable only to web pages
	2.4.10 Section Headings (AAA)		Applicable only to web pages
2.5 Input Modalities			
	2.5.1 Pointer Gestures (A)	Yes	
	2.5.2 Pointer Cancelation (A)	No	
	2.5.3 Label in Name (A)	Yes	
	2.5.4 Motion Actuation (A)	Yes	
	2.5.5 Target Size (AAA)	No	
	2.5.6 Concurrent Input Mechanisms (AAA)	Yes	
Understandable			Applicable only to text content
3.1 Readable			

(*continued*)

Table 2. (*continued*)

Principle	Success criterion	Evaluation	Comment
	3.1.1 Language of Page (A)	No	
	3.1.2 Language of Parts (AA)	No	
	3.1.3 Unusual Words (AAA)	No	
	3.1.4 Abbreviations (AAA)	No	
	3.1.5 Reading Level (AAA)	No	
	3.1.6 Pronunciation (AAA)	No	
3.2 Predictable			
	3.2.1 On Focus (A)	Yes	
	3.2.2 On Input (A)	Yes	
	3.2.3 Consistent Navigation (AA)	Yes	
	3.2.4 Consistent Identification (AA)		Applicable only to web pages
	3.2.5 Change on Request (AAA)		Applicable only to web pages
	3.2.5 Change on Request (AAA)	No	
3.3 Input Assistance			
	3.3.1 Error Identification (A)	No	
	3.3.2 Labels or Instructions (A)	Yes	
	3.3.3 Error Suggestion (AA)	No	
	3.3.4 Error Prevention (AA)		Applicable only to web pages
	3.3.5 Help (AAA)	Yes	
	3.3.6 Error Prevention (AAA)		Applicable only to web pages

(*continued*)

Table 2. (*continued*)

Principle	Success criterion	Evaluation	Comment
Robust			
4.1 Compatible			
	4.1.1 Parsing (A)		Applicable only to web pages
	4.1.2 Name, Role, Value (A)	Yes	
	4.1.3 Status Messages (AA)		Applicable only to web pages

4 Analysis

The results of our evaluation process are presented below. We believe it is important to summarize the evaluations' results before proceeding with their analysis. Thus, Table 3 presents the results of Moodle's compliance with WCAG 2.0 obtained from the agreement of the experts, whereas Table 4 presents the results for the same evaluation, but obtained by the majority of the experts' opinion, which includes those criteria excluded in Table 3. Table 5 demonstrates the results of our SL evaluation. All the tables are organized in the same way: the first column present the principles, the second the guidelines leading to the principles, and the third column presents the indexes of the success criteria separated by level (From "A" to "AAA").

Table 3. Compliance evaluation by agreement of Moodle

Principle	Guideline	Success criterion		
		Level A	Level AA	Level AAA
Perceivable	1.1 Text Alternatives	1.1.1		
	1.2 Time-based Media	1.2.2		
	1.3 Adaptable	1.3.1/1.3.3		
Operable	2.4 Navigable			2.4.8/2.4.9

The WCAG 2.1 is the most recent version of a recommendation for web content evaluation, which extends WCAG 2.0 by adding several new success criteria: 1.3.4 to 1.3.6, 1.4.10 to 1.4.13, 2.1.4, 2.2.6, 2.3.3, 2.5.1 to 2.5.6, and 4.1.3. The compliance of content is obtained by verifying if the success criteria is implemented. The level of compliance is categorized from A to AAA, concerning if all the success criteria of the respective level are met, as well as all the success criteria of lower levels, if applied.

Indeed, based on Tables 3 and 4, we can see that Moodle covers only the principles of "Perceivable", "Operable" and "Understandable", and only some guidelines at an

Table 4. Compliance evaluation by majority of Moodle

Principle	Guideline	Success criterion		
		Level A	Level AA	Level AAA
Perceivable	1.1 Text Alternatives	1.1.1		
	1.2 Time-based Media	1.2.2/1.2.3		
	1.3 Adaptable	1.3.1/1.3.3		
	1.4 Distinguishable	1.4.1		
Operable	2.4 Navigable	2.4.2/2.4.5		2.4.8/2.4.9
Understandable	3.2 Predictable	3.2.1		

Table 5. Compliance evaluation of Second Life

Principle	Guideline	Success criterion		
		Level A	Level AA	Level AAA
Perceivable	1.1 Text alternatives	1.1.1		
	1.3 Adaptable	1.3.1	1.3.4/1.3.5	
	1.4 Distinguishable	1.4.1/1.4.2	1.4.13	1.4.7
Operable	2.1 Keyboard Accessible	2.2.1/2.1.2/2.1.4		2.1.3
	2.2 Enough Time	2.2.2		2.2.3–2.2.6
	2.3 Seizures or Physical Reactions			2.3.3
	2.4 Navigable		2.4.7	
	2.5 Input Modalities	2.5.1/2.5.3/2.5.4		2.5.6
Understandable	3.2 Predictable	3.2.1/3.2.2	3.2.3	
	3.3 Input Assistance	3.3.2		3.3.5
Robust	4.1 Compatible	4.1.2		

"A" level, exception made for the guideline "2.4 Navigable". This means that, under the compliance requirements of WCAG, Moodle does not comply for accessibility, even if we exclude the new success criteria brought by the WCAG 2.1.

Table 5 shows that SL covers all the principles of WCAG 2.0/2.1 and several more guidelines than Moodle. In fact, in guidelines "1.1 Text Alternatives" (principle "Perceivable"), "2.1 Keyboard Accessible" (principle "Operable"), and "3.2 Predictable" (principle "Understandable"), SL achieves all the success criteria of level "A". Despite that, and under the WCAG 2.0/2.1 compliance scheme, SL also fails to comply for accessibility.

5 Conclusions

In this work we present an accessibility evaluation on SL and compare it to Moodle. We have seen that Moodle does not cover all success criteria in the respective guidelines, not even at the "A" level. On the other hand, SL does cover all the principles, and in some guidelines at the level "A". Despite that, under the compliance rules of WCAG 2.0/2.1, both fail to comply with accessibility. In this regard, to answer our first research question Q1, SL is not compliant with the accessibility requirements of WCAG 2.0/2.1 and, thus, is not entirely accessible for the impaired. Answering our second research question Q2, despite both Moodle and SL not qualifying for accessibility under the WCAG 2.0/2.1 rules, SL does meet more success criteria than Moodle.

Indeed, during this evaluation we realized that there are several WCAG 2.0/2.1 principles and/or criteria that do not apply to SL, because they are specific for web pages. Evidently this is expected, since WCAG 2.0/2.1 was developed to evaluate web content. Nevertheless, we resorted to it because there seems to be no tools to evaluate accessibility of 3DVW, in the extent of our knowledge, and WCAG 2.0/2.1 was used on Moodle, our benchmark focus. We present all those principles/criteria in Table 6. As expected, it suggests some inability of WCAG 2.0/2.1 to properly evaluate accessibility of SL, and probably of 3DVW in general, like far example Metaverse, because they share so many properties. Moreover, some guidelines such as "1.2 Time-based Media", could comply in accessibility as long as the users creating the contents take WCAG 2.0/2.1 in consideration. That is possible because in SL users are free to create contents, and by creating contents compliant with WCAG 2.0/2.1, the SL accessibility can be improved.

Not only 3DVW, but also Augmented Reality (AR), is being increasingly used for eLearning. The relationship of reality and virtual reality can be seen as a continuum that passes over different formats: the mixed reality [5]. Under this conception, 3DVW are in the other end of the continuum, opposed to the reality, and somewhere in the middle is AR. Because of this relationship, AR shares some properties with reality, and some with 3DVW thus being acceptable to conceive that some of the difficulties of properly evaluating accessibility of 3DVW by WCAG 2.0/2.1, also occur in the evaluation of accessibility of AR.

Table 6. Not applicable criteria to Second Life

Principle	Guideline	Success criterion		
		Level A	Level AA	Level AAA
Perceivable	1.3 Adaptable			1.3.6
	1.4 Distinguishable		1.4.3–1.4.6 1.4.10/1.4.12	1.4.8/1.4.9
Operable	2.4 Navigable	All	2.4.5/2.4.6	All
Understandable	3.2 Predictable		3.2.4	3.2.5
	3.3 Input Assistance		3.3.4	3.3.6
Robust	4.1 Compatible	4.1.1	4.1.3	

In the future, we intent to study the accessibility of AR and 3D virtual environments that uses AR, like Metaverse, under the WCAG 2.0/2.1. This could help us understand the difficulties of a proper accessibility evaluation on the virtual part of reality and, hopefully, find a solution that can mitigate this problem.

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On Modeling LMS Users' Quality of Interaction Using Temporal Convolutional Neural Networks

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Abstract. Learning Management Systems (LMSs) have been widely employed following the Covid-19 pandemic. The user modeling of LMS including educators and learners is a point of interest for Higher Education Institutions (HEI), stakeholders and system users. In this work user's engagement with LMS is modeled using the Quality of Interaction (QoI) indicator under a combined approach of blended and collaborative learning. The present research extends the previous work of 'Fuzzy QoI' and 'DeepLMS' to develop a generalized model that substitutes the fuzzy logic system with a deep learning model. In this line, Temporal Convolutional Neural Networks (T-CNN) were used to predict QoI, achieving MAE (0.027), RMSE (0.066) and R2 (0.698). The feedback received from the T-CNN model provides insights to educators and stakeholders in order to enhance the pedagogical experience.

Keywords: Learning Management Systems (LMSs) · Quality of Interaction (QoI) · Temporal Convolutional Neural Networks (T-CNN)

1 Introduction

Learning Management Systems (LMSs) have gained an increased adoption rate by Higher Education Institutions (HEIs) as a result of increased demand for new emerging technological and pedagogical approaches/practices [1]. Additionally, with the advent of Covid-19 pandemic, most of HEIs were motived to support blended learning (hybrid) fully or partially [2]. This meant higher dependence on LMSs for potential sharing of

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knowledge, learning material creation, student engagement and evaluation/assessment, especially for HEIs switching to fully online modalities during the Covid-19 pandemic [3]. LMSs have many advantages that were further accentuated during the Covid-19 pandemic, for instance, they allow engagement of larger number of learners compared to face to face (F2F) modalities and offer different types of approaches (blended, mobile, game, etc.) [4].

The aforementioned aspects bring up the need to re-evaluate the pedagogical processes and practices under these "new" online learning environments/conditions. In this vein, Ponce et al. [5] suggests that an assessment of educational research should follow a model that allows it to generate *generalizable data*. LMSs have a plethora of brands, they are not limited to a single type of software, and they expand to all forms of digital media (videos, articles, etc.) [6], and to fulfill that condition a more generalized approach to model learner/user's Quality of Interaction in online learning environment is required. Authors in [4] suggest that for any learner model three important questions should be answered, namely:

(i) What are the characteristics of the user we want to model?, (ii) How we model them?, and (iii) How we use the user model? [4]. Thus, an indicator that can model the users' engagement with the LMS based on their interactions within the online environment and, possibly, provide feedback to users as to take action and/or gain insight about their usage/interactions, could answer all the three questions.

2 Literature Review

Learner or user modeling while using a LMS is a point of interest not just to educators, but also to stakeholders and policy-makers. The question of effectiveness of LMS in HEIs can be difficult to answer when a model to quantify the users' engagement with the system is not in place. Most LMSs collect data about the user's interaction in the form of views, access, forum discussions etc., and using those they offer recommendation to increase system access/usage based on the average usage of same cohort. This section will review several approaches to model learner/student interactions within an online learning environment in order to evaluate the effectiveness of knowledge acquisition or suggest a better online learning approach.

Colace et al. [7], proposed a system for adaptive learning that consists of four main components. Two of its components relate to student modeling; one related to user model (UM) and the other concerning observations (OBS). UM describes the knowledge level of the user and learning style, while the OBS is more concerned with the interactions with the system (e.g., clicks, views, time spent). The approach focused more on the evaluation aspect of learning (level of knowledge) as to improve or adapt the learning experience to the user. Another approach [8] used four predictors (online learning self-efficacy, learner interactions with content, instructors and other learners) to estimate student satisfaction and perceived knowledge level. The method used a survey to collect the data, and found that these factors were relevant to the learning process outcomes. The use of survey questionnaire questions the objectivity of the method, as it is reliant on student perceived level of knowledge and satisfaction, which was noted by the author. Hussain et al. [9], predicted the student engagement in an online course using the engagement time, clicks and student's scores to predict students with low engagement during the

1st course assessment allowing for interventions before the final evaluation (exam). The focus of the model was on evaluation, and the interactions (i.e., clicks, time) were used as predictors of engagement, which is relative to the online course environment but can be difficult to adapt in a blended learning environment. Authors in [10]; studied the student engagement in a massive open online course (MOOC) and its relation to the course completion. The study used a survey along with a model of the user adopted on data composed of the number of viewed videos and posts made. The study found that student engagement on forums has significant impact on course completion versus videos viewed. Generalization of the study approach to different online learning environments could be considered as the main limitation.

From the discussed literature it can be noted that the main factor utilized in most studies is the evaluation or assessment of the student/learner. In a physical class or F2F, the assessment of student interactions with the content, instructor, other learners and the environment could be achieved without relying on student's evaluative scores of their quality of interaction (*i.e., effective utilization of spaces/resources, and quality of engagement with the instructors*), which brings the question of which parameters are required to evaluate the user's quality of engagement with the learning system regardless of their final score or assessment. For example an instructor using a LMS will not have a score assessment but their engagement with the learning system still needs to be evaluated. A/B/C-Teach framework suggested by [11] models the user based on three aspects, in particular: (i) quality of interaction (QoI), which evaluates user engagement with the LMS purely on direct interactions with the system, (ii) quality of collaboration (QoC), which investigates user interaction with other users [12], and (iii) affective state(AS) which evaluates the users' emotions during engagements/interactions within a LMS. The framework uses a multidimensional approach to model LMS users. The QoI indicator was validated in several studies [13–16], through which the QoI was proven to be a valid predictor across all institutional levels (macro, meso, and micro). A follow up work predicted the QoI of the LMS users in a model named DeepLMS [17]. The model uses LSTM to forecast QoI of users and provide feedback in order to maintain a good QoI with the learning system. The original QoI is based on fuzzy logic and fuzzy inference system (FIS), and was applied to the Moodle LMS. In particular, 110 metrics, plus engagement time and time period (for a total of 112) were used to infer the QoI indicator (final output). The system consisted of several smaller FIS blocks. The model was developed based on metrics extracted from Moodle and further evaluated by an expert to quantify the QoI using fuzzy logic. Generalizing such model would require assessment by same experts to other/new LMS parameters in order to derive the QoI and adjust FIS, unless a standardized system of parameters is applied across all LMSs, which is unrealistic. The Fuzzy QoI [13] was modeled using fuzzy cognitive mapping (FCM-QoI) in both a static approach (not taking the time period of the academic year in consideration) and a dynamic approach. The dynamic approach utilized 12 action parameters that are congregated from the 110 parameters, along with time period and engagement time as input. The model demonstrated the potential of applying machine or deep learning in QoI indicator modeling [16]. As such, the question of the validity of machine and deep learning techniques in modeling the QoI using the same approach as FCM-QoI remains unanswered. Thus, the purpose of the present work is it to apply different deep learning models in order to replace the Fuzzy QoI using the 12 action parameters, allowing for potential flexibility in the generalization and adaptability of the QoI modeling.

3 Methodology

In order to model the QoI using a deep neural network; the dataset DB1 was used (see Sect. 3.1). Overall, this section covers the methodology of the development of the proposed deep learning models upon DB1.

3.1 Dataset

The dataset DB1 consists of raw data of the LMS use from a total of 1037 students and 75 professors, with a duration spanning of 51 weeks across two academic semesters (2009/2010). The DB1 was used to develop the Fuzzy QoI [13], and the FCM-QoI [16] the latter is used to evaluate the performance of models that are proposed in this work.

Data Preprocessing. The Fuzzy QoI, derived 12 action parameters based on the 110 metrics extracted from the Moodle LMS. These 12 action parameters are divided into three main categories (4 each); view, add and alter. The three categories group the 110 parameters based on users' interactions with the LMS. For example, the view action parameters group any user interaction that pertains to viewing LMS content, whether it is a course module, quiz, post and/or grades. Similarly, the add and alter action parameters are concerned with user interactions that add new content(quizzes, posts and course material) and edit existing content (editing, updating and deleting) respectively. As such, the 110 parameters are grouped into 12 action parameters resulting in dimensionality reduction [13]. The proposed models used the 12 parameters along with time period (which refers to the week number in the academic year) and total engagement time. To avoid bias from the engagement time; for example, users leaving the screen open while away; a threshold of around 2 h per day or 14 h per week was put. The daily users' action parameters and engagement time were aggregated as the QoI output was derived on a weekly basis. The data splitting was done in 90:10 and 75:25, the latter to match the FCM-QoI split. In both instances; the data was scaled to range (0 -1). The input data is represented as a 1D vector having the 12 action parameters (frequency/week), time period and total engagement time per week. The output consists of the weekly QoI indicator value which is between (0–1).

3.2 Developing Deep Learning Models

Models using 90:10 Split. The performance of four different models was tested; the parameters of loss function (mean squared error (MSE)), epochs (50), optimizer (ADAM), batch size (32), learning rate (0.001), dropout (0.15) and output of a sigmoid activation function (Dense = 1, activation = 'sigmoid') were fixed for all four models. Such choice could affect the models' performance negatively, but it was made while considering this step (90:10 split) as a preliminary check for the feasibility of the proposed models in predicting the QoI indicator. The models were artificial neural network (ANN), long short term memory recurrent neural network (LSTM), one dimensional convolutional neural network (1D-CNN) and temporal convolutional neural network (T-CNN).

ANNs or multilayer perceptron (MLPs) [18], are formed of input layer, hidden layer(s) and output layer. ANNs are used to learn real world data representations, and they can be used to model the QoI which is a regression problem. The ANN developed consisted of 3 hidden layers containing 64, 32 and 16 hidden nodes.

LSTM is a type of recurrent neural network (RNN) that was developed to overcome the vanishing gradient problem with regular RNN [19] and, similar to ANN they can be used for regression. The LSTM developed consisted of one layer containing 50 nodes followed by three hidden layers similar to ANN.

CNNs are the standard model for computer vision and image processing applications [20]. To generalize application to 1D signals (not images) 1D-CNNs were proposed. In this study the 1D-CNN consisted of two layers; 64 filters with kernel of size 9 and 32 filters of kernel size 3 respectively, followed by fully connected layer of similar parameters to ANN.

T-CNNs or TCN are a modification of CNN and can be considered an evolution of both CNN and RNN [21, 22]. The T-CNN uses dilated convolution instead of regular convolution; which applies convolution across input points separated by fixed step, and thus by extension increasing the history of the data being covered. So for example, a kernel size 3 will always apply convolution for current data point and two points before it, but with dilated convolution of (2) it will apply to current point and two points at (2) and (4) steps behind it, respectively. In this way, by adjusting the size of step (dilation) and kernel size the extent of history modeled can be controlled. In this study, the parameters used to infer QoI are a total of 14 (4 view, 4 add, 4 alter, time period and engagement time) and adjusting the kernel size and dilation would effectively correlate these factors at different points. For data splitting of 90:10; two levels of dilation are used (2) (one step in between), (4) (three steps in between) in the T-CNN layer which is followed by fully connected layer of similar parameters to ANN.

Models using 75:25 Split. Five different T-CNN models were developed with fixed single hidden layers of 64 neurons and dropout of 0.15. The five models had different dilations, namely; T-CNN248: (2, 4, 8), T-CNN24: (2, 4), T-CNN2: (2), T-CNN4: (4), and T-CNN8: (8). Note that the numbers in brackets indicate the levels of dilation. All models were trained for 100 epochs and the results are for 4-fold cross validation.

3.3 Evaluation of Models

Models developed were compared to the results of FCM-QoI model, using parameters of root mean squared error (RMSE), mean absolute error (MAE) [23] and correlation of determination (R^2) [24]. RMSE (Eq. 1) and MAE (Eq. 2) could give a good idea about the error in prediction, while R^2 (Eq. 3) will provide a good indicator of how well the predicted QoI follows the True QoI.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(x_i - \hat{x}_i)^2}{N}} \tag{1}$$

$$MAE = \frac{\sum_{i=1}^{N}\left|\hat{x}_i - x_i\right|}{N} \tag{2}$$

$$R^2 = \left(\frac{\mathrm{N}(\sum x\hat{x}) - (\sum x)(\sum \hat{x})}{\sqrt{(N\sum x^2 - (\sum x)^2)(N\sum \hat{x}^2 - (\sum \hat{x})^2)}}\right)^2 \tag{3}$$

N: Total number of data points.
x : True value.
$\hat{x}$: Predicted value.
i : Variable i.

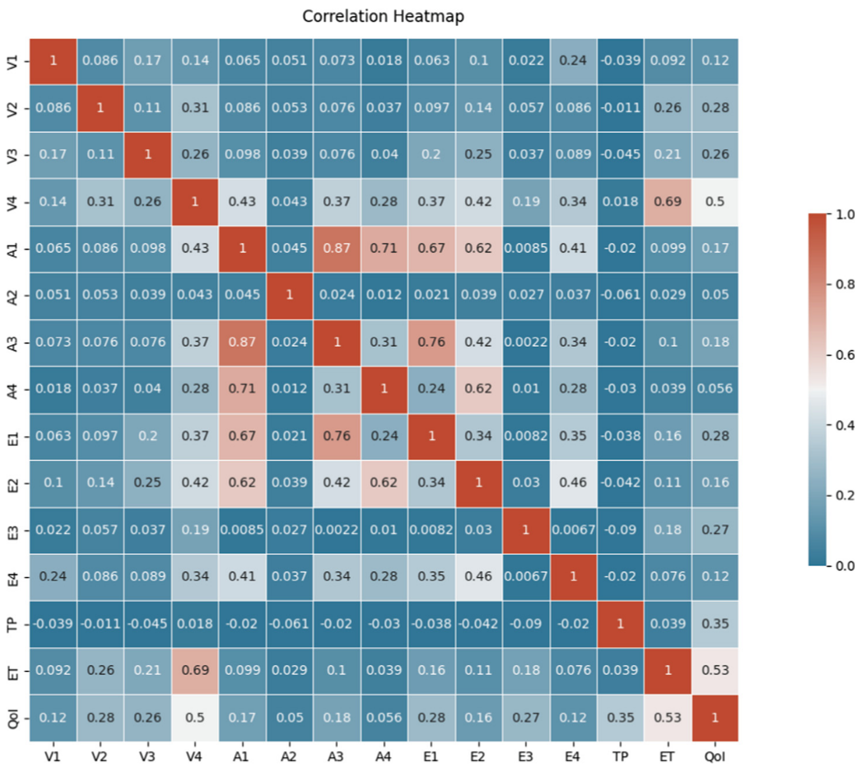

Fig. 1. Correlation heat map; V = view, A = add, E = alter, TP = time period, ET = engagement time, QoI = quality of interaction.

4 Results

The correlation between the 14 parameters and the QoI are shown in Fig. 1. Pearson's correlation coefficient [25] was used to find correlation between the numerical variables, which includes the action parameters, engagement time and QoI indicator value. The time period is an ordinal value (categorical) as it represents which week the aggregated data refers to in the academic year (week 1- week 51). Spearman's rank correlation coefficient [26] was used for the time period correlation with all the other variables. The final correlation matrix represents the combined Pearson's and Spearman's correlation coefficients. It can be noticed that the time period has a low correlation (0.35) with the QoI. Moreover, the highest correlation was between view parameter 4, engagement time and QoI. This can indicate that the most common action between users that affect both time and QoI is viewing content.

4.1 Results for 90:10 Split

Table 1 shows the results for the ANN, LSTM, 1D-CNN and T-CNN models compared to the FCM-QoI model, which are for 10-fold cross validation. The lowest MAE was for T-CNN at (0.029), FCM-QoI had the lowest (RMSE) better than T-CNN. T-CNN also had best R^2 score at (0.685).

4.2 Results for 75:25 Split

Table 2 shows the results for the 5 T-CNN models. Overall, the best performance was for T-CNN248 (three levels of dilation), while worst was T-CNN8 with (8 step dilation). T-CNN248 performed better than T-CNN with 90:10 split though RMSE is still higher than FCM-QoI.

Table 1. Results for 90:10 split.

Model	MAE	RMSE	R^2
ANN	0.038	0.069	0.649
LSTM	0.055	0.09	0.437
1D-CNN	0.048	0.084	0.479
T-CNN	**0.029**	0.066	**0.685**
FCM-QoI	___	**0.026**	0.536

Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Correlation of Determination (R^2).

Table 2. Results for 75:25 split.

Model	MAE	RMSE	R^2
T-CNN2	0.029	0.067	0.664
T-CNN4	0.029	0.067	0.678
T-CNN8	0.068	0.096	0.37
T-CNN24	0.027	0.066	0.685
T-CNN248	**0.027***	0.066*	**0.698**
FCM-QoI	___	**0.026**	0.536

* Rounded value, Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), Correlation of Determination (R^2).

5 Discussion

Several models were developed in order to represent the Fuzzy QoI model and derive its output value. The 90:10 split utilized more of the data for training and tested several models. Though parameters for LSTM and 1D-CNN can be tweaked for better performance, T-CNN outperformed both, though RMSE was still higher than FCM-QoI model, while T-CNN had a better R^2 score. The performance of ANN highlighted that the data can be interpreted as separate non-temporal parameters as compared to a time series signal, which might explain the drop in performance of LSTM and 1D-CNN. The T-CNN developed models with different dilations can be used to interpret the relations between the parameters and their impact on the value of QoI. In addition, through the correlation heatmap (see Fig. 1), the relations between the parameters and value of QoI are demonstrated. On the other hand, the T-CNN models look into the effect of the parameters when convoluted at different intervals. Moreover, the worst performance was for TCNN8; this can be explained by how the process of convolution is applied, as the kernel (size = 3) fills the missing values (padding) with zeroes and since the input has 14 total parameters, the convolution is mostly applied between two parameters at a time with the 3rd always padded by zero effectively reducing the kernel to size 2. For single level dilations; the T-CNN4 had better performance than both T-CNN8 and T-CNN2, which shows that inter-parameter relations (i.e., view, add, alter) are more relevant as features, as the steps usually include parameters across two categories. Using highest level dilation (2, 4, 8) correlated the data across all parameters and thus had highest performance, though at cost of increased training time. It seems that the parameters in each category affect the QoI derivation and, although some seasonality might be present through the time period variable, its correlation is low and thus has modest effect on QoI inference.

To sum it up, the deep learning models developed and proposed here can be used to replace the Fuzzy QoI model with good fidelity. The parameters can be preprocessed into the three main categories allowing for easier deployment of the model for QoI prediction. The QoI as an indicator holds an advantage over the previously discussed methods in its modeling of the learner irrespective of their score. So, it provides an overview of the user's interactions within a LMS for both learners and educators. The T-CNN allows for flexibility in model development, as it can be used to both predict current and future QoI values in a single output given that sufficient time steps are provided, which can be developed in a follow up work.

6 Conclusion

The present study presented several deep learning models in order to replace the fuzzy QoI model, and the best performance was for T-CNN248. The proposed model can be deployed in a LMS after a preprocessing step dividing the metrics into three categories of view, add and alter. The present model can be considered the first step in fully replacing the fuzzy QoI model, where the best outcome is to utilize the LMS metrics with minimal preprocessing to predict the QoI. Additionally, the QoI can be considered a good indicator that models the user's engagement with the LMS, giving users, policy-makers and stakeholders insights on how LMS affects the pedagogical process and feedback to improve users' experience. Finally, the future work includes applying T-CNN to forecast future QoI values, and also the utilization of the full 110 metrics from Moodle actions category in development of the deep learning model.

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Computer Science Education and STEM

From Stories to Science: An Exploration Guide to Promote Epistemic Practices in Primary School

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Abstract. Interdisciplinary approaches between science and literature can increase students' interest and promote the development of essential skills. However, studies report that interdisciplinary approaches are still scarce and that teachers do not feel confident to implement those. To overcome this problem, we developed an exploration guide (EG) to support teachers in the planning and implementation of interdisciplinary practices that articulate scientific and literary education. We aim to know if this EG can impact teachers' mediation (TM) and students' epistemic practices (EP). We recorded three lessons planned and implemented by the teacher: one before being introduced to the EG and two using the EG. We organized the data through multimodal narratives (MN) and performed content analysis of these MN to identify TM and EP. A cluster analysis was performed to study the relationship between the TM and students' EP. The results, show that the EG impacted TM, facilitating the development of students' EP. The main contribute of this study is that EG was useful for the teacher to articulate science and literature. EG impacted her TM with new TM traits emerging in the classroom, increasing the frequency and diversity of students' EP.

Keywords: Scientific education · Multimodal narratives · Literary education · Interdisciplinarity · Teachers' mediation · Teachers' professional development

1 Introduction

According to the National Research Council [1] of the United States of America science teaching should be meaningful to students so that they become engaged in scientific practices and understand how scientific knowledge is developed. This direct engagement gives them an appreciation of the diversity of approaches that are used to investigate, model and explain the world. It is in this context that epistemic practices (EP) become

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very relevant to science education [2]. EP are the work that the students do, with the aim of building scientific knowledge, in classroom context, taking the activity of scientists as a reference [3, 4] According to [5] EP are interactive (built between people through activities), contextual (situated in social practices and cultural norms), intertextual (communicated through coherent discourses, signs and symbols), and consequential (legitimate knowledge instates power and culture). In this study, we will focus on students' EP that can be developed at elementary school education. Some EP in classroom context are describe phenomena, recognize phenomena in their context, represent physical phenomena, change empirical language into conceptual language and predict what happens based on conceptual knowledge [6] and [7] propose six levels of epistemic practices. The basic epistemic level concerns epistemic activity that deals directly with empirical aspects of the situation or with raw data from the situation. Intermediate epistemic levels deal with transformations of the data and the relations between them. Higher epistemic levels deal with specific theoretical models of the problem situation, or even with more general theories. According to these authors, epistemic activity cannot take place only on a given epistemic level; it has to take place in a 'coming and going' between the empirical referent and the successive levels of abstraction of the respective theoretical approaches. In order to promote PE, it is necessary to change learning environments [2]. A key aspect of this transformation is teacher mediation (TM), here understood as the teacher aids and practices that best foster meaningful learning and allow learners to gradually become autonomous in learning [8]. TM has been shown to strongly impact students' engagement in scientific practices [8, 9]. TM that are known to promote the development of EP in the context of teaching natural sciences, in basic education include: problematization; questioning; content review; engagement in scientific activities; presentation of new content/information; clarifying ideas; information systematization; promoting autonomy; encouraging deeper reasoning; assessment and feedback; valuing collaborative work and error valorization [9].

Some studies suggest that integrating literature into science education can engage students in creative projects and encourage them to express science in multiple ways [10]. Various authors suggest that literary education is a good articulation context, introducing topics close to the students' reality, promoting the understanding of scientific contents, engaging them in scientific tasks and problem-solving activities that increase their interest, admiration, enthusiasm and curiosity towards sciences [10–12]. According to Lomas [13] literary education helps students developing skills for the analysis and interpretation of increasingly complex texts, communicate literarily and write with literary intent. Furthermore, interdisciplinary approaches have been shown to allow the development of reading skills, argumentation, autonomy and other competences capable of triggering the processes of discovery, exploration, cognition, emotion and imagination [10–15]. In Portugal, for example, the BiblioLab platform (https://bibliolab.pt) offers Open Educational Resources (OER) that articulates science with literature to be used by teachers, parents and students [16]. Reis et al. [17] developed a project that aims to simultaneously promote literature and scientific literacy, not only among children, but also among the adults such as family members, educators and teachers. Along these lines, a number of approaches have emerged, namely STEM [18] and STEAM [19, 20] which main objective is to integrate different areas of knowledge, such as science, technology, engineering, arts and mathematics, in a holistic way. But, some studies report that teachers do not feel confident or capable of planning and implementing interdisciplinary practices in formal educational context and, for this reason, these dynamics are still scarce [21]. Russell and Zembylas [22] argue that some of the challenges of this kind of integration for teachers are related to self-efficacy perception and to the structure of the school day in traditional school systems. According to these authors, interdisciplinary approaches make science teachers feel out of their comfort zones. This highlights the importance of empowering the teachers to autonomously plan and implement interdisciplinary approaches.

The collaboration among teachers and researchers is a way to support teachers' professional development [23, 24]. An exploration guide (EG) co-constructed by researchers from the field of science and literature education and by in-service teachers may effectively empower other teachers to develop and implement interdisciplinary approaches. According to [25] EG are resources with strong potential to impact teachers' practices and learning because these can influence the way they prepare and think about their teaching practices and focus not only on the type of didactic guidelines that the teacher should follow but also on the students' previous knowledge [24]. However, according to [26] it should be noted that the human element – the pedagogical experience of a good teacher – is always what really matters. Managing the balance between organized guidance and creative freedom will depend upon the teachers who create or modify each EG [26]. In this context, the EG can work as a relevant tool for teachers' professional development, impacting their pedagogical knowledge and teaching practices [27]. According to [27, 28] this tool is adapted to the teachers' previous knowledge and their professional experiences. The same authors, suggest that teachers consider this tool attractive and an integral part of teaching practices. So, an EG to support teachers in the planning and implementation of science – literary interdisciplinary education activities is expected to improve teaching mediation in lessons and engage students in epistemic practices. Despite of the potential of these resources, few information is available regarding how EG are used by teachers and how these can be used to enhance their TM for the development of students' EP. In this context, given the scarcity of formal educational practices that link science education with literary education, at elementary school education, and the need for teacher training to foster the development of EP in students from a very young age, we propose to answer the following research question: To what extent an exploration guide that articulates scientific and literary education affects teachers' mediation and students' epistemic practices?

1.1 Research Focus

The present research aims to:

1) Identify the impacts of the EG in the TM and its potentialities for science education.
2) Study the relation between TM and the students' EP developed in the classroom.

2 Methodology

2.1 Development of the Exploration Guide

The EG aims to support teachers during the planning of activities and educational practices, and also in the planning and implementation of their students' tasks. As we can see in the Fig. 1, this EG was developed over two cycles of design science research (DSR) [29] (Fig. 1).

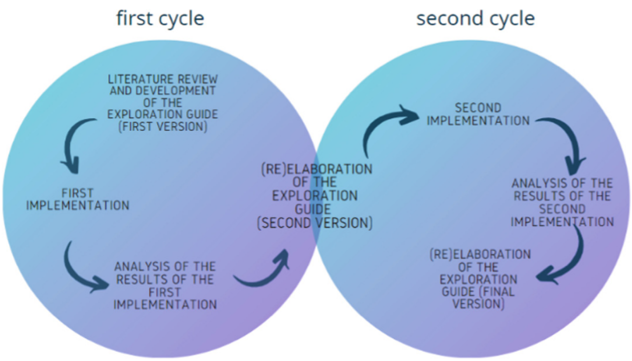

Fig. 1. Exploration guide development process.

The EG was constructed according to the following sections: a) criteria for the selection of the literary text; b) task design for students (literary exploration section); c) task design for students (scientific-technological exploration section) and d) articulation of science-technology and literary education. The structure of the EG was based in the theoretical framework for art integration in science teaching of [21]. It is also informed on the work already developed by authors such as [10, 11, 15] on how to explore a scientific topic, linking these two areas. The "criteria for selection of the literary text" was designed bearing in mind that the goal was to select literary texts to be appropriated by the students. The quality of the texts was ensured by choosing texts from the National Reading Plan or from an author that critics and literary history consider important. We also introduce guidelines to support the choice of texts that allow to pose questions related to Science, Technology and Society (STS). The section "task design for students (literary exploration section)" presents guidelines for the teacher to explore a pre-reading moment, getting students to read, analyze and understand the text, to give voice to the text and to raise interest for further reading. This section was developed according to the National Program for the Teaching of Portuguese and the Portuguese "essential learnings" for basic education. The didactic structure is based on the principles of [30] that highlights the importance of investing in a line of preparation for an appreciation of literature that can become a source of pleasure. The section "task design for students (scientific-technological exploration section)" was developed according to the Portuguese "essential learning" for basic education. This section has been developed according to the theoretical constructs and aims to engage students in scientific, technological and ethical practices and discussions, designated in the literature as EP. We informed the guidelines in the available information about TM practices that promote the development of EP in the context of teaching natural sciences in basic education [9] Table 2, appendix A2, https://bit.ly/3lFNq9h. The section "articulation of science-technology and literary education" aims to articulate science-technology and literary education, so that it results in the review and consolidation of students' learning of scientific and literary contents, through activities of artistic nature. This section was developed in accordance with the official guidelines of "essential learning" for basic education. To further ensure the validity of the EG, and following the suggestion of [23], we collaborated with a teacher to pilot our solution. This teacher applied the initial version of the EG to develop an educational activity that she implemented in her educational context. The teachers' feedback was used to inform changes to improve the EG.

2.2 Participants

This research was implemented in a class of a Portuguese elementary school. The class had 26 students – 8 boys and 18 girls – with ages between 8 and 9 years. The teacher was highly experienced and has been teaching elementary grades for 23 years at full time. She was also responsible for co-supervising pre-service teachers of Basic Education Degree, under a protocol with a Portuguese University. Informed consent for participation in this study was obtained from the students' parents, the school board and the teacher.

2.3 Data Collection and Procedures

To understand the impact that the EG had on teachers' TM we observed and recorded a lesson, developed and implemented by the teacher before the contact with the EG. After, we introduced her to the EG, we asked her to use it to develop two lessons, at different times. The first lesson without the use of the EG lasted 55 min. The second lesson lasted 3 h and the third lesson 90 min, both planned and implemented with the support of the EG. In the three observed lessons, we collected audio records, photographs, lesson plans, students' work, tasks proposed to students and field notes. With this data, we produced a Multimodal Narrative (MN) for each of the three lessons following a protocol developed by [31, 32]. The interview and the teachers' answers to the questions are presented in Appendix A4 (https://bit.ly/3lFNq9h).

2.4 Data Analysis

Based on the validated MN, we defined units of analysis (within MN) to identify the TM and the students' EP along the three MN. Each unit of analysis corresponded to an interaction between the teacher and the students. The interaction, according to Hinde [33], is a type of action that occurs between two or more entities (in this case: teacher-student[s], student[s]-teacher or student[s]-student[s]) when the action of one of them causes the reaction of the other or others. In this study, there is a new interaction whenever there is a change in:

1- the group of interlocutors: (e.g.: change of interaction from teacher-student(s) to student(s)- student(s) or student(s)-teacher).
2- the topic or subject being dealt with within a task.

After defining the units of analysis, we performed a content analysis of these in MN to identify and record the frequency of the types of TM and students' EP.

Based on a literature review we identified and defined sixteen categories of analysis for EP (Table 1, appendix A1, https://bit.ly/3lFNq9h).

Fourteen categories of analysis were defined for TM, based on those that, according to [9], promotes, or inhibits, EP (Table 2, appendix A2, https://bit.ly/3lFNq9h). Based on the categories of EP and TM we performed a content analysis of the three MNs. We performed this process in two phases: In a first phase, the units of analysis where TM and/or PE existed were analyzed in all NM. In a second phase the TM and EP categories were identified. To ensure the content analysis' reliability, we redone it with an interval of 14 days and performed a concordance analysis between the data collected in the first and second content analysis, for both the EP and TM occurrences, by calculating the intraclass correlation coefficient (ICC). This was done using IBM SPSS Statistics 27 and a reliability scale analysis, selecting the random sample: two-way mixed and the type of analysis: absolute agreement. The ICC values obtained in the reliability analysis for the TM and EP show confidence Intervals greater than 88% and 97% respectively, which are considered "Excellent". Ten percent of the units of analysis were independently coded by a second researcher (JBL), to estimate inter-rater concordance, which was 80% for EP and 93% for TM, values that are considered Very Good [34].

To study the patterns of relationship between the TM and students' EP, we performed an analysis of clusters as this multivariate analysis allows the organization of a certain group of entities or "natural groups of cases that exist in a certain set of data" identifying which cases are grouped, to have an interpretation of the characteristics of these same groups [34], p. 89). A cluster analysis was done to the set of the three lessons, using the SPSS v.27 software. We performed a cluster analysis in a hierarchical way (identifying which cluster we should create) and elaborated the cluster's dendrogram of the relationship between the teaching mediation and the students' EP. For that we used Ward's method [35] labelled by case, with a quadratic Euclidean distance.

Finally, in order to understand the effect of the EG in the types of TM, we determined which were the most frequent types of mediation before and after the use of EG and identified the percentages of each MN by clusters to understand the weight of each lesson in each cluster. Afterwards, we looked for evidence of the teacher's speech regarding these same types of mediation that met the specific guidelines of the different sections of EG.

3 Results

3.1 Changes in Teachers' Mediation and Students' EP Through the Three Lessons

The first lesson – planned and executed by the teacher without the use of EG – presents the lowest EP's occurrences and diversity. From the first to the third lesson there is a gradual increase in the diversity of EP (Fig. 2) and a slight increase in the number of occurrences of EP1, EP2, EP7, EP8, EP10, EP11, EP12 and EP14.1 The EP14.2 was not observed in any lesson. The EP3 EP5 EP6, EP9 EP13 and EP15 are observed at the same frequencies throughout the three lessons.

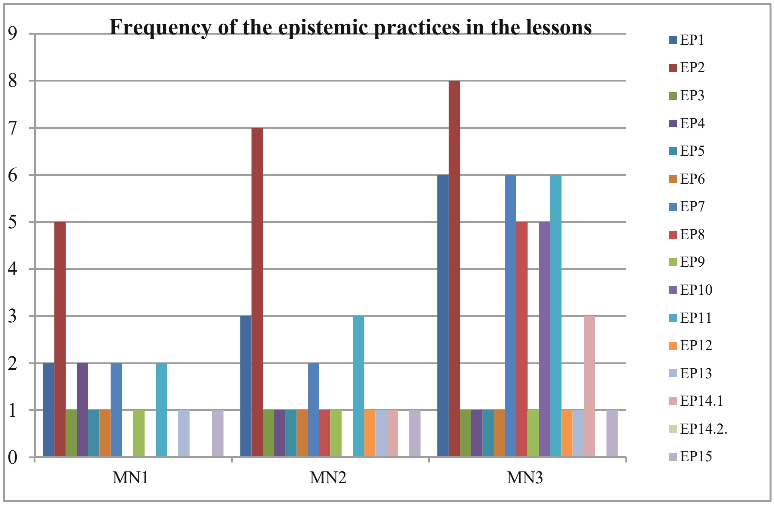

Fig. 2. Frequency of students' epistemic practices (EP) in the three lessons (subtitle coding – NM1 – "class The air" (no exploration guide); MN2 – "class Ph and acidity" (with exploration guide version 1); MN3 – "class Sustainable fishing" (with exploration guide version 2); EP1: observe; EP2: describe; EP3: ask questions; EP4: estimate/predict; EP5: formulate hypotheses; EP6: planning procedures and the use of materials/equipment; EP7: use materials and/or equipment; EP8: control variables; EP9: interpret; EP10: use mathematical and/or computational thinking; EP11: organize information; EP12: arguing on data basis; EP13: relate; EP14.1.: using representations; EP14.2.: create representations; EP15: communicate on data basis.)

The TM2.2 is highly frequent in all classes, and as TM2.1, TM7, and TM12, does not show strong frequency changes across the three classes, probably representing a characteristic of this teacher's teaching practices. Besides the TM observed in the first lesson (open questioning; systematizing information; engagement in scientific activities; presentation and revision of contents, clarifying ideas; valuing error; Fig. 3) new types of mediations arise with the use of the EG. These include: TM1; TM8 and TM11.There is also a frequency increase of TM4, TM6 and TM10 and a decrease of the TM2.3 that was not observed in the last session. TM1, 3, 9 e 12 are of little relevance because of their low frequency.

3.2 Relation Between TM and the Students' EP Across the Three Lessons

From the cluster analysis, using the quadratic Euclidean distance of 5 as the cut line in the resulting dendrogram, we obtained 8 clusters characterized by the combinations of TM and EP that are described in Table A1 (see, Appendix A3, https://bit.ly/3lFNq9h). From

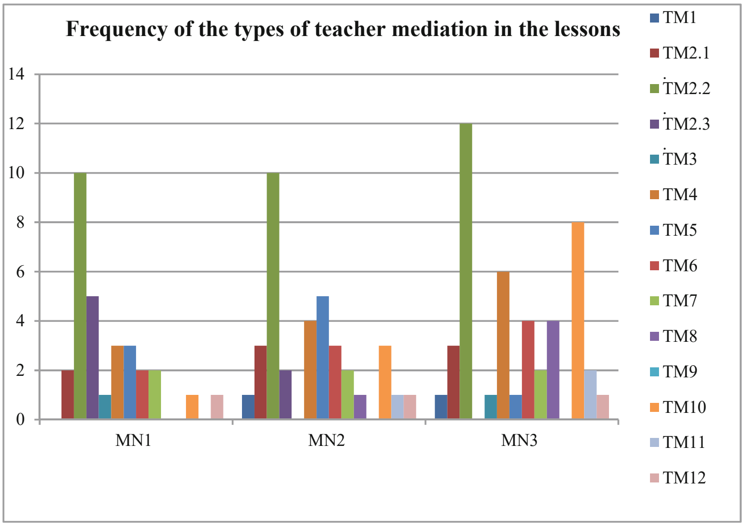

Fig. 3. Frequency of the types of teacher's mediation (TM) in the three lessons (subtitle coding – NM1 – "class The air" (no exploration guide); MN2 – "class Ph and acidity" (with exploration guide version 1); MN3 – "class Sustainable fishing" (with exploration guide version 2); TM1: problematization: TM2.1: open questioning; TM2.2: closed questioning; TM2.3: rhetorical questioning; TM3: content review; TM4: engagement in scientific activities; TM5: presentation of contents/ new information; TM6: clarifying ideas; TM7: information systemization; TM8: promotion of autonomy; TM9: encouraging deeper reasoning; TM10: assessment and feedback; TM11: valuing collaborative work; TM12: error valuation).

these 8 clusters, we selected the 5 most relevant clusters that explain, together, more than 82% of the results. The clusters are numbered according to their richness in terms of frequency and complexity of EP, cluster 1 being the poorest in terms of frequency and complexity of EP and cluster 8 being the richest. Cluster 1 presents types of TM for students to work on an active empirical level and has the least complex EP and the lower diversity of EP (Fig. 4 and Table A1, see Appendix A3, https://bit.ly/3lFNq9h). Cluster 2 includes TM for students to reflect about a problem. This cluster has the lowest number of EP (although we consider asking questions more complex than describing and using materials/equipment) and the most frequent EP is asking questions. Cluster 3 presents TM that facilitate students' communication in the classroom (Table A1, see Appendix A3, https://bit.ly/3lFNq9h). Cluster 4 presents TM that facilitate a more active empirical work from the students (Table A1, see Appendix A3, https://bit.ly/3lFNq9h). Finally, cluster 5 presents TM that facilitate empirical work at a more complex level, allowing students to work according to three levels: empirical, information processing and representations. Seven EP are observed in cluster 5 and these are more complex than those found in cluster 4 (Table A1, see Appendix A3, https://bit.ly/3lFNq9h). According to the data cluster 1 is the most frequent before the use of EG (Fig. 4). After the use of EG, cluster 5 increases its frequency, becoming one of the most frequent. In the lessons where the teacher uses the EG we observe changes in TM frequency (emergence of two new

TM - promotion of autonomy (TM8) and appreciation of collaborative work (TM11) – a frequency increase of the “engagement in scientific activities” (TM4), “clarification of ideas (TM6)”, and “assessment and feedback” (TM10) and, changes in students’ EP frequency (four new EP – control variables (EP8), argue based on data (EP12), use mathematical/computational thinking (EP120), use representations (EP14.1) and the increase of four EP - observe (EP1), describe (EP2), use material and equipment (EP7), and organize information (EP11). The clusters with less complex EP decrease their frequency from the first to the other sessions. The clusters with more complex TM increase their frequency. In fact, clusters 3, 4 and 5 together sum a total frequency of 29% in lesson 1, 38% in lesson 2 and 50% in lesson 3. There is a change in TM and students´ EP profiles from the lesson 1 to lesson 3, possibly due to an increasingly appropriation of EG.

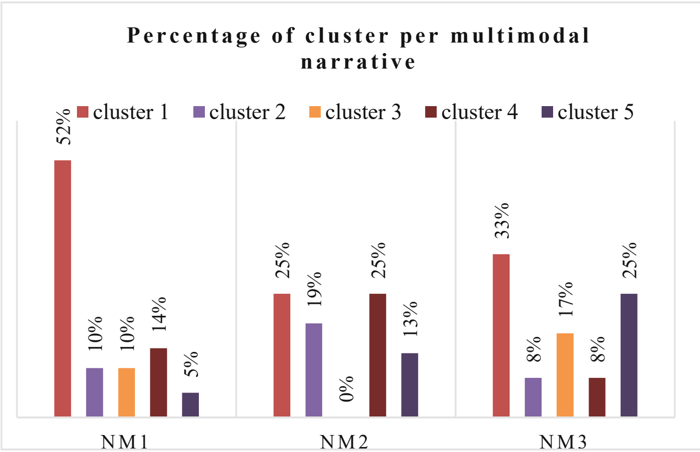

Fig. 4. Percentage of the 5 clusters that explain more than 82% of the results per Multimodal Narrative (MN).

4 Discussion

The main contributions of the present work to answer our research question: are:

1) The EG developed to articulate science and literature impacted teacher’s TM and her students’ EP.
2) The changes in TM profile are linked to changes in students’ EP. Changes in TM are associated with the increase of the frequency, diversity, and complexity of students’ EP, and distinct sets of TM are associated with distinct types of EP.

Regarding the first contribution, we present here an EG for the articulation of literature and science education that proved to be useful for the teacher impacting her TM and consequently her students’ competencies. [21] present a guiding framework for activities linking science and arts in general. Although our proposal was based on these authors' framework, the EG presented here is specifically oriented towards the articulation of literature and science. This EG further extends the work of [11], by developing a generalist EG that allows primary school teachers to autonomously plan and implement a lesson in which they explore literature and science, starting from any literary text or scientific content. For that, our EG has very detailed pedagogical, scientific and didactic guidelines to guide teachers during the planning and implementation of the lessons. Our results suggest that the teacher appropriated the EG autonomously and this had an impact on her professional practice (Fig. 3). These results thus support the claim of [25–28] related with EGs: that these resources can effectively work as relevant tools for teachers' professional development, impacting their pedagogical knowledge and teaching practices. It should be noted that despite the observed changes, the teacher maintains her main teaching trace throughout the three lessons, characterized by a high frequency of TM 2.2. This is in line with the idea of [27, 28]: EG are adapted to the previous knowledge of teachers and their own professional experiences. Our results also suggest that this EG that articulates science and literature was appropriated by the teacher in a way that allowed students to engage in diverse and complex EP (Fig. 2). In this aspect, our results are similar to those of the study of Franco-Mariscal [15] that showed that the articulation of the "Don Quixote of La Mancha" with astronomy concepts allowed students to develop several competencies, such as: identification of a scientific question, scientific explanation of phenomena and use of scientific evidence. In that study, students were also able to recognize investigable questions, differentiate problems and scientific explanations and develop mathematical thinking, among other essential skills and EP [15]. Through the exploration of a literary work, the students worked not only on scientific competences, but also reading competences and made the necessary inferences to raise a problem/question to be solved with a scientific experiment. These results are in line with those presented by [10, 11] who show that activities that articulate science and literary education and engage students in scientific tasks and problem-solving activities increase their interest, admiration, enthusiasm and curiosity towards science. In fact, besides fostering students' learning of scientific contents and engagement in scientific practices, these dynamics promote the students' engagement in the construction of a meaningful learning, where text comprehension skills and scientific concepts are explored. Our EG can be a breakthrough to address the difficulty felt by teachers [21, 22] in implementing this type of activities because it presents a tool that supports them in this regard, fostering changes in their TM and consequently impacting the development of students' EP in the classroom. However, it is important to understand if the impacts observed with this teacher can be extended to other teachers. It would be also interesting to study the teacher's perceptions of the impact of the EG on her practices and those of her students and the reasons for that, as this information could inform the improvement of this EG. Concerning the second contribution, the results suggest that there are changes in the TM profile, which are associated with an increase in the diversity, frequency and complexity of students' EP (Fig. 2). Note that, in the development of the EG (Appendix A5, https://bit.ly/3lFNq9h), we took into consideration that its orientations should include guidelines for TM that are known to foster EP (according to [9]). In fact, the EG has specific guidelines about how to problematize, how to foster the raising of scientific hypotheses and how to carry out an experiment, among others. These orientations may have contributed to the observed changes in the types of TM in the classroom influencing the development of EP in the classroom. In particular, it should be noted that certain TM traits are associated to the emergence of new EP and the increased frequency of others, which confirms the results obtained by other authors [31–36-37–38, 39]. What is new, is that certain TM traces, at elementary levels of education, are also associated with the emerge of students' EP, and EG played a relevant role on TM change. The recognition of the importance of building resources, such as EG, that help teachers to build a learning experience to promote EP is aligned with some previous studies [2, 6]. According to our results (Fig. 4) the clusters that present TM associated with epistemic work at a more complex level increase in frequency from the first to the third lesson, allowing students to work according to three complexity levels (empirical, information processing and representations [7] after the use of the EG by the teacher.

We should notice that certain EP did not occur in our study, and it would be interesting to study what kind of TM could be associated with these EP.

5 Conclusion

Our study was developed to overcome a problem: interdisciplinary approaches between science and literary education are still scarce, and teachers do not feel confident to implement those. For that we applied a DSR approach, to develop and improve an Exploration Guide (EG) to support teachers in the planning and implementation of interdisciplinary practices that articulates scientific and literary education. The main results from this work are:

1) an EG to articulate science and literature was indeed useful for teacher, impacting Teacher's Mediation.
2) evidence that shows that when the teacher uses the EG, the changes in teachers' mediation impacted students' Epistemic Practices.
3) evidence supporting that certain Teacher's Mediation traits are associated with the emergence of new, more diverse and complex Epistemic Practices in the classroom and the frequency increase of others.

We should however note that this work has a major limitation: it was performed with a single teacher. Data collected from a higher number of teachers in diverse contexts is needed to better study the impact of the EG in the teachers' mediation and how this is influenced by teachers' previous experience on interdisciplinary education and their conceptions of education on science, literature and the articulation between those two fields.

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Teacher Training in the Fields of STEAM: From Physical to Digital Tools

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Abstract. The twenty-first century presents fundamental challenges for education systems focused on skills development. With this requirement, the training of teachers is changing little by little. Where the learning of the knowledge to be taught seeks to articulate itself in different modalities. Teachers can use various resources, from manipulative materials to technological resources, which can make the class more attractive and contribute to the student's interest in the content being worked on, thus building knowledge. The Poly-Universe in Teacher Training Education (PUNTE) project aims to develop innovative and transdisciplinary pedagogical methods that are mainly related to a revolutionary educational tool called Poly-Universe. This work aims to describe and analyse the material of the PUNTE project, which allows the development of a new methodology for visual mathematics education in the physical and digital aspects to improve the quality of students' learning. Based on classroom observations and workshops for prospective teachers, the results have shown that this tool can be used in a science, technology, engineering, art, and mathematics (STEAM) context.

Keywords: Transdisciplinary · Manipulative material · Technology resource

1 Teacher Training

Today's society bases its way of being on great scientific, technological, and cultural development. In this context of rapid and profound transformations that characterize world education, a fundamental role is thus attributed to education, which is seen as an indispensable asset to humanity. New challenges are posed to teachers, which can only be overcome through the training of these education professionals, the central objective of which is the acquisition of knowledge and skills that enable them to fully exercise the functions they will have to perform during their professional activity.

The use of manipulative materials or technological resources associated with methodologies aimed at building concepts is associated with support for the teaching process and learning in the classroom [1].

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Prestridge [2] and Freire [3] mention that teaching and learning occur mutually in a classroom. There is a need to think about innovative teaching methods, which, according to Souza, Iglesias and Filho [4, p. 285], emerge as a "break with the dominant paradigm, the advance in different areas, alternative forms of work that break with the traditional structure". According to Hoffmann [5] and Nussbaum and Diaz [6], manipulative resources, digital and non-digital, can enable the exploration of observable properties by students because of more diversified forms (virtual objects, non-virtual objects, drawings, textual productions, etc.), greater are the chances that these concepts will be learned and not simply memorized to be repeated.

The process of teaching and learning through manipulative materials brings benefits to students, strengthening cognitive development and peer interaction. The development of pedagogical materials – physical and digital – for STEAM education aims at more effective, playful, and creative learning today.

STEAM focuses on developing some essential skills for twenty-first century students. The integrated approach to education in STEAM aims, essentially, to promote an innovative and efficient approach to learning, enabling the development of numerous essential skills for the training of all students. The teacher has an important role here, being a mediator of this new pedagogical proposal. It is the teacher's responsibility to point out new ways to solve the same problem. Active teaching and learning methodologies, through hands-on approaches and maker culture, focusing on mathematical connections, establish relationships between the complexity of the transformations and challenges of contemporary society and the rapid evolution of technology. The practical activities, which value students' participation in their learning process, focus on the dynamic construction and exploration of tangible or digital objects.

There are countless possibilities for active methodologies that can help the teacher in teaching practice and qualify learning, among which we can quote: Poly-Universe materials, GeoGebra, and Stop Motion App. The same material can be used in different ways and at different levels depending on the activity planned for the students.

2 Methodology

The research presented in this article is of a qualitative nature [7] and intends to contribute to the reflection on technological resources and manipulative materials, supporting the development of future experiences by higher education teachers. The investigation was carried out during the 2nd semester of the academic year 2021/2022 with prospective students of teacher training for preprimary and primary education at Comenius University in Bratislava. It was used in the work with students' discovery-oriented teaching (DOT). This kind of teaching in the natural and technical sciences and mathematics is now receiving worldwide attention. This type of education is associated with expectations geared towards increasing the interests of students and improving their learning. The students discover new notions with their own discovery activity. Empirical studies about DOT tend to focus on students (see [8–10]).

3 Study Description

Following that, we presented examples of how to use the material of the PUNTE project in physical and digital formats [11].

The first part of this study involved 45 participants, 100% female students from Comenius University Bratislava Faculty of Education Department of Preprimary and Primary Education. In the second part, technologies were used based on the Poly-Universe project pieces, allowing for a work strategy with students.

3.1 Poly-Universe: Mathematics Education

A task was proposed to the students to construct rings of 7 basic element circles (see Fig. 1), the highest number of rings applying either type of symmetry only from one set. In this task, we move on and connect the rings with one another. If we ignored colours and only observed sizes when connecting the elements, we could make rings with two types of symmetry. Let's say that rings with point symmetry have symmetry type "one", and rings with rotational symmetries of 120° and 240° (rings with 3 lines of symmetry) have symmetry type "two". Construct a connected shape from the circle set with same size connections, connecting the rings. This task is included in the topic of geometry about symmetries.

Fig. 1. Students' construction – 7 rings

Another task was proposed, to use squares (see Fig. 2) – the rule was to connect the shape with the same colour connections at the vertices.

Fig. 2. Students' construction

3.2 Technologies: GeoGebra Apps Inspired by Poly-Universe

GeoGebra's dynamic nature lets you experiment to change proportions, shapes, and dimensions. The basic Poly-Universe shapes of triangle, almost square (hereafter just square), and almost circle (hereafter just circle) are easy to represent in GeoGebra. An e-book is featured on GeoGebra, where material from Poly-Universe is used as a digital resource. We can find it at https://www.geogebra.org/m/ms8nzfym

The table of contents contains the basic elements (see Figs. 3 and 4), changing side numbers in 2D, changing ratios, Poly-Universe in 3D (see Fig. 5), and Poly-Universe and Fractals by the PUNTE project.

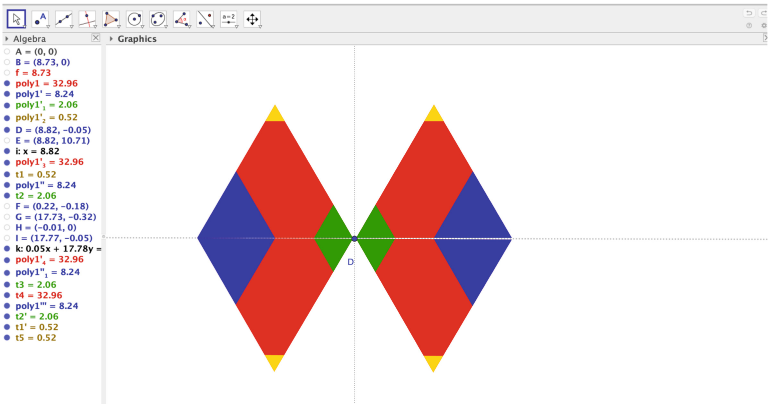

Fig. 3. Poly triangle: frieze symmetry (pmm2)

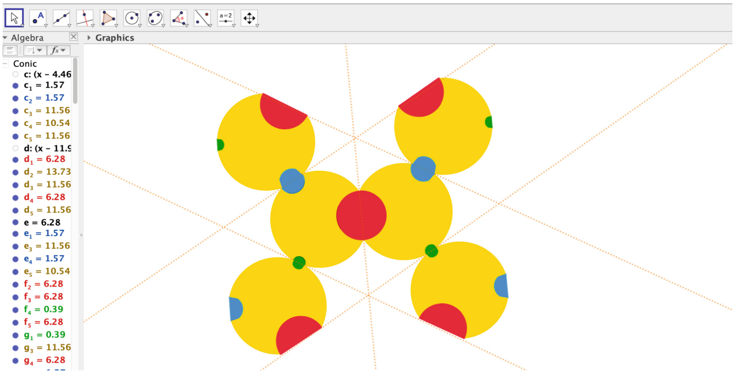

Fig. 4. Poly circle: frieze symmetry (pm11)

The 3D extension of the square element is naturally the cube. The enlargement from point in GeoGebra also applies to spatial shapes, so editing is easy and can be done in a few steps. The proportion of the golden ratio appeared for the first time when a three-dimensional extension of the square of the Poly-Universe was thought [12].

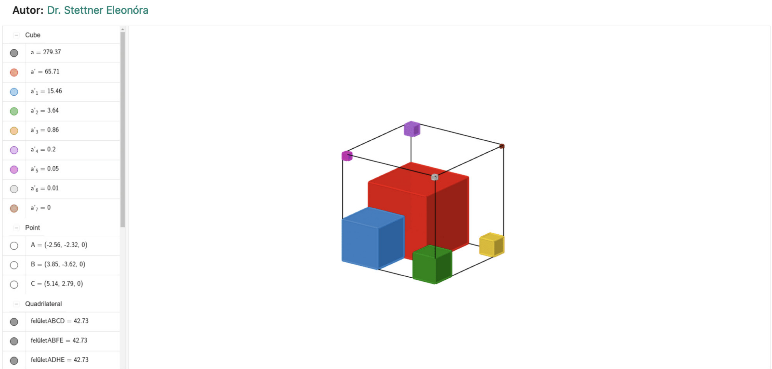

Fig. 5. 3D cube ratio: golden section

3.3 Technologies: Stop Motion App Inspired by Poly-Universe

Another aspect is the production of a short Stop Motion movie. The use of the Stop Motion technique can be an ally in the teaching and learning process, considering that the student will be involved in a participatory way in the construction of knowledge, providing a pleasant and playful environment. With this technique, the students must have developed an idea and main theme, the script and storyboard of their film, and build or choose their own characters (in this case, the Poly-Universe triangle/square/circle) that each group needs to make their short film [13] (see Figs. 6, 7, 8 and 9).

Fig. 6. First step

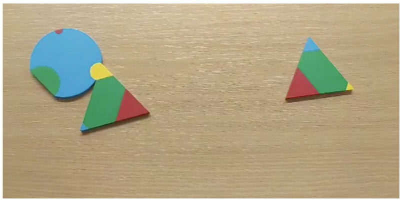

Fig. 7. Next pictures

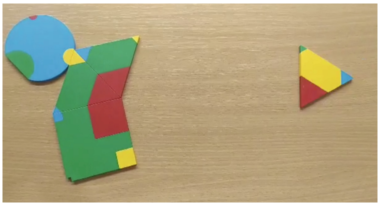

Fig. 8. Intermediate steps

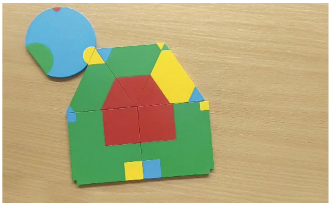

Fig. 9. Final steps

The Stop Motion App allows students to see and demonstrate mathematical concepts in a variety of contexts using different representations. For example, the Poly-Universe material allows for the development of good conceptual understanding.

4 Conclusions

Faced with digital or physical resources relevant to the teaching and learning of mathematics which are available to teachers and students, there is the double problem of how to choose the most suitable for the teacher and/or the students' purposes and how to take advantage of their use to learn mathematics. There are different theoretical approaches to integrating manipulative materials with technology in mathematics education to promote mathematical learning.

Physical resources bring advantages in terms of abstraction and group involvement, while digital resources have greater availability and accessibility of the material but bring some loss of motricity. The ideal is to use several resources, either physical or digital. The Poly-Universe tool demonstrates the potential for developing mathematical and computational thinking by implementing strategic and heuristic approaches in problem-solving [12] and it has a unique potential in multidisciplinary/STEAM learning [12].

There are effective ways to integrate digital and physical resources into mathematics learning. It is possible to create educational contexts using various artifacts as epistemic tools, and if an instrumental orchestration with certain characteristics is made, it is effective to promote mathematics learning.

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Virtual Laboratory in Electromagnetism: A Study of Instrumental Orchestration

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Abstract. The integration between virtual learning environments of recognized individual success, such as the PhET project and the Moodle Platform, presents itself as a path to be explored in the context of Instrumental Orchestration (IO), due to the broad benefits that this type of junction can bring to STEM teaching and learning. In this perspective, we conducted a purely interpretive study to investigate the role of IO, in different resources, on the academic success of students in a Bioengineering course, by comparing two activities, corresponding to the extremes of their scores, in electromagnetism laboratory practices, converted to Hybrid Teaching, by means of the COVID19 pandemic. For this, an evaluative framework was built based on the bibliographic reference, which underwent refinements adapting it to the available data, to finally analyze the IO dimensions referring to PhET, Moodle, proposed activities and interactions among participants. The main contribution of the research refers to the need for a better orchestration between simulated activities and laboratory practices, naturally accompanied by more productive interactions. This kind of research also contributes to the elaboration of new pedagogical practices, anchored in facts concerning the different approaches of IO and the way students learn.

Keywords: Instrumental orchestration · Moodle · PhET · Hybrid teaching

1 Introduction

Founded by Carl Wieman, a 2001 Nobel laureate in physics, the University of Colorado's *Physics Education Technology* (*PhET*) project is becoming firmly established in academia after its first decade of operation [1]. Currently, completing 20 years in full operation, its importance is reaffirmed, especially in these last two years, marked by the pandemic of COVID19, which made the Remote Learning modality more evident. Since its creation in 2002, much research has been done on the effectiveness of *PhET Interactive Simulations* in the teaching and learning of Physics [1–8]. However, based on interviews directed to the project members, regarding research already developed in this area, there is a need to improve the way teachers use these applications, to take better advantage of their educational potential [1, 2, 9].

Coincidentally, in the same year that PhET was born, version 1.0 of one of the most popular and successful platforms in education, Moodle, a *Content Management*

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System (CMS) designed to support teaching and learning, founded by Australian Martin Dougiamas, was launched [10]. Given these events, one would naturally expect that at some point in STEM history these two great trajectories would intersect.

It is also worth noting the similarities between laboratory experiments and computer simulations, pointing to the relevance of developing studies involving both methodologies within the field of teaching and learning science [11]. In this context, PhET simulations are generally well suited for use as a virtual laboratory, since they allow the variation of parameters commonly used in laboratory experiments. This has certainly stimulated users of the platform, spread around the world, to produce a significant number of activities associated with such applications, which can be found in the portal repository [12].

For the present work we are particularly interested in the concept of Instrumental Orchestration, relative to the STEM teaching and learning context, as it occurs in [13]. *Instrumental Orchestration (IO)* is one of the theoretical approaches to the use of *Information and Communication Technologies* (*ICTs*) in education, with a focus on improving teaching practices [14].

The objective of this research is to investigate the role of the instrumental orchestration of different resources in the academic success of the students, performing a interpretive study of two practices, corresponding to the highest and lowest averages scores achieved by students in their reports, within the curriculum unit: “Electromagnetism and Optics”, adapted to the pandemic reality through Hybrid Teaching (face-to-face and remote), integrating the conventional laboratory with PhET through the Moodle Platform.

2 Literature Review

2.1 Instrumental Orchestration (IO)

In a bibliometric review study on how the concept of IO applied to the teaching of mathematics has developed over the years, the three most cited articles in this context were revealed, establishing a tripe that allows us to support an overview of the subject [15]. The authors refer to the research of [16], which became a starting point when I suggested the concepts of *Instrumental Orchestration* and *Instrumental Genesis*, in the sequence came [17], stating that such a definition is a framework for “Managing the Complexity of human/machine interactions in computerized learning environments”, by detailing the concept in a more introductory character, which in turn was refined by [18], by compiling six possible types of orchestrations, through a range of observations.

This repertoire was later enlarged to 13 varieties of possible IO, eight of them for collective use and five for individual support [15, 19]. The six types of initial orchestrations can be classified according to whether they focus on the teacher or on the students [18, 20, 21]. The Fig. 1 represents this division.

A complete description of the six fundamental IO types can be found at [19], by means of a characterization in the light of instrumental genesis, in terms of didactic configuration and modes of exploitation, for each of the cases mentioned.

In a recent publication on the subject, the use of digital resources was studied under the dimensions of instrumental orchestration analysis in time (IO_T), in the teacher’s

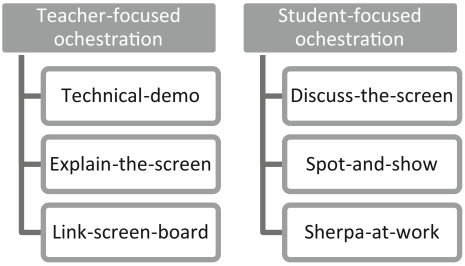

Fig. 1. IO types according to focus, structured from [21].

mediation (IO_{Med}) and in the type of networking (IO_W) with which the practices were being developed. Regarding the IO_T dimension, the time of use and the moment in which the digital resource was integrated were analyzed, verifying if the digital resource (DR) was related to introductory, deepening, or extension concepts. As for the IO_{Med}, we verified the presence of a challenging task for students to solve autonomously, if the teacher mediated the connection between the use of DR and learning during the resolution of this possible task, and, finally, if students were given autonomy to use the DR. We also analyzed whether there was IO_W and, if so, whether the practices were performed in a sequential manner, or in a web [13].

In this context, the formulation of activities through the Moodle Platform, to make Instrumental Orchestration (IO) with PhET simulations, reveals itself as a path to be explored in the search to maximize learning, through the intermediation of these DRs. For this, we propose to perform an interpretative study on how the virtual laboratory of electromagnetism was developed, inspired by current research on IO [13], for the dimensions associated with PhET (IO_{PhET}), Moodle itself (IO_{Moodle}), script-type activities usually used in the conventional lab (IO_{Activ}), interactions between students, and with the teacher (IO_{Int}), as depicted in Fig. 2.

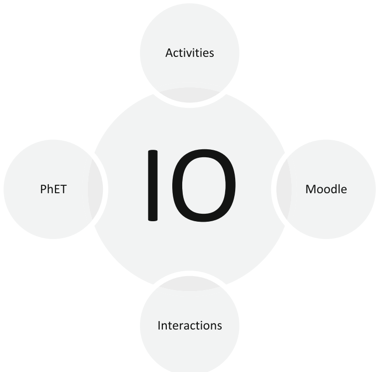

Fig. 2. IO analysis dimensions.

2.2 The Moodle Platform

Moodle is the predominant *Learning Management System (LMS)* in universities around the world, and has been found to effectively improve student performance, satisfaction, and engagement when taking STEM courses [22, 23]. It is a DR that allows the management of a virtual learning environment, to support the interaction between participants, through features such as blogs, discussion forums, spaces for file exchange, among others [19].

This is a powerful system, capable of offering its users, in the context of course creation, 15 *activity* options [10], general term for one of the feature sets that enables interaction between teachers and students [10, 22], plus seven other *resources*, such as *book*, *file*, *folder*, *IMS content package*, *label*, *page*, and *URL* [10], that can be analyzed from an IO perspective, as to the variety of their use in a course.

Regarding *activities*, studies involving *quiz*, *forum*, *workshop*, *lesson*, *wiki*, and *survey* were identified, of which, *quiz* and *workshop* are among the most analyzed, being added to these, the possibility of incorporating external tools, such as videos, virtual tours, e-portfolios [22].

Through the *forum* it is possible to promote asynchronous debates, which can last for several consecutive days, giving those involved more time to reflect on the feedback and structure their arguments, as well as the viability of consulting external sources to strengthen the discussions [24, 25].

System logs are also among the most used LMS functionalities, since through them, and with the help of the appropriate tools, it is possible to perform sophisticated analyses regarding access statistics [23].

In the universe of all these possibilities offered by the platform, it is pertinent to check the impact of IO_{Moodle} with PhET and other resources, such as experiments and lab scripts.

2.3 PhET Interactive Simulations

With its origins in physics, PhET has advanced to other sciences, levels of education and languages, consolidating its success through various propagation strategies, which have made it a globally used resource [1].

Research that proves the effectiveness of PhET simulations in learning spans several areas of physics [3, 4, 8, 26, 27], such as Geometric Optics [5, 6], reaching even those contents considered more abstract, such as Quantum Mechanics [2]. There are reports of the effectiveness of PhET applications in different teaching modalities, showing that learning occurs both for students who do group activities, in school spaces, and for those who study at home, individually [7]. There are also a number of studies recommending PhET as a virtual laboratory, as an alternative to traditional experiments [28–34].

However, it is necessary to reinforce that, regardless of the proposals for professional development already available today, the use of this type of resource in teaching, as well as the impact of PhET simulations in the classroom should, in addition to becoming a new line of research, remain active [3].

Among the applications available on the PhET portal, suitable for use as virtual laboratories, it is notable the presence of two basic types of simulations: (1) those that allow students to build their own virtual experiments, and (2) those that allow only the variation of parameters in previously established experiments. Given the options formulated, there is an expectation that better academic performance is generally revealed for (1), by virtue of results once obtained for the specific content of electrical circuits [35]. Figure 3 shows an example of an application in which the student is allowed to build his own electric circuit.

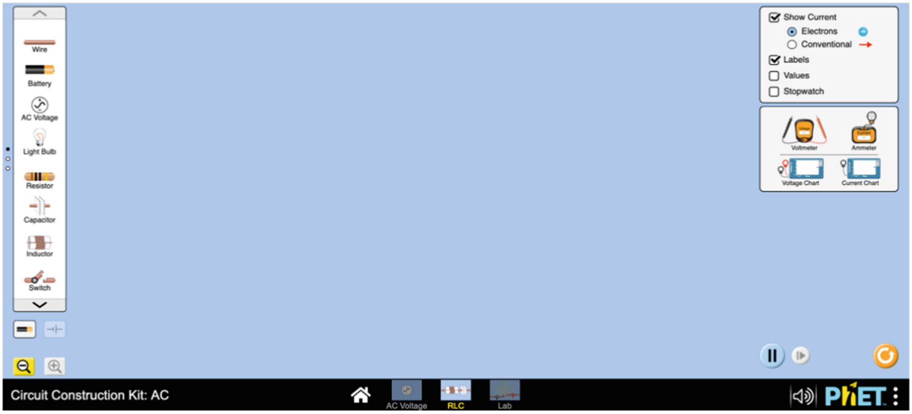

Fig. 3. Screenshot of the PhET simulation – circuit construction kit: AC [12].

In this context, it becomes relevant to investigate the impacts on learning, when doing IO_{PhET} involving these two mentioned formats of simulations, with diversified resources, whether physical or digital.

2.4 Research Question

Given the extremes in the scores achieved by the students, which were repeated in the same practices related to the curricular unit: "Electromagnetism and Optics", although taught by different teachers, for two classes of the Bioengineering course, of the University of Trás-os-Montes e Alto Douro – UTAD, we sought to answer the following research question.

- What is the role of instrumental orchestration on used by teachers in virtual laboratory for academic result?

3 Methodological Aspects

3.1 Data Characterization

The present work is a purely interpretive study, developed based on empirical data, provided for the purpose of this research after the consolidation of the course unit: "Electromagnetism and Optics", taught by professors at the University of Trás-os-Montes e Alto

Douro – UTAD. The professors were responsible for two classes of the Bioengineering course, which worked in a Hybrid Teaching system, with its members arranged in pairs or trios, alternating between six face-to-face/remote practices, in which one should participate in a minimum of four activities, which were developed in the institution's laboratory and in the PhET virtual laboratory. From this set of activities, only two were selected for the research, according to the criteria of the predominant content in the discipline, in this case, electromagnetism, and the greatest discrepancy between the grades achieved by the students, to investigate the most influential IO elements to obtain such a result.

Besides the applications themselves, were available for the study, the laboratory scripts and the guidelines inserted in Moodle, in order to make the instrumental orchestration with the respective PhET simulations, the results of the interviews with the teachers responsible for the curricular unit, aiming to understand the learning objectives, as well as the context in which the activities were developed and, finally, the reports produced by the students, in order to evaluate the learning achieved. Table 1 characterizes the respective data.

Table 1. Data characterization.

Description	Prof. A's class	Prof. B's class
Course	Bioengineering	Bioengineering
School year	2020–2021	2020–2021
Semester	2°	2°
Total students grouped	22	20
No. of groups/No. of students per group	Six trios and two doubles	Six trios and a duo
Activities developed	1.1.Electric field mapping 2.2.Electric circuits assembly 3.3.Electrical resistance measurement – voltmeter/ampermeter method 4.4.Charging and discharging a capacitor 5.5.Coil as electromagnet 6.6.Measuring a human hair by diffraction	
Activity about electromagnetism in which the highest scores were concentrated	2. Electric circuits assembly	2. Electric circuits assembly
Activity about electromagnetism in which the lowest scores were concentrated	5. Coil as electromagnet	5. Coil as electromagnet

(*continued*)

Table 1. (*continued*)

Description	Prof. A's class	Prof. B's class
No. of students who participated in the activity with the highest scores	14	14
No. of students who participated in the activity with the lowest scores	16	20

As can be seen in Table 1, although the classes were conducted by different teachers, the activities in which the students achieved both the highest scores and the lowest scores are coincident, bringing the focus of attention to how the resources were used. It is also noted that the students possibly felt more motivated to perform the activity for which, later, the lowest success rates would be verified, since a larger number of students were willing to perform it, in both classes. After the observation, we proceeded with the application of the analysis instrument, built based on the IO theoretical approach, to identify its influence in this process, revealing the preponderant factors that intervened to obtain the different classifications between the two selected activities.

3.2 Analysis Instrument

For the analysis, an evaluative instrument of the grid type was structured, based on review of previously constituted literature and on adjustments motivated by the available data, in the IO field, under the categories of analysis related to the DRs: PhET and Moodle, as well as those related to the activities, which correspond to the laboratory scripts and instructions included directly in Moodle, besides the interactions between the participants teachers and students.

For the IO_{Moodle} dimension, the benefits of a greater diversity of Moodle *activities* and *resources* were considered, included to facilitate the development of the practices, increasing the time of use of the platform and, possibly, contributing to a more consistent learning.

About IO_{Activ}, it was considered the importance of the student being the agent of his own learning, participating from the planning of the activities, by knowing the intended objectives, the problem to be solved and the reasons for it. There was also an analysis of the need to formulate and test hypotheses, as well as actions related to the verification of the consolidation of knowledge [36], making a parallel about the purpose of simulation in these last aspects.

As for IO_{PhET}, the type of simulation involved was verified, i.e., if the application allowed students to build their own virtual experiments, or only the variation of parameters for previously established experiments. In addition, the level of use of the digital resource was studied, in relation to the offer of functionalities, analyzing if these were adequate to the purpose of the activity, if the students made satisfactory use of what was available and if the practice was conditioned to the laboratory experiment.

Regarding the IO_{Int}, we interviewed the teachers responsible for the classes, seeking to know how the interactions between teacher and students were established, regarding the existence of moments for introductory clarifications, discussions and validation of the knowledge built [36]. Table 2 shows how it all came about.

Table 2. Instrument of analysis.

Dimension	Category	Options or questions
Instrumental orchestration in Moodle (IO_{Moodle})	A) Activities used	1. Forum; 2. Lesson; 3. Assignment
	B) Resources used	1. Page; 2. Label; 3. URL
	C) Embedded tools	1. Iframe of Sims; 2. Zoom link
	D) Access statistics	1. Is the average number of hits accessed by the groups equal to or higher than the highest scoring group? 2. Is the average number of *activities* or *resources* marked as completed by the system equal to or greater than the highest scoring group?
Instrumental orchestration in activities (IO_{Activ})	A) Learning objectives	1. Was the overall learning objective revealed to the learners at the beginning of the activity? 2. Were the specific objectives of the activity presented to the students?
	B) Problematization	1. Was any justification/motivation provided regarding the relevance of the proposed activity? 2. Was a problem proposed for the students to solve autonomously?
	C) Hypothesis formulation and testing	1. Were students asked to formulate hypotheses? 2. Was simulation indispensable to test these hypotheses?
	D) Consolidation of knowledge	1. Were verification questions proposed at the end of the activity? 2. Did these questions induce the reuse of the simulation?

(*continued*)

Table 2. (*continued*)

Dimension	Category	Options or questions
Instrumental orchestration in PhET interactive simulations (IO_{PhET})	A) Simulation type	Did the simulation enable the student to build his own virtual experiment?
	B) Use of the tools	1. Did the simulated activity correspond to the same experiment performed in the laboratory? 2. Were the functions provided in the simulation sufficient for the development of the activity? 3. Were the functions provided in the application well used by the students for the development of the activity?
Instrumental orchestration in interactions (IO_{Int})	A) Introductory moment	Was there a time for initial clarifications by the teacher before each activity?
	B) Discussion spaces	1. Was there any specific space for discussion between the groups and the teacher, such as a *forum*? 2. Did most of the students make use of this resource? 3. Was there any space for simultaneous discussion between the class and the teacher, such as lives or chats? 4. Did most of the students make use of this last resource?
	C) Moment of validation of the knowledge built	Was there any moment of knowledge validation between the peers and the teacher?

Inspired by [13].

Finally, a second layer of analysis followed, related to the observable articulations, which in turn were focused on PhET, due to the relevance of this component amidst the results obtained in the first instance evaluated. Such relations were established transversally, from the laboratory experiment (PhET-Lab) to the laboratory script (PhET-$Script_{Lab}$), and from the Moodle Platform (PhET-Moodle) to the simulated activity script (PhET-$Script_{Moodle}$). Figure 4 schematizes the Instrumental Orchestration type.

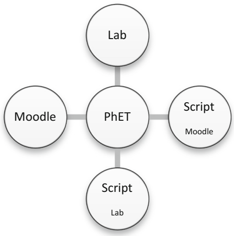

Fig. 4. IO scheme

4 Results

Regarding the IO_{Moodle} dimension, both practices were very similar, differing only in the *URL* aspect, where it was possible to access the embedded simulation, also through a direct link to the portal, with the clear purpose of maintaining simultaneous navigation in Moodle and in PhET, for the specific case of the activity about the electromagnet, not being observed in the practice referring to the assembly of electrical circuits. Both activities were structured through *lesson* and *assignment*, and there was also a general *forum*, for communications, and the *resources*: *page*, destined to the support elements to the practices related to electromagnetism, being them: "Assembly", "Connections" and "Scale", associated to the electric measurement instruments, as can be seen in Fig. 5. In addition, as already mentioned, there was complementation through tools outside Moodle, using frames, to embed the simulations in the platform environment and the link to access the lives, via Zoom.

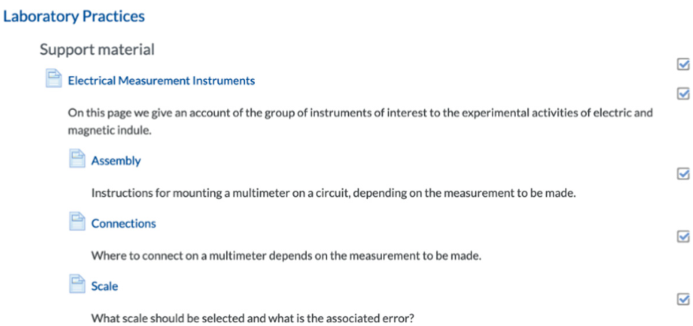

Fig. 5. UTAD Moodle screenshot [37].

The categories of analysis present in the IO_{Moodle} dimension showed that the navigation time on the platform was relatively short, indicating the relevance of an orchestration to lead students through a sequence of use of the *activities* and *resources* of Moodle, ensuring a more lasting use, to reinforce learning through this environment.

In terms of learning objectives, within the IO_{Ativ} dimension, the general objectives were clearly presented for each of the practices, being identified specific objectives only for the activity of the coil as electromagnet. The categories referring to problematization, formulation and hypothesis testing, followed by knowledge consolidation actions, were not verified for any of the analyzed activities.

Within the field delimited for IO_{PhET}, the simulations used in both activities are characterized in the category that offered the necessary instruments for students to build any desired electrical circuits. However, according to the purpose established for the activities, it was not necessary to explore this potential, since the circuits to be assembled were already predefined in the scripts, following the traditional model for conducting laboratory experiments. Regarding the use of the tools, it was verified that the functions provided in both applications were satisfactory and well used by the students during the development of the activities. However, the simulated experiment concerning the practice of the electromagnet coil was not the same as the one performed in the laboratory, as it occurred for the assembly of electrical circuits, although it was strictly within the same theme.

IO_{PhET} brought the aspect of greatest relevance to research, making evident the difficulty that the students had in recognizing variations of the experiments, in different laboratory contexts, as can be observed for the practices referring to the coil as electromagnet.

The interviews with the teachers responsible for the classes ended up revealing the last aspects listed for the conclusion of this study, that is, those related to IO_{Int}. During these interviews, the teachers claimed that there was not enough time for introductory moments dedicated to each of the practical activities, and that there was only room for a single generic action at the beginning of the course. No specific *forum* for discussion was found, this function being used to send notices, and no student participation was registered. In this *forum*, an access link was made available with the respective times for attending lives, reserved for monitoring the work, to be carried out through the Zoom Platform. Finally, it was informed that there was no moment for peers and the teacher to validate the knowledge built.

The factors of Instrumental Orchestration that effectively explain the different academic results are related to the articulations between its dimensions. PhET-$Script_{Moodle}$, promoted by the script of the simulated activity that, because of the succinct writing, performed directly on Moodle, indicated the need to produce a more detailed material, like the laboratory script itself. As for PhET-Moodle, it was observed that the inclusion of the PhET simulation in the Moodle environment itself, although usual, compromises navigation, making the insertion of a link more effective, to maintain simultaneous access to both sites. The PhET-Lab relation showed that, although within the same subject, significant differences between the laboratory experiment and the simulation, constitute another obstacle for the students' comprehension, besides hindering the PhET-$Script_{Lab}$ orchestration.

5 Discussions

It has been identified in the literature that when using DRs, teachers run the risk of focusing too much attention on the tool, leaving the actual learning of science in the background, when the opposite does not occur, working with reduced supply of guidance relevant to the use of the instrument, through a greater preoccupation with the syllabus [20]. For the case studied, it was found that the instructions posted on Moodle, concerning the development of the simulated activities, were more concise and general, when compared to the laboratory scripts. However, the evidence extracted from the analyzed data showed that the students made good use of the functions available in the applications, revealing evidence of the instrumental genesis initially predicted by [16].

The difficulty that the students encountered, in the midst of the variation of the coil practice as electromagnet, probably points to the need for a better integration between the simulated activity and the laboratory practice, accompanied by productive interactions, as already predicted in the literature, Although computer simulations have proven to be effective in science education, when traditional education is taken into account, they are insufficient to present scientific concepts when used in isolation, and there is a need for complementation with other methodologies in order to build “Science Process Skills” [4].

It is also necessary to reveal to the students, besides the general objectives of the activities, their respective specific objectives, problematize, presenting justifications or motivations to carry out the activity, propose a problem to be solved autonomously [13], by formulating and testing hypotheses [36], simulation should be indispensable in this process, and promote actions to consolidate the knowledge built [36], for example, questioning to verify the concepts learned, which induces a retaking of the simulators.

It is worth reaffirming the importance of spaces dedicated to interaction between peers and the teacher, such a *forum*, as advocated by [24, 25], in addition to moments destined to the validation of the knowledge built [36].

As already discussed, PhET is a digital resource of great versatility [7], providing teachers with a vast repertoire of instrumental orchestration, with a diversity of resources, such as.

6 Conclusions

In the work of adaptation to the reality of Remote Teaching, to which the practices related to the curricular unit “Electromagnetism and Optics” were submitted, developed by the teachers who took the lead in obtaining the data provided, it is evident the presence of traces of instrumental genesis, listed by the fundamental types of IO, naturally adapted to current contexts, such as a didactic configuration that includes access to technology, characterized by the orchestration between Moodle and PhET, with exploration modes that favored the interactions teacher-students and students-students.

After the analysis of the data in its completeness, it is pointed out the great similarity between the applications used, so that both were classified as belonging to the category that offers a high degree of freedom regarding the possibility of building the desired experiment.

In response to the research question, it was possible to identify a predominant factor to explain the extremes obtained in the scores associated with the two practices analyzed. This responsibility was attributed to the adaptive modulation that was performed for the practice of the coil as electromagnet, an unnecessary action for the assembly of electrical circuits, since in this specific case, the simulation was perfectly suited to the format that was customarily used in the conventional laboratory.

It was proposed to investigate the role of the instrumental orchestration of different resources in academic success, in electromagnetism laboratory practices, converted into Hybrid Teaching, due to the COVID19 pandemic. In this teaching context, the research contribution to STEM education points to the relevance of prioritizing the quality of integration between in the physics and virtual laboratories.

Although much progress has been made in research on IO involving teaching methodologies and learning strategies for mathematics, making this a promising and increasingly understood area of science, much still needs to be done in relation to the teaching and learning of physics in this area. Investigations of this kind can contribute to the formulation of pedagogical practices, based on concrete evidence about the relationship between different approaches to IO and the way students learn, thus allowing progress like what has been occurring in relation to mathematical topics.

Evidently, there are limitations inherent to the use of small samples from cases. Because of this, it is recommended that more and more extensive research be done, carrying out investigations involving simulations of different types, as well as for different contents, in addition to the analysis of a possible effect, previously detected in this research, revealing an improvement in the results of simulated activities, over time, compared to laboratory practices.

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Instrumental Orchestration in the Primary School and the Use of Digital Resources to Link STEM and Art: Systematic Literature Review

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Abstract. Curricular articulation allows students to develop skills and competencies in a meaningful way. The primary school is the grade level that most easily promotes this type of approach, given its ease of articulating contents. It is fundamental that digital resources are used in a way that turns them into epistemic tools, that is, tools for learning. The way these tools are orchestrated in the classroom can influence student learning. Thus, it is up to the teacher to use an Instrumental Orchestration that fits the educational specificities of the session. This paper presents a systematic review of the literature on Instrumental Orchestration and curriculum articulation. It intends to present a vision of teaching that uses Instrumental Orchestration for the articulation of science and mathematics education with literature. Fourteen articles were analyzed and the studies contained in them were characterized. We conclude that, although there are studies in these areas, there is still a need for investment in the research of Instrumental Orchestration related to curricular articulation.

Keywords: Instrumental orchestration · Curriculum articulation · Digital resources

1 Introduction

Since the 1980s, the integration of digital tools has been used in mathematics education [1]. Since then, teachers are confronted with how to integrate technology into their lessons [2]. It was necessary to adapt the way of being and doing, inside the classroom. As a result, in 2002, the concept of Instrumental Orchestration (IO) emerged and has been developed and used in research practices [2–4]. This concept is defined as the process of turning the digital resource into a beneficial tool [5]. It is a theoretical perspective

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with an eye on teaching practice that inserts ICT (Information and Communication Technologies) in educational contexts [6].

The indication of IO characteristics has been mentioned over the years [3, 5–9]. First by Guin and Trouche [10], where IO is defined by four elements: a set of individuals, a set of goals (task-related or work-environment related), didactic configuration (teaching environment and artifacts involved), and mode of exploitation of this configuration. Drijvers et al., [11], later added to these elements the didactic performance (decisions taken by the teacher in the didactic configuration and in the set of exploitation to put his intentions into practice and which is linked to the temporal dimension of IO).

Aiming at improving student learning, teachers can use digital resources and orchestrate them, consequently improving epistemic learning [3, 12, 13]. Epistemic learning is understood as an "epistemic change in thinking manifested in terms of a shift from frontal teaching to inquiry-based approaches" [14, p. 23]. In this follow-up, artifacts take on the role of epistemic tools [3].

The IO can be defined as "(…) the teacher's intentional and systematic organization and use of the various artefacts available in a (…) learning environment in a given mathematical task situation, in order to guide students' instrumental genesis" [15, p. 988]. Thus, it is up to the teacher to figure out which IO best suits his or her objectives. Currently, 14 types of IOs are known: *Technical-demo* (before the students perform the task, the teacher explains the technical details for using the tool - technical demonstration); *Explain-the-screen* (explanation that the teacher gives, to the class, after the projection of works. This explanation goes beyond mathematical content); *Link-screen-board* (the teacher creates connections between the projected representations and the connections present in the manual or on the board); *Discuss-the-screen* (collective discussion of what is projected); *Spot-and-show* (review of previous work, done by the students, that the teacher identified as fundamental to the discussion exposing the student's reasoning); *Sherpa-at-work* (the student uses the technology to present his work or to perform actions requested by the teacher) [11]; *Not-use-tech* (the teacher chooses not to use the technology he has available) [6]; *Work-and-walk-by* (the teacher circulates among the students and monitors their work giving guidance when necessary); *Discuss-the-tech-without-it* (discussing the technology without it being present at that moment); *Monitor-and-guide* (the teacher interacts with students at a distance through voice messages) [16]; *Collaborative* (use of the platform to exchange materials and ideas between students and teachers); *Based-on-content* (the teacher focuses on the content available on the platform, e.g. description of proposed classroom activities); *Experimental* (focused on laboratory and experimental activities, where the platform is an implementation aid) [17] and *work-ask-for-show* (the teacher asks a random student to take a picture of his work to be corrected/commented by the class by projecting it) [18].

From the study of Lopes and Costa [3], it was concluded that for IO to influence the use of digital resources as epistemic tools it is crucial that the classroom task be challenging and that the following characteristics of IO be taken into account [3]: the time of use and exploration in class (free exploration for at least seven minutes); the teacher's mediation regarding the type of task, student autonomy, the teacher's epistemic moves, and the link between the use of digital resources and learning (reinforcement of the idea that students can use digital resources for better learning outcomes); the way digital resources are articulated.

Digital resources were integrated into the educational context as a support to the various areas of knowledge (e.g. music, mathematics, etc.). Interdisciplinarity answers the need to break boundaries between traditional disciplines and emerges as an articulation of knowledge that allows students to develop meaningful learning.

In summary, the main purpose of this systematic review is to analyze how IO articulates science and mathematics education with literature. Thus, the following research question arises: how does the use of Instrumental Orchestration articulate science and mathematics education with literature in primary school?

2 Methods

The structure of this systematic literature review was guided by the principles of the Declaration PRISMA [19], taking into account the inclusion criteria defined and explained below [20].

2.1 Search Strategy

The research was conducted in the third week of april 2022 in two databases: SCOPUS by Elsevier and Web of Science by Clarivate. The search terms were "instrumental orchestration" associated with the descriptors "digital tools" or "digital resources" and "elementary school" or "primary school" or "K-6" and "sciences" and "math" and "literature" and "music" and "arts", and the Boolean operators "AND" and "OR" were used. To understand the evolution of research on this topic, articles published in the last ten years were considered. Next, the articles that included "instrumental orchestration" were analyzed by title, abstract and keywords. One grey literature article was found.

2.2 Eligibility Criteria

The following research inclusion criteria were applied: (i) articles published between January 1, 2012 and April 12, 2022; (ii) articles written in Portuguese, English, French or Italian; (iii) articles not part of the same study; (iv) articles with indexation to the SCOPUS database; (v) articles that used the terms "instrumental orchestration". The following exclusion criteria were used: (i) articles published before January 1, 2012; (ii) publications without access to the full text; (iii) academic thesis or dissertations; (iv) review articles; (v) articles that did not substantiate the concept of "instrumental orchestration".

The selection process followed the following steps: (i) serach guided by the description in the mentioned database; (ii) exclusion of duplicate articles; (iii) exclusion of articles that did not grant access to the abstract; (iv) exclusion of articles by grey literature; (v) exclusion of articles outside the selected period; (vi) exclusion of articles that did not make the full text available; (vii) exclusion of articles that only listed "instrumental orchestration" in the references; (viii) exclusion of articles that on reading the title, abstracts, and keywords, it was verified that "instrumental orchestration" was not relevant; (ix) critical reading and evaluation of articles (cf. Figure 1) [21].

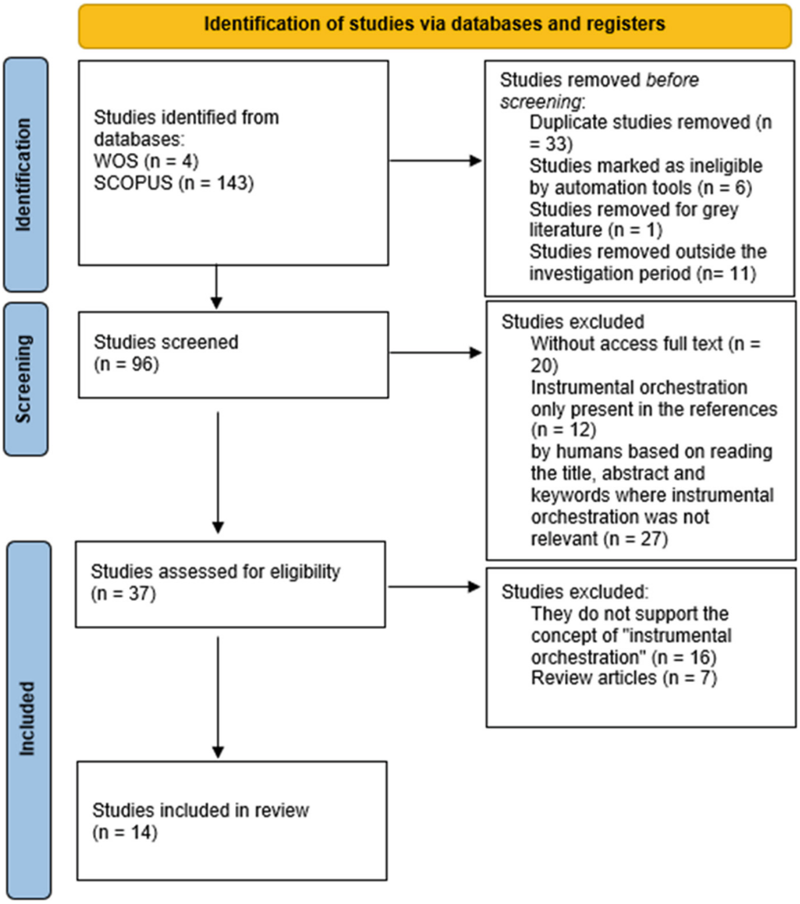

Fig. 1. Prisma Flowchart (adapted from [21])

2.3 Data Extraction Procedure

Data extraction tracked the following units of analysis: (i) presence of the term “instrumental orchestration”; (ii) definition of “instrumental orchestration”; (iii) school level where “instrumental orchestration” is used; (iv) beneficiaries of the IO use; (v) articulation of science and mathematics education with the literature; (vi) conclusions presented in the use of IO. In Table 1 we see the sections of the articles associated with each unit of analysis and examples of coding in use. The data extracted are only those that are explicit. For data omitted or not clear enough, the code “not specified” was used.

Table 1. Description of the units of analysis.

Analysis unit	Sections under analysis	Encoding
1. Presence of the term IO	- Title	- Specified
	- Abstract	- Not Specified
2. Definition of IO	- Abstract	- Direct
	- Introduction	- Indirect
	- Theoretical Framework	
3. Educational stage where IO is used	- Abstract	- Kindergarten
	- Methodology	- Primary School
	- Procedure	- Middle School
		- High School
4. Beneficiaries of the IO use	- Abstract	- Teachers
	- Methodology	- Students
	- Procedure	- Students and Teachers
5. Articulation of science and mathematics education with literature	- Summary	- Not Verified
	- Procedure	- Checked
	- Discussion	
	- Conclusions	
6. Conclusions presented in the use of IO	- Discussion	- Specified
	- Conclusions	- Not Specified

2.4 Description of the Articles Under Analysis

Table 2 shows the main characteristics of the 14 articles selected for this systematic review: author/s, year of publication, country, educational stage for which each educational intervention was designed, study design. The keywords in our search focused on "elementary school" or "primary school" or "K-6". However, articles outside this educational stage were included because of their relevance and direct influence on primary school. For example: studies of teacher education were developed in higher education but aimed at applicability with elementary school students; studies of educational stages beyond elementary school were included because the results were found to be like studies already done at the elementary school level; kindergarten studies were developed based on studies already done at primary school. In this systematic review, studies were also included that, although not developed in primary education, in their rationale integrate studies that were focused on primary education.

Table 2. Article features

Authors	Year	Country	Educational stage	Study design
Roberto Araújo Filho, Verônica Gitirana [22]	2022	Brazil	High School	Experimental method
Carolyn Mitten, Zachary K. Collier, Walter L. Leite [23]	2021	EUA	Middle and high school	Quasi-experimental
Renata Vágová [13]	2021	Slovakia	Secondary school	Exploratory study
J. Bernardino Lopes, Cecília Costa [3]	2021	Portugal	High School	Exploratory study
Ana Silva, J. Bernardino Lopes, Cecília Costa [24]	2021	Portugal	Middle School	Case study
Carlos Monteiro, Cecília Costa [18]	2021	Portugal	Secondary school	Case study
Gulay Bozkurt, Kenneth Ruthvena [25]	2018	England	Secondary school	Exploratory study
Said Hadjerrouit, Harald H. Gautestad [26]	2018	Norway	High School	Exploratory study
Silvia Mazza, M. Beatrice Ligorio, Stefano Cacciamani [17]	2018	Italy	Middle School	Case study
Jana Trgalová, Laetitia Rousson [27]	2017	France	Kindergarten	Case study
Gulay Bozkurt, Kenneth Ruthven [28]	2017	England	Secondary school	Case study
Alice Hansen, Manolis Mavrikis, Eirini Geraniou [29]	2016	England	High School	Iterative design e DBR
Martin Carlsen, Ingvald Erfjord, Per Sigurd Hundelan, John Monaghan [30]	2016	Norway	Kindergarten	Case study
Paul Drijvers, Sietske Tacoma, Amy Besamusca, Michiel Doorman, Peter Boon [15]	2013	Netherlands	Middle School	Exploratory study

3 Results and Discussion

From the two databases analyzed, 147 results were obtained that were considered eligible: SCOPUS (n = 143) and Web of Science (n = 4). For this systematic literature review, 14 studies were analyzed. The remaining studies were excluded according to the criteria already explained.

3.1 Summary of the Selected Studies

Table 3 shows the details of the studies analyzed for this systematic review.

The purpose of this systematic review is to analyze how IO articulates science and mathematics education with literature. By analyzing the selected articles and the state of the art, we can affirm that IO is articulated with some areas of knowledge simultaneously, such as mathematics and science [24, 26, 27, 31], or alone, as in the case of mathematics [13, 15, 17, 18, 22, 23, 25, 28–30].

IO, when used in preschool, supports educators in structuring sessions where digital resources are present [27, 30]. In Basic Education, teachers use digital resources in order to increase student performance [15, 17, 23, 24]. In secondary education, we find that teachers use various IOs [13, 18, 25, 28]. As far as higher education is concerned, the use of IO also appears in initial teacher training [22, 26, 29, 31]. As it turns out, in this systematic review, no studies involving the Primary.

All the studies analyzed present a strong theoretical framework of the IO concept, which reinforces the idea that each teacher selects one or more instrumental approaches according to his/her educational objective [23]. In this way, the teacher, transforms an artifact into an epistemic tool, increasing the students' understanding of each topic taught [3], as well as, promotes the appropriation of epistemic tools by the students [27].

In the 14 studies selected for analysis we found the use of digital artifacts, such as: AN (Algebra Nation) plataforma de tutoria online, GeoGebra, Fraction Lab, Cube Cross-Section, SimReal, Google Form, Digital Game, BSalaby, DME, Digital Piano. The time that is given for the introduction of a digital tool has a direct consequence on the transformation into an epistemic tool [3]. For this reason, the interaction of the teacher with the student in the introduction of digital tools is fundamental, as Mitten et al. state that the use of digital platforms "(…) did not replace teachers' primary instruction (…)" [23, p. 262]. For these instructions to be successful, the teacher needs to develop his/her professional knowledge [15, 22, 27], changing the trend that teachers are still uncomfortable with the use of technologies [29].

From the research carried out, only one study involving the arts with IO through music was found [24]. The remaining arts were not observed in this research. The same is true of the literature. Most of the studies analyzed here intend to solve mathematical questions with the use of these artifacts. Only 3 studies involve other areas of knowledge, such as music [24], engineering [26] and physics [3]. However, whatever the area of knowledge associated with IO, it is the appropriation of the artfact as an epistemic tool that enables meaningful learning [32].

The results of the selected studies reveal the use of the various IOs advocated by Drijvers et al. [11]. Mazza et al. [17], in their study, presents 3 new IOs: collaborative (use of the platform to exchange materials and ideas between students and teachers),

Table 3. Structured summary of the studies selected in the review

n	Author/s	Title	Objective	Intervention	Results	Conclusions
1	Filho and Gitirana [22]	Pre-service Teachers' Knowledge: Analysis of teachers' education situation based on TPACK	To analyze the IFP students' knowledge in the IO planning stage, using collaborative work	- TPACK - GeoGebra - FIP - Students - Duration: 5 Sessions	Didactic configuration planning	- The knowledge that stood out in group context, at the stage under study, were: the pedagogical and the pedagogical content knowledge (PK and PCK) - The knowledge that stood out in individual context, at the stage under study, were: pedagogical (PK) and the technological pedagogical content knowledge (TPACK) - Collaborative planning and theoretical training is the way forward for ITE
2	Mitten et al., [23]	Online Resources for Mathematics: Exploring the Relationship between Teacher Use and Student Performance	Engage students with one online mathematics resource, AN (Algebra Nation) and the relationship between classroom use and student performance in algebra	- Use of AN online tutoring platform - Teachers and students - Duration:160 min	- Teachers' involvement with AN resources produced an increase in student averages and exam pass rate - AN was used by teachers in a variety of ways: introducing, assessing, or synthesizing mathematical concepts. However, it did not replace teacher's instruction	- The increased use, by the teacher, of AN improved the students' performance - By using the IO around AN complemented the instruction given initially

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
3	Vágová [13]	Designing Combinations of Physical and Digital Manipulatives to Develop Students' Visualisation	Assist students in their instrumental genesis and support the development of paper visualizations and constructions	- Cube Cross-Section - 3 D Impressions - GeoGebra - Teachers and Students - Duration: 6 Sessions	- Visualisation as a cognitive process was supported to be developed through the manipulation and/or creation of physical, digital representations, but also pencil and symbolic representations - The development of all visualisation elements was supported in this study based on the operations related to the intrinsic and extrinsic treatments, and verbal, visual and graphic conversions - The semiotic genesis was activated in each pilot lesson by using and/or creating multiple representations of the same or different register - the operations related to the combined use of physical, digital, pencil and symbolic representations, activated the cognitive process of visualization in each pilot lesson when using any designed toolkit - Two types of difficulties were recognized: those of the cognitive plane and those of the epistemological plane	- The development of the subjects' spatial abilities was supported in the pilot cube cross-section lessons - Visualisation and the cognitive process was supported to be developed through the manipulation and/or creation of mainly physical, digital representations, pencil and symbolic representations

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
4	Lopes and Costa [3]	Converting Digital Resources into Epistemic Tools Enhancing STEM Learning	To know what IOs teachers use in their classes for students' use of digital resources as an epistemic tool	- FIP - Teachers - Duration: 5 classes of 50 min. Each and 3 classes of 100 min. Each	- Any of the modes of IO with digital resources have an influence on the use of digital resources as an epistemic tool - IO in mediation has the clearest influence, because it gives the possibility to use the digital resource as a high-level epistemic tool - The time of use and insertion of a digital resource is crucial for the use of a digital resource as an epistemic tool - IO on the WEB can have an influence on the use of digital resources as an epistemic tool	The important characteristics for an IO to influence the use of digital resources as epistemic tools are: - the time of use, the moment of insertion in class; - the teacher's mediation; - the way digital resources are articulated The existence of a challenging task is indispensable The degree to which digital resources are used as epistemic tools is related to the characteristics of the IO
5	Silva et al., [24]	Doing Math with Music – Instrumental Orchestration	Understand how artifacts are used in interventions in educational settings that enable doing mathematics with music	- Digital Piano - Students - Duration: 6 Sessions	- The manipulation of technological artifacts promotes the discovery of mathematical concepts - The use of artifacts allowed for the creation of a context in which student learning was active, which elevated the status of artifact to epistemic tool	- The use of artifacts, in an educational context, promotes the learning of mathematics from music as long as the teacher orchestrates the artifacts to be used, by the students, as an epistemic tool - Students show autonomy in solving most of the proposed tasks/challenges

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
6	Monteiro and Costa [18]	Instrumental Orchestrations in a Math Teacher's Practices to Enhance Distance Learning of Integral Calculus	Analyze the didactic configurations, modes of exploration, and types of instrumental orchestration applied in distance education	- Teams - Microsoft Whiteboard and Openboard - Paint.NET - Virtual School - Student - Duration: 7 Sessions of 2 × 50 min	- Use of various IOs - In the didactic setup PowerPoint and the whiteboard were used - The IO that was predominant was Explain-the-screen - Other IOs such as Discuss-the-screen, link-screen-board were used - Spot-and-show was less prominent	- The main characteristics of the didactic configurations and exploration modes used were identified - The IOs indicated in the literature were verified - A new IO named work-ask-for-show was created
7	Bozkurt and Ruthvena [25]	The activity structure of technology-based mathematics lessons: a case study of three teachers in English secondary schools	- Identify activity structures associated with the use of technology in dynamic mathematics lessons - Synthesize interconnected aspects of the IO structure	- GeoGebra - Teachers - Duration: 2 to 4 sessions	- Teachers used similar types of activity formats, such as: Technical-demo, Walk-and-work-by, Predict-and-test and Spot-and-show - Different patterns of interaction emerged between technology, students, teacher, and mathematics	- Relating the SFCP framework to IO provides richer descriptions and increases understanding of the activity structure construct - Contributes to expanding the IO framework with respect to the emergence of new activity formats
8	Hadjerrouit and Gautestad [26]	Using the Visualization Tool SimReal to Orchestrate Mathematical Teaching for Engineering Students	Identify orchestrations that have emerged in teaching mathematics to engineering students	- SimReal (graphing calculator) - Teachers and students - Duration: 10 sessions of 2 × 45 min. Each	Orchestrations linked to SimReal: Video-simulation, Problem-solving	Students are expected to benefit from SimReal-based orchestrations combined with multiple representations of mathematics through video lectures, live streaming of lectures, and interactive simulations

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
9	Mazza et al., [17]	Orchestrazione strumentale per l'inserimento di "Aule Virtuali" a scuola	To investigate the orchestration methods implemented by teachers of different school subjects in the use of technologies in the classroom, during the experimentation of the online learning environment called Aule Virtuali ClassroomsViva	- Google Form - Teachers - Duration: 30 min	- Emergence of collaborative IO, not present in the literature (use of the platform to exchange materials and ideas between students and teachers) - Emergence of content-based IO (teacher focused on the content available on the platform. E.g. description of proposed activities in class) - Emergence of experimental IOs focused on laboratory and experiential activities (the platform is an implementation aid) - Use of IO Technical-demo	- Four types of orchestration were identified; of these only one is present in the literature, Technical-demo, while the other three - colaborative, content-based, experimental- are original - Each orchestration scenario underlies a diverse perception of the technology, though always positive

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
10	Trgalová and Rousson [27]	Model of appropriation of a curricular resource: a case of a digital game for the teaching of enumeration skills in kindergarten	Testing the effectiveness of a digital resource appropriation model	- Digital game for teaching and learning enumeration skills - Teacher - Duration: 9 Sessions	- The IOs follow the preferences already used by the teacher: first individual work and then in pairs with different roles - IOs in groups: "technical demo-DT", "discuss the screen-DE/ discuss without support-DSS", "explain the screen-EE/explain without support-ESS" - IO in autonomous work: "assistance when needed-TA-i-AL", "guided use/ autonomous use-TA-i-UA/ Ua" - IO in group discussions: "discuss the screen-DE/discuss without support-DSS", "Sherpa at work-ST"	- The appropriation of a resource requires flexibility - Being able to decide the order of activities and adapt them to the educational needs of the group increases the teacher's appropriation of resources and consequently contributes to his or her professional development
11	Bozkurt and Ruthven [28]	Classroom-based professional expertise: a mathematics teacher's practice with technology	To analyze the craft knowledge practiced in the classroom of a teacher considered an expert in integrating the use of technology in the area of mathematics	- GeoGebra - Teacher - Duration: not specified	IO: Technical - Demo, Link-screen-board, Discuss-the-screen, Explain-the-screen, Spot-and-show, Sherpa-at-work, Work-and-walk-by	- Spot-and-show is used as the main activity format for discussion in all sessions involving GeoGebra and the interactive whiteboard - In the tasks that did not use GeoGebra: Discuss-the-board, Spot-and-show, Work-and-walk-by

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
12	Hansen et al., [29]	Supporting teachers' technological pedagogical content knowledge of fractions through co-designing a virtual manipulative	- Verify the mathematical development of the teachers' creations - Verify the impact of designing the Maestro lab within a MaST community of practice to improve technical teaching knowledge	- Fraction Lab - Teachers - Duration: 50 min	Teachers are uncomfortable using Fraccions Lab	- Working on the co-design construction of the Fraction Lab allows Workshop participants to engage more deeply with the digital resource and its functionalities - To promote the use of multiple representations, it is important to appreciate the pedagogy to be used and the design principles of the digital resource
13	Carlsen et al., [30]	Kindergarten teachers' orchestration of mathematical activities afforded by technology: agency and mediation	Characterize the roles and actions of teachers in activities and extend the considerations of current teacher orchestrations in the literature	- BSalaby - Teachers and Students - Duration: 3 sessions of 30 min. Each	- There was no presence of IO: Discuss-the-screen, Guide-and-explain, Spot-and-show, Sherpa-at-work, Board-instruction - Supporting children through IO: Tech-nical-demo, Technical support, Explain-the-screen, Link-screen-board - There was no Link-screen-board	- This study looks at three roles with differences and similarities in teacher orchestrations and roles (pro-teacher, child, digital tool, and math)

(*continued*)

Table 3. (*continued*)

n	Author/s	Title	Objective	Intervention	Results	Conclusions
14	Drijvers et al., [15]	Digital resources inviting changes in mid-adopting teachers' practices and orchestrations	To analyze how teachers without experience with digital resources orchestrate technology-rich mathematical activities	- DME - Teachers - Duration: 120 h	Preference for individual orchestrations, with Guide-and-explain being the most frequent, followed by Technical-demo	- Teachers initially used orchestrations where digital technology had a central weight. Later, the orchestrations focused more on mathematics where teachers mainly use their pedagogical content knowledge (Guide-and-explain) - Teachers' self-confidence increased with their participation in the project, as did their technological problem-solving skills

content-based (teacher focused on the content available on the platform, for example, description of proposed classroom activities), and experimental (focused on laboratory and experimental activities, where the platform is an implementation aid). On the other hand, Monteiro and Costa [18] add the IO called work-ask-for-show.

The findings of the studies reinforce the importance of IO in student learning, as it: allows for richer descriptions [25]; complement the teacher's instructions [23] and allow you to adapt the activities to the educational needs of the group [27]. For teachers, the use of IO has increased their self-confidence and their technological problem-solving skills [15].

As technologies evolve, new IOs have emerged. The development of online practices originated the creation of new IOs [17]. On one hand, the last three years have seen a Covid-19 pandemic, which has allowed for the exploration of online learning and boosted the emergence of a new IO [18]. In short, the trend we see is the emergence of new IOs, resulting from new teaching practices fostered by the evolution of technologies.

4 Conclusions

This literature review reveals that IO has been used in various educational stages, from kindergarten to higher education. The results also show that the digital resources used in educational interventions have been orchestrated to make them epistemic tools. It is also concluded that there is a concern, over the years, to train teachers for the efficient use of digital resources. In what concerns curricular articulation, it was evident that IO is mostly associated with the subject of mathematics, where arts are little considered for the use of IO. Thus, the disciplinary integration needs more intervention, and there is no study that develops inter, trans or multidisciplinary interventions.

In brief, we can state that IO allows curricular articulation, although in the analyzed studies it has been limited to the subject of mathematics alone or associated with another subject. An investment in teacher training regarding digital resources is fundamental, since this way new innovative paths for teaching and learning are created, using dynamic strategies that go beyond the curricular contents. Finally, it is important to develop research on curricular articulation using IO.

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Digital Tools and STEM Learning

Know Me: Promoting Gender Equality in Education Through an Interactive Digital Narrative

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Abstract. The main objective of this article is to present the video game "Know Me" and expose the obtained results with the performed usability tests and user eXperience evaluations. Gender inequality in STEM (Science, Technology, Engineering and Mathematics) areas still exists, so it is important to act to tackle this gap. "Know Me" integrates an interactive digital narrative that promotes gender equality in STEM educational areas, as well as several mini-games to make the experience more challenging. The aim of "Know Me" is to raise awareness among students, between 14 and 16 years old, about the existence of gender inequality in STEM areas and to demonstrate to students, of the same age group, the potential of these areas.

The ideation process of the video game is described, as well as the methodology used throughout the investigation. Thus, this research integrates several sequential phases: i) research, analysis and planning phase, which involved 6 participants, 3 male and 3 female, aged between 14 and 16; ii) development phase of the product (video game); iii) test and evaluation phase, with 8 participants, 4 female and 4 male, aged between 14 and 16; and iv) interpretation of the results.

Keywords: Interactive digital narrative · Game · Education · Gender equality · STEM

1 Introduction and Context

Today, young women have more and better access to education, but they still do not have the same opportunities to complete and/or benefit from the choices they effectively want for their career. There are still many prejudices, social norms and expectations that influence the quality of young women education and the subjects they study. Thus, women are under-represented in STEM education (Science, Technology, Engineering and Mathematics) globally and, consequently, in STEM careers [1].

For education to reach its potential, immediate changes are needed, such as measures to eliminate disparities in access to education, especially in developing countries. Improving the quality of education will allow training students who have the knowledge, skills, attitudes and behaviors to ensure inclusive and sustainable societies [2].

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The problem highlighted in this article encompasses the universe of STEM areas, as such, it is important to start by perceiving the term, which is an acronym for Science, Technology, Engineering and Mathematics. In this article, the term STEM in-corporates the social sciences and related areas, being perceived as a single concept that integrates the four areas, grouping different technical skills and knowledge do-mains.

With regard to the relevance of conducting a study on this theme, two points should be considered: 1) what is proposed to young people since childhood and 2) the 2030 Agenda for Sustainable Development.

Regarding the first point, it is known that in early childhood education children can be exposed to opportunities where they learn about science and mathematics [3]. However, not all children have equal opportunities concerning education and learning through educational games, since some studies report that boys benefit more from these opportunities [4]. Contact with these educational experiences in childhood has a positive effect on the later choice of study areas related to science and mathematics, as well as on career aspirations in these areas [3, 5]. Although gender differences begin in childhood, they become more pronounced from the phase when students have to select which areas and subjects they want to pursue in the future, and these differences become even more evident as the level of education increases [2].

Another reason why it is pertinent to carry out a study on this theme is related to the 2030 Agenda for Sustainable Development. In this case, the most relevant SDDS are objective 5 of gender equality and objective 10 of reducing inequalities [6].

In sum, this study is important to contribute to the non-creation of stereotypes, and it should be the young people who have to understand and decide what their preferences are to trace their path as they grow [7–9].

There are also several factors in different areas that influence the participation, performance and progress of young women and women in STEM studies and careers. Some can be highlighted, such as psychological factors of the individual scope, school-level factors and social-level factors because these are the considered factors that may have the most impact when the subject is gender inequality in STEM. To consult more information on this topic and in order to see a more in-depth theoretical framework in these areas, it is possible to read the dissertation entitled “Interactive digital narrative: promoting gender equality in STEM” [10].

In this regard, the aim of this article is to present the prototype of a video game with an interactive digital narrative which promotes gender equality in STEM areas. The video game developed – “Know Me” – aims to raise gender awareness among students aged 14–16 about gender inequalities in STEM fields and demonstrates to female students of the same age group the potential of these areas. Having said that, the research question that guided this study was: “What prerequisites should an inter-active digital narrative (aimed at students aged 14–16) follow in order to support the promotion of gender equality in STEM fields?”.

2 Methodology

The used methodology starts from a macro to a micro approach, where the focus and nature of the study was established. Regarding the focus, it is an applied investigation, as there is a presupposition of "wanting to do", resulting in something concrete, in this case a video game, so that a measurable output is reached, providing answers to a problem felt by a set of individuals. Concerning the nature of the study, it is explanatory, since the objective of this research is to contribute to the exploration of gender inequality in STEM areas and to understand why the phenomenon is happening. Moreover, this research wants to understand which assumptions an interactive digital narrative should have to support the promotion of gender equality in STEM.

This investigation followed the mixed approach proposed by Cresswell and Creswell [11], since it involved collecting mostly qualitative data and a small number of quantitative data, integrating both types. Within the mixed methodologies, there are three possible investigation designs and in this project the sequential explanatory design was applied [11] through the following phases:

Phase 1 – Research, Analysis and Planning: This phase began with the search for articles, books, and important materials to learn more about the topic of gender inequality in STEM areas, interactive digital narrative and the issue of gender in video games. Subsequently, a theoretical framework was elaborated and a survey was carried out regarding the state of the art, in order to understand what already existed on the subject.

Through the theoretical framework and the state of the art, a review of relevant requirements/specifications for the development of the prototype was carried out. In addition, a focus group was organized with the target audience (6 participants, 3 male and 3 female, aged between 14 and 16) to understand any needs, opinions and guidelines on the subject. In this way, there was initially a qualitative data collection, coming from the analysis of the theoretical materials explored and from the focus group, which helped in the ideation and development of the multimedia product.

Phase 2 – Development of the Product: After identifying the relevant features and concepts, a multimedia product was developed. The objective in this phase was the development of a prototype of a video game with an interactive digital narrative promoting gender equality in STEM areas.

Primarily, the interactive digital narrative was built, then the mechanics of the video game were established and its graphics were developed. In the end, the code implementation of the video game prototype was carried out.

Phase 3 – Final Rvaluation: With the prototype finalized, it was necessary to test and evaluate it with the target audience. In this way, qualitative and quantitative data related to the developed video game were collected through usability tests and User eXperience (UX) evaluations, using observation and inquiry techniques (8 participants, 4 female and 4 male, aged between 14 and 16).

Phase 4 – Interpretation of the Results: After the evaluation phase, it was essential to interpret the results obtained so that improvements and adjustments to the prototype could be carried out.

3 Development of Narrative Game for the Promotion of Gender Equality

3.1 Focus Group: Exploration of Concepts and Game Idea

With the target audience involved in the first phase of the investigation it was possible to create a video game more directed to this type of audience and that corresponded to their preferences. The focus group script was divided into five blocks of questions regarding different subjects, i) Introductory questions on how often they play and whether they think the games convey important messages to young people; ii) questions about important aspects in a video game and what motivates them to play; iii) Questions about the importance of interactive digital narratives in video games; iv) Questions about video games as a means of solving social problems, such as gender inequality; and v) Final questions that were not the subject of analysis, since they related to the possibility of contacting the participants (doubts in the analysis of the answers given and willingness to participate in the final tests of the video game).

After analyzing the answers collected, potential ideas were identified for the concept of the game. Some of them have been implemented the video game "Know Me", while others although interesting, could not be able applied at this stage but can be developed in future work. Table 1 shows these ideas divided into topics. The ideas that are present in the prototype are displayed with a "Yes", and with a "No" ideas that may be implemented in the future.

Table 1. Gathering ideas from focus group responses

Topics	Ideas for video game	Implementation
Content and narrative	Learn with the video game	Yes
	Different characters with different characteristics	No
	To have history	Yes
	Story divided by levels or events that appear only in specific or remarkable points	No
	To have several paths	Yes
	Do not have a predefined character	No
	Characters have a story	Yes
Game mechanics	Different difficulty levels	No
Graphic construction	Appealing graphics	Yes
	Attractive colors	Yes
Game visibility	Promote the video game on social networks	No

3.2 Concept of the Video Game

During the analysis of the collected data from the focus group, it was possible to perceive that young men play games regularly while young women play less. So, since the beginning, there was the certainty that it was necessary to encourage young women to play, creating a video game that also corresponded to their preferences. In order to include the theme of gender equality in STEM areas, an interactive digital narrative was created, which is embodied through dialogues between the characters of the game, and in these dialogues several problems of gender inequality in STEM are subliminally incorporated.

Through the problems depicted in the video game, it is intended to raise awareness among young people and show them that there is gender inequality in these areas, sometimes very close to their day-to-day realities. After playing this game, it is expected that young people will be more attentive and receptive to this type of problem. So that the video game was not only informative, some challenges were also presented (mini-games – see Fig. 1) during the narrative, related to the theme of the STEM areas.

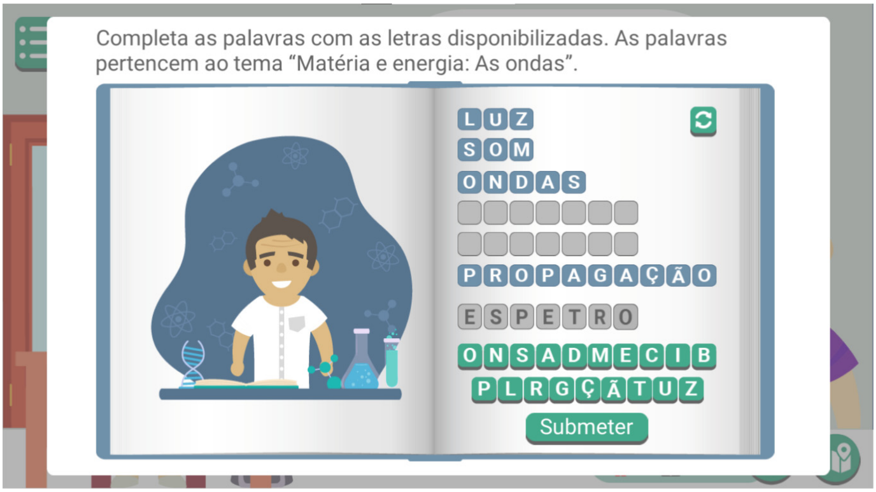

Fig. 1. Mini-game 3 – the objective is to guess all the words related to the theme "Matter and energy: The Waves". From the set of provided letters, these words have to be formed.

3.3 Interactive Digital Game Narrative

Throughout the analysis and further elaboration of the theoretical framework, it was realized that there are several factors that influence female gender involvement, participation and motivation in STEM. Thus, as the participants mentioned in the focus group, it was determined that the different characters had their own story, and from each story one or several preponderant factors for female engagement with STEM would be discussed. Through this approach, which presents the factors that contribute to gender inequality and how this problem can be solved, players are able to learn from the game (topic also indicated in the focus group).

Since it was not possible to create several stories for the different characters and also to make different graphics to implement them later, it was decided to develop only a complete story/narrative. Ideally, the player could choose one of the four characters, depending on their preference, noticing that they have different physical and psychological characteristics. Focus group participants also suggested that there should be multiple characters available in the game narrative. However, this has not yet been implemented in the present prototype. The story of the character Matilde was the chosen one to create a full game experience. In the design of the theoretical framework, it was possible to perceive that the psychological factors of individual scope, namely the perception of stereotypes and gender roles, are the most reported in studies [2]. During the focus group, participants also mentioned that in their schools there is a distinction of study areas according to gender due to stereotypes and gender roles established in society. For these two reasons, it was decided that the narrative should have gender stereotypes as its main problem.

Throughout the narrative (see Fig. 2), in addition to stereotypes and gender roles, other problems and factors that influence young women's participation and motivation in STEM were also exposed, such as:

- School-level factors: it was presented how learning materials depict the different gender characters, conveying messages about gender roles and STEM skills, which can strengthen gender stereotypes.
- Family-and peer-level factors: the beliefs and expectations of parents and friends were represented, which often influence the choice of study areas, perpetuating gender stereotypes.

Fig. 2. Bedroom screen – the player has to interact with the robot that exists in the bedroom to start Matilde's story. Afterward, the player needs to find the other interactive objects.

3.4 Prototype[1] and Game Mechanics

In the challenge and dramatic arc of the game, it has been established that as the game progresses, the player is confronted with various situations, which are presented during the dialogues with other characters of the game. In these moments of conversation, the story is presented to the players in a natural and engaging way. The player can also make choices in some dialogues, which lead to the creation of a character personality. So that the game was not just informative, mini-games were included to challenge the players. The themes of the mini-games are explicitly and implicitly related to STEM areas. In these challenges, interactions are based on dragging and clicking the mouse.

The objectives of the game and consequent actions are: i) observe the scenario and understand where to click; ii) interact with the other characters to know the story of the chosen character (protagonist); iii) choose hypotheses to define the personality of the protagonist character; and iv) solve the challenges.

In the video game prototype, the player does not have many chances to decide what he is going to do first. Or in other words, there is a sequence that the player has to follow, but which ends up becoming implicit. Thus, it was necessary to include the following rules in the prototype: i) click on the correct game elements to continue; and ii) interact with the characters, who can give clues about what to do next.

For future development, it would be interesting for the player to have more choices than he can currently select. This adjustment will predictably create a greater number of rules.

The end of the game occurs when the player goes through all the scenarios, knows the complete story of the main character and solves all the challenges. At the end of the game, it is revealed which personality the player has built for the character, through the choices he has made during the game.

4 User Experience Assessments and Usability Tests

The last phase of the research design refers to the final evaluation, which was carried out using usability tests and UX evaluations. The objective in this phase was to test and evaluate the prototype with the target audience, students aged 14 to 16 (boys and girls). By involving the target audience in this last phase, it was possible to see what could be improved, both in the narrative and in the mechanics of the "Know Me" video game. The script of the usability test and UX evaluation was divided into four parts, which aimed to collect different information, these being: i) Pre-experience; ii) Experience; iii) Game content; iv) Post-experience.

In the pre-experience, a question was posed that allowed characterizing the participants in the universe of video games. In the experiment phase, the goal was to understand, through observation, if users understood how to interact with the game and if they understood what they had to do, applying a usability test. Furthermore, the UX evaluation was also used in the experience part, to ask the participants how they felt about a certain scenario of the game, for example, if it was confusing, pleasant, etc. As for the part called

[1] The prototype of the video game "Know Me" is available at: https://play.unity.com/mg/other/know-me-web.

game content, we tried to understand if the message and story of the game reached the young people and if they understood it correctly. Finally, three questions were asked, two of which served to characterize the participants, and the third question aimed to understand what the participants thought of the game in general. All the questions in the script were selected and analyzed so that they would not influence the views of the participants (negatively or positively). The analysis and discussion of the collected data is presented below.

Pre-experience. To begin the usability test and UX evaluation, each of the participants was asked about how often they play video games. This question was also asked in the Focus group and since six of the participants collaborated in both techniques, the answers converged. Therefore, it was observed that the four male participants played video games regularly and the four female participants played them rarely.

Experience. In this part of the usability test and UX evaluation there were no specific questions in the script, it was simply observed how the players interacted with each of the screens of the game. After completing a game scenario, they were asked if there were any difficulties and how they felt playing the video game. To make it easier, this analysis was done based on the sequence of appearance of the screens in the "Know Me" game:

i) *Map*
On the map, six of the eight participants easily realized that they had to click on the only unlocked location to advance to the next scenario. Two of the participants felt confused, not being able to understand what they needed to do to move forward but, after exploring the screen more carefully, they realized that there was only one unlocked scene and this was the area they had to click on.

ii) Home scene – Bedroom
All but one of the participants made numerous clicks through the scenario, including three of them clicking on the map right away, confirming that there was no other scenario unlocked besides the "House". After several clicks through the scenario, all participants understood that the goal was to click on the robot, since they would have to interact with the elements to advance. When the task of picking up objects arose, all participants immediately understood the actions they had to perform. To progress to the next scenario, four of the participants went to the map, perhaps because on the previous screen they had perceived that it would be possible to advance to different locations (School and Park). After the participants could not move forward in this way, they realized that the click to move forward had to be on the door. The eight participants said that at the beginning of the exploration of this scenario they felt confused and did not know what to do, but as they interacted with the game they realized how it worked and what the objectives were. In order to solve this problem felt by young people, a tutorial could be included at the beginning of the game or in the rules section, so that players become more familiar with the game mechanics. Furthermore, a positive aspect is that the participants were able to understand the game by trying it out, showing that the game is intuitive.

iii) Home scene – Kitchen

In this scenario the objective is for the players to click and interact with the characters present in the kitchen. Five of the eight participants did this action very quickly. After interacting and talking with the characters, the mini-games are played. To start one of them, you have to click on the cereal box, and here was noticed that all the participants understood that this was the action to take. The other mini-game arises with a click on the newspaper. In this case, only three of the participants were able to perform this action immediately. One of the reasons for not quickly realizing that the newspaper is clickable may be related to the size of the clicking area of the graphic element itself, as it is a little small, which may make the player not interested in that object or even give up clicking because they didn't get it right on the first click attempt. With regard to the mini-games, participants were asked about the ease of each game. In the robot mini-game (where one had to construct the right sequence of directions to reach the end of the maze), three participants considered the game easy, four considered it medium and one considered it difficult. As for the quiz mini-game (questions about content linked to STEM areas), three of the participants said it was easy, as it had accessible questions. On the other hand, four of the participants said that the quiz was average and one participant mentioned that it was difficult, because there were questions he did not know the answer to, but said that he had learnt from them. When it became necessary to advance from one scenario to another, five of the participants still made several clicks on the interface but then they were able to understand that they had to access the map where a new unlocked macro scenario appeared.

Participants found the scenario enjoyable and felt that although it was more complex than the previous bedroom scene, the interaction became easier and more fluid because they were familiar with what needed to be done.

iv) School scene – Hallway

This scenario proved to be the simplest in the game. During the evaluation, it was found that participants considered this to be the most intuitive and straightforward scenario, where all participants quickly understood what they had to do.

v) School scene – Classroom

Overall, this scenario was accessible and easy for participants to interact with. Regarding the word discovery mini-game that occurs from the interaction in this scenario, six participants stated that the mini-game was difficult and two that it was medium. Regardless of the level of ease they associated with the mini-game, all participants mentioned that if there were any tips available, they would have asked for them. This is because, out of six words to unravel, the maximum number that one of the participants got right was three. The most commonly mentioned types of help which are considered appropriate for this format of game are: providing letters of words that need to be discovered and giving clues of words that need to be revealed, just like in a crossword game. Participants report that the aids would make the game easier to solve, without breaking the challenge inherent in the game. Thus, it is considered that the implementation of aids is really necessary for this challenge to be solved.

vi) School scene – Schoolyard

In this scenario, the evolution of the players was notorious. The tasks proposed to the participants were performed in a more intuitive and natural way, without many clicks. The gears mini-game (correctly fitting the gears so that the robot's antennae light up) was qualified as easy for two participants, medium for four participants and difficult for two participants.

vii) Park scene – Park
At this stage of the game, again, the participants are more at ease and perform all the tasks without too much difficulty. In the logic and reasoning mini-game (about arrival times and means of transport of various people), three participants said the mini-game was easy, another three said it was medium, and the remaining two participants considered it difficult. However, some of the participants suggested that in the information about the goal of this mini-game, it should be specified that both the schedule and the transport have to be different for all people. If this is not mentioned, participants feel that the player may be misled.

viii) Park scene – Park entrance
Like the school hallway scenario, this was also considered to be one of the simpler scenarios where players found it easier to interact.

ix) Character personality
Lastly, the screen with the character's personality, which was built on the basis of the various choices made by the player, was presented. All the participants understood the purpose of this screen, they found the idea of building the personality original and a potential motivator to play the game more often.

With this more detailed analysis of each scenario of the game, it was possible to verify that there were no great differences in the way of playing, nor in the perception of the game according to the genders, showing that both young men and young women have the same abilities in video games.

Content of the game. In this phase of the usability and UX evaluation test, it was intended to understand if the message to be conveyed by "Know Me" reached the participants in a perceptible and clear way. Accordingly, the first question asked was: "Is the language used in the dialogues, during the course of the game, appropriate for your age group?". All participants answered yes.

The second question was: "In your understanding what message does the game convey? Or none at all?". In this question, all participants understood that the game passes a message and described it with different words but the central notion was identical in all the speeches. In this way, the messages of the game "Know Me" that were perceived by the participants are the following:

- There is gender inequality both in school and professional contexts;
- Parents should accept their children's choices, regardless of whether the society considers that the degree or job tends to be more masculine or feminine;
- Gender stereotypes exist regarding which areas are considered feminine or masculine and it is a very ingrained concept in today's society that should not exist;
- Individual desires and rights should always be fought for.

Following these two questions, the participants were asked about how they see the message of the game and if it is relevant or not to talk about it. Once again, a unanimous response was obtained as they refer that it is relevant to talk about the issues related to gender inequalities and stereotypes. The reasons mentioned by some participants for taking this position were:

- Believing that stereotypes and gender roles should end;
- Parents' attitude in the game (which resembles the stance of many parents in real life) should not happen. Parents should accept their children's choices about the field they want to follow. It was also mentioned by one participant that the game would be very interesting for adults so that they could perceive the problem as they often do not even realize that they create it;
- The need to raise awareness of the problem of gender inequality in STEM. One of the participants even mentioned that if he belonged to a robotics class which included a young woman he would be surprised as this is not common in his school context. However, this would not mean that he would stop supporting his colleague. The participant also mentions that this situation can happen due to the stereotypes that are instilled still in children, when it comes to gender division by study areas.
- This was followed by the questions, "What does the character Matilde represent to you? And what do you think of her role in her community and in society itself?". Regarding the first question, the participants characterized Matilde through various adjectives, saying that she is:
- Determined and courageous, she stands up to her parents to follow the area of study she loves;
- A fighter and hard worker, she follows her dreams, overcoming all obstacles without ever giving up or becoming discouraged;
- Determined and courageous, because she stands up to her parents to follow the area of study she loves;
- A fighter and hard worker, she follows her dreams, overcoming all obstacles without ever giving up or becoming discouraged;
- Revolutionary, she tries to change other people's ideas, always expressing her opinion so that there may be gender equality in STEM areas.

For the second question, the participants mentioned that Matilde's role is to be an influential person and leader, who stands out in society with a positive attitude. According to them, she demonstrates that one should not give up on one's dreams.

The last question of this phase was: "Did you know any of these problems? Which one or ones?". The answer immediately obtained was related to the fact that Matilde's parents did not understand that their daughter wanted to follow an area of studies which, in their opinion, is considered a male domain. Almost all the participants indicated this problem and only one mentioned that he didn't know about it. Another problem mentioned by some participants was the existence of some young people who do not support other colleagues/friends in this type of choice, as they also think that there is a division between male and female areas of study.

Post-experience. In the final part of the usability and UX evaluation test, the following question was asked: "Do you like video games that convey a message and promote problem solving, for example social problems?". All participants answered yes, two of them justified by saying that this way it is easier to show people that there are problems and that it is necessary to fight them.

Another question was whether the participants were aware of the existence of gender inequality in STEM, and, once again, all of them answered yes.

To finish the data collection, the participants were asked, on a scale of 1 to 5 (1 being "would not recommend at all" and 5 being " would highly recommend"), how much they would recommend this game to their friends. Of the eight participants, seven answered 5 and one answered 4. The participant, who mentioned 4, would recommend the game to some friends, depending on the personality of each one but mentions that it is still an interesting game. The participants, who mentioned 5, gave reasons such as:

- The game helps to convey the message that there is gender inequality in STEM and is a good example of what is still happening in today's society;
- The narrative is captivating, making people want to know more stories that promote gender equality in STEM;

The game has different levels of difficulty, motivating people to want to advance in the game and at the same time learn more about a social problem.

5 Conclusion and Future Work

The study that was presented fits into the field of action of promoting gender equality, as well as in the area of interactive digital narratives. When researching support materials that would help to study the interconnection of these two areas, it was quickly realized that this is a very little explored strategy, finding here a window of opportunity for the creation of an innovative multimedia product. Thus, the idea arose of creating a video game that would integrate an interactive digital narrative, with the purpose of promoting gender equality in STEM educational areas. It is believed that this work adopts a distinguishing strategy, being able to make a transformative contribution to the subject under study, since the interactive digital narrative is a very powerful tool to convey messages to different audiences.

With this investigation, it was possible to answer the research question initially posed (see 1 Introduction). Therefore, the assumptions that an interactive digital narrative must follow, in order to support the promotion of gender equality in STEM areas are:

- The language used must correspond to the age group you are working with, in this specific case, a more relaxed and informal language was used;
- Issues and problems should be treated in a subtle and natural way, presenting and providing information little by little, so that young people do not feel unmotivated and bored;
- Within the theme under study, the issues to be addressed should be diversified;
- When players have to interact with the narrative and choose hypotheses, this choice should be relative to an important moment, resulting in responsibility for the option they have made. In this way, players can make decisions and experience reactions that would have if a certain action happened in their real life.

Some of the aspects that may be worked on in the future are the improvements that participants in usability tests and UX evaluations have proposed regarding the prototype of the video game "Know Me", which are:

- The presentation of a tutorial at the beginning of the game;
- The click zone in the newspaper be larger, in the kitchen scene;
- Including hints in the mini-game of discovering the words;
- Explain the information about what is necessary to do in the mini-game of logic and reasoning.

The question of clarifying what is necessary to do in the mini-game of logic and reasoning, it was decided to be solved in this prototype, because it is something simple and that made the game easier to understand.

Due to time constraints and in the sense of not complicate the development and implementation of the prototype, some aspects and functionalities of the video game narrative had to be excluded. Thus, other aspects that could be improved in the future are:

- Create more stories for the remaining characters;
- Give the player more chances to choose what they want to do first in a given scenario;
- Finish the story of the game with a small animation that better ends the character's journey;
- Optimize code scripts;
- Implement different difficulty levels in the game;
- Implement a "Save Game" and "Continue Game" features, so that players who have to leave the game can return to where they left it;
- Include background music and sound effects, so that the player has a more enriched experience throughout the game;
- Replace the ellipsis in the game's speech balloons with a visual element, e.g. an arrow;
- Give visibility to the game through a transmedia campaign.

Although these improvements are not yet implemented, it is assumed that a proof of concept has been created in which the player can have a complete experience, from the game's narrative and graphics, to its mechanics.

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Enabling Educators to Self-assess their STEAM Readiness

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Abstract. Self-assessment tools (SAT) are critical to educators' professional development, allowing them to reflect upon the challenges they face towards accomplishing their teaching and learning goals and the necessary actions to meet them. This work focuses on designing and developing a web-based tool that facilitates educators self-assess their STEAM education readiness. The tool is based on the Competence Framework for STEAM educators, following the successful practice of SELFIE and SELFIEforTeachers SAT. It aims to help educators reflect on their competences and identify their needs for further training and professional development related to STEAM education. This paper describes the design and development of the online tool, along with its first evaluation by educators.

Keywords: STEAM education · Self-assessment tool · Competence development · Teacher professional development

1 Introduction

STEAM education has been applied to enhance the understanding of the "structural coupling" of the fields of science, technology, engineering, arts, and mathematics [1] and to enhance the teaching of STEM fields by utilizing skills that are common in the STEM and Arts disciplines [2]. However, the role of STEAM educators has been characterized as challenging and demanding because STEAM education requires adopting new teaching approaches, content knowledge of different disciplines, and professional attributes [3, 4].

On the other hand, educators need and use self-assessment and reflection tools to help them assess fundamental beliefs and assumptions about learning, learners, and teaching, as well as differences between their perceptions of practice and those held by students in their classroom. A process of reflection helps to identify the personal characteristics and practices that must change to improve motivation and achievement for each student [5]. In this context, self-assessment tools (SAT) are key to educators' ability to pursue their professional development. SAT tools allow educators to reflect upon and describe their teaching and learning goals, challenges, and accomplishments. Self-assessment allows instructors to reflect upon and describe their teaching and learning goals, challenges, and achievements. The provision of a self-assessment tool can contribute to their

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development by (1) influencing the educators' definition of excellence in teaching and increasing their ability to recognize mastery experiences; (2) helping the teacher select improvement goals by providing him/her with clear standards of teaching, opportunities to find gaps between desired and actual practices, and a menu of options for action; (3) facilitating communication with the educator's peers; and (4) increasing the influence of external change agents on teacher practice [6]. The format of self-assessments varies and can include reflective statements, activity reports, annual goal setting, tracking, or web-based applications.

STEAMonEdu[1] project aimed to enhance STEAM educators' competence through online tools and communities. By nominating educators as the pillars of the implementation of STEAM education, this project supported their professional development by identifying the necessary STEAM competences and the skills required for teaching STEAM and then by providing targeted training together with a set of supportive tools. A significant outcome of the project is STEAMCompEdu, the STEAM educators' competence framework, based on which we developed the STEAM Education readiness SAT.

This tool fills a gap in the available SAT because most focus on assessing educators' digital skills. The most prominent among them is the SELFIE tool[2], an excellent example of how a framework could be utilized to develop a self-assessment tool. SELFIE has a strong basis in educational research and is a free tool designed to help schools embed digital technologies into teaching, learning, and assessment. Recently, the JRC Science Hub of the European Commission made the companion SELFIE for Teachers tool available, which helps primary and secondary teachers reflect on using digital technologies in their professional practice. Both tools are based on the European Framework for the Digital Competence of Educators (DigCompEdu).

However, no similar tools exist that focus on STEAM education. As various studies explore the benefits of teacher self-assessment in several state education systems worldwide [7], the current work is the first proposal of an online self-assessment tool to support and enhance the role of STEAM educators. This paper describes the STEAM Education readiness Self-Assessment Tool (STEAMEdu SAT), aiming to help educators assess and improve the competences that are important for the successful implementation of STEAM education programs. Based on the STEAM educators' Competence Framework [8], the STEAM SAT tool aims to help educators reflect on their competences and identify their needs for further training and professional development. In addition to the SAT, we present its evaluation by 36 educators during an online training program for STEAM education, together with the educators' views about the STEAM SAT tool's usability, content, and the produced reports are presented.

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[1] https://steamonedu.eu/.

[2] https://ec.europa.eu/education/schools-go-digital_en.

2 Development of the STEAMEdu SAT Tool

2.1 The STEAM Educators Competence Framework

The STEAM Educators Competence Framework (STEAMCompEdu) was designed, as a result of desk and field research, to align with the professional development requirements of educators by providing a complete set of competences that accommodates all the roles that educators (teachers, tutors, trainers) undertake to facilitate STEAM education. Teaching, creating content, managing class, empowering students, participating in communities, professional development, and other key roles have been integrated and grouped adequately in a common framework to compose the profile of future educators in different levels and setups of any educational context. For the design of this competence-based framework, we followed the methodology described in [9], which includes multiple rounds of surveys, while we were inspired by the European Framework for the Digital Competences of Educators (DigCompEdu) [10], related procedures regarding STEAM education teaching, other European frameworks of teacher competences and research regarding STEAM educators' perceptions about challenges, difficulties, training needs and the role of STEAM educator [11, 12].

The aims of the STEAMCompEdu framework are twofold [9]. On the one hand, it aims to be usable by educators for self-assessment to evaluate themselves and find specific competences they need to improve. On the other hand, it supports their professional development as a guide for formulating the learning outcomes of specific training programs and as an assessment tool for evaluating the training program. It is organized in a top-down approach; the top level contains five perspectives that cover the most critical aspects of the educator's role:

- Educator as teacher-trainer-tutor, implementing the educational procedure
- Educator as designer and creator, designing and producing outputs
- Educator as orchestrator and manager, coordinating procedures and outputs
- Educator as a community member, interacting with the environment
- Educator as professional, developing and applying competences.

Each perspective comprises a set of dimensions (competences) combined in areas, i.e., coherent groups of competences. Each perspective includes a different group of competences (areas), including five perspectives, 16 areas, and 44 competences. Table 1 presents the STEAM Educators Competence Framework perspectives, different areas of the competence framework, and one example of each competence/statement.

Table 1. STEAM educators' competence framework perspectives, areas, and example of competences

Perspective	Area	Example of competence/statement
Educator as teacher-trainer-tutor/implementing the educational procedure	Pedagogy	Apply collaborative learning methods in STEAM related activities
	Content Knowledge	Understand what STEAM education approach represents and what it means
	Instruction	Guide STEAM-related activities
	Use content and tools	Organize and share appropriate content and tools for STEAM education
	Learner empowerment	Ensure accessibility and inclusion in STEAM related-educational procedures
	Feedback and Assessment	Use assessment strategies for STEAM education
Educator as learning designer and creator/designing and producing outputs	Course/curriculum/activity design	Design STEAM-related courses
	Content and tools design and development	Create and modify appropriate content for STEAM education
	Learner development	Facilitate learners' STEAM competences
Educator as orchestrator and manager/coordinating procedures and outputs	Educational Procedure management	Apply teaching organization methods for STEAM education
	Resource management	Apply educational resources management methods for STEAM education

(*continued*)

Table 1. (*continued*)

Perspective	Area	Example of competence/statement
Educator as a community member/interacting with the environment	Community building	Engage in institutional-based communities for STEAM education
	Application of policies	Apply policies that promote STEAM education approach
Educator as professional/developing and applying competences	Transferable skills	Apply ethic skills
	Digital skills	Develop digital literacy skills
	Professional development	Participate in lifelong learning experiences related to STEAM educational approach

2.2 Development Methodology

The development methodology of STEAMEdu SAT tool design is based on self-assessment questions, following the successful practice of SELFIE and SELFIEforTeachers and the three principles that they used during their tools development [13]: (i) to condense and simplify the critical ideas of the framework, (ii) to translate competence descriptors into concrete activities and practices, and (iii) to offer targeted feedback to teachers according to their level of competence for each of the indicators/competences. Following these principles, 44 items were developed so that each competence of the STEAMCompEdu is represented by one item. Each item consists of a statement describing the core of the competence in concrete, practical terms, and examples were added when possible. The educator is asked to select the answer that best reflects their practice for these 44 obligatory items. The questionnaire format follows a simple 1–5 answer scale from "Strongly disagree" to "strongly agree" and one extra option for not applicable (N/A).

Regarding its technical development, the technologies used to implement the specifications include PHP, Javascript (JQuery), HTML5, CSS3, and MySQL Database. The open-source CMS WordPress platform was exploited. The platform consists of a management interface for entering questions, relating the questions with questionnaires, and relating questionnaires with users. It also includes a complete user management interface, page management functionality, and a complete interface for the platform's settings. Only the platform administrator has access to the content management environment of the platform. The main entities of the platform are the questions, the questionnaires, and the users, as presented in Fig. 1.

We designed the questionnaire application with two different options, one for individual use and another for use by groups of educators. In the group mode, there is also an

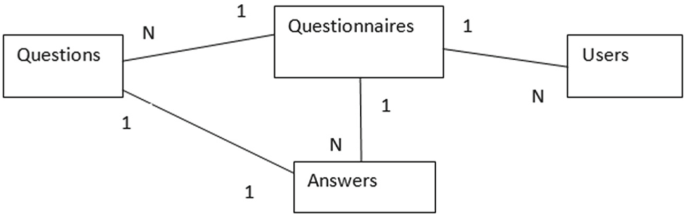

Fig. 1. The main entities of the platform

additional feature that allows both optional and custom items so that the questionnaire can be personalized based on the needs of each educational organization. The first step in using the platform requires the registration of the User. Then, the Users logs in to the Account. After the User fills in and selects all the necessary options and data, the tool activates the questionnaires for a specific period. Finally, the questionnaire deactivates at the end of the provided period. The tool generates a detailed report with the results that can be accessed only by the User through their platform account. Once participants have completed the questions, the SAT tool generates a report including a visual presentation of the results. In the case of individual self-assessment, the answers to the questions are not anonymized. Only the platform administrators and the registered User (educator) who answered the relevant questionnaire have access to those data. The results are fully anonymized in the group of educators' assessments. They can be accessed only by the User (educator or representative of the school organization) who sets up the questionnaire at the SAT tool. Access to specific survey data has only those Users who have generated the questionnaire. The policy adopted by the STEAMEdu SAT tool regarding personal data protection fully adheres to the General Data Protection Regulation (EU) 2016/679 (GDPR) recommendations.

3 The STEAMEdu SAT Tool

The STEAMEdu SAT tool was designed as an online tool, including information pages with all the general information about the tool, guides, and sample reports (Fig. 2). At the guides section, Users may find a tutorial on how to use the tool. Users to use the tool can easily register and fill in the necessary demographic data through the account selection. In the Login / Registration screen, Users can select the Register link to create their accounts. First, the User must enter a valid email address and a password. After successful registration, a message will be sent from the platform to the User's email containing the link that the User will have to follow to activate the account and select the purpose of using the questionnaire (for individual or group educator purposes) (Fig. 3).

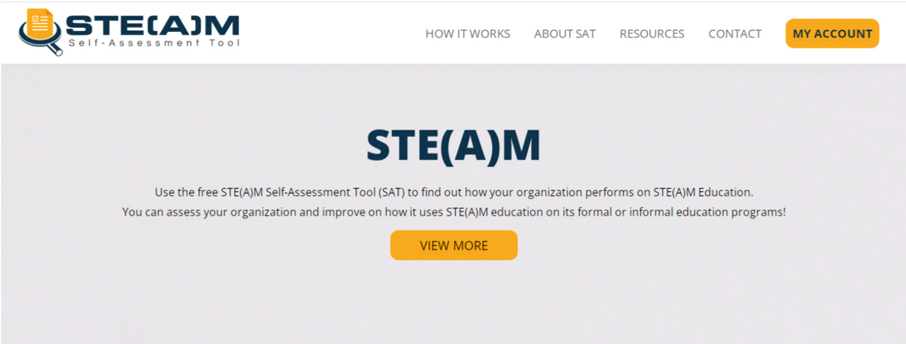

Fig. 2. Main page of the STEAM SAT tool

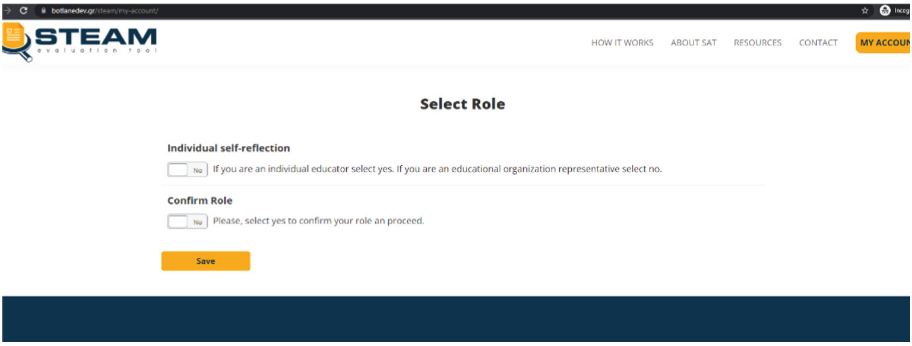

Fig. 3. Selection role during registration

Individual Self-assessment. Educators can easily register to the tool and fill in the necessary demographic data through account selection, such as name, surname, gender, and country. This data is used to create the educator profile in the tool and the personalized report. After registering in the tool, educators have to fill in the active questionnaire. When all the items are completed, the tool generates a customized report using graphs (see examples in Fig. 4 and 5). Per perspective, area, and each item (competence), the results are provided. This assessment aims to support teachers' professional development by helping them reflect on their practices and identifying strong and weak competences areas that are important for STEAM education. Note that the User can repeat the questionnaire at any time and see all the generated reports on the history page. This iterative process will help track the progress and make other necessary changes.

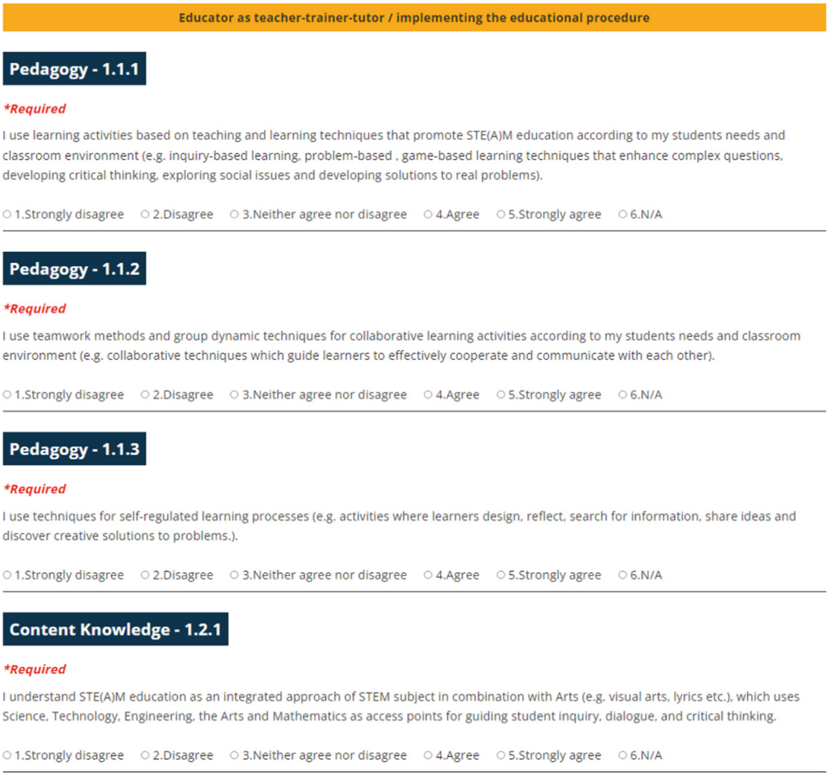

Fig. 4. Active questionnaire of the STEAM SAT tool

Group of Educators' Self-assessment. To set up the questionnaire for a group of educators (for example, for the teaching staff of a school), an authorized representative (an educator or a manager/director of a school) must first register on the platform and then set up the questionnaire. Then, he/she can have an overview of all the tool's standard (mandatory) questions and set up the questionnaire's active period. He/she can also select from a list of optional questions or add a few custom questions to "adapt" the self-assessment as much as possible to the specific school. After the questionnaire is set up, a link is produced, and he/she has to invite the school educators to participate in the self-assessment on an anonymous basis during the active period of the questionnaire. After the end of this period, the tool generates a report containing the results. In addition to the abovementioned uses of the tool for groups of educators, this assessment can help start a dialogue within the learning and school community about ways and actions to better support STEAM educators.

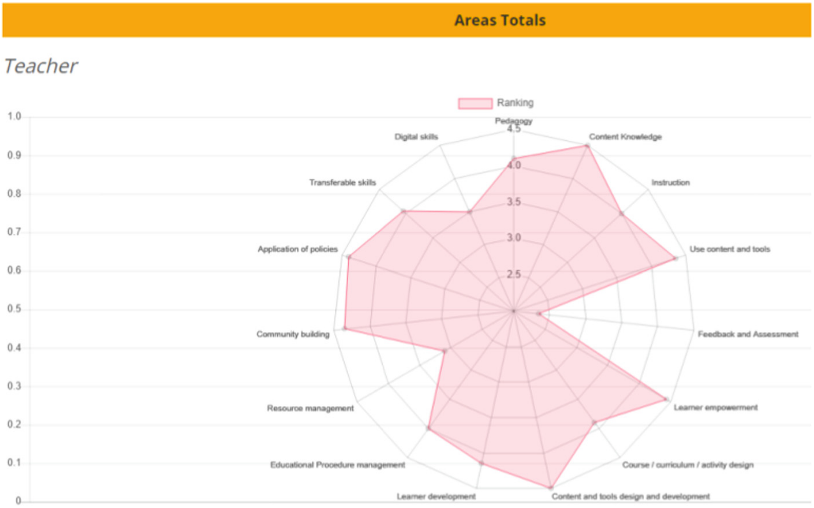

Fig. 5. Overall graph preview of the all areas score results

4 User Evaluation of the STEAMEdu SAT Tool

Users evaluated the STEAMEdu SAT tool during an online training program[3] for STEAM educators that was organized in the context of the STEAMonEdu project in September 2021. Participants in the evaluation were educators from different countries and different types and levels of education. One training program module contained practical and critical reflection activities regarding the design of European Skills, Competences, Qualifications, and Occupations (ESCO) job profiles for STEAM educators and the development of Self-assessment tools to support STEAM education in the classroom and educators. Thus, an online workshop was organized to support educators in identifying the aim of the self-assessment tool for STEAM educators, how to use it and how to assess it with all the necessary guides and steps.

4.1 Evaluation Methods

To evaluate the STEAMEdu SAT tool, we used an evaluation questionnaire that included questions about the tool's usability to help us gain knowledge about the usability of the proposed tool, as well as closed and open-ended questions related to the content of the tool (self-assessment questions and assessment report). The tool's usability was evaluated using the System Usability Scale (SUS), which was first introduced by Brook in 1996. Currently, it is one of the most reliable and widely used methods to evaluate usability. The SUS questionnaire contains 10 questions [14]. Positive and negative items or questions are used alternately to balance the variance biases and this encourages respondents to answer the questions after thinking carefully [14]. Respondents answer the question using a seven-point Likert scale from 1- Strongly Disagree to 7-Strongly

[3] https://mooc.cti.gr/steamonedu.html.

Agree. According to Bangor et al. [14], a SUS score above 51 is interpreted as "OK" with low marginal acceptability ranges, a SUS score above 72 is considered acceptable with "good" usability levels, and a SUS score above 85 corresponds to "excellent" usability levels.

The evaluation questionnaire was delivered online as an embedded survey on the LMS Moodle course in which the training course was implemented. The questionnaire contained four sections; the first section included questions to collect demographic data about the user sample, such as country, gender, occupation, and STEAM education expertise. The second section provided the SUS questions on the STEAMEdu SAT tool, closed questions regarding the organization (structure, examples) of the questions in the tool, and open space for comments regarding the tool's design. The third section included questions regarding the report of the STEAMEdu SAT tool, where participants were asked to provide strong points (advantages) and disadvantages. Finally, the final section asked the users to record their overall impressions and provided an open space for recommendations for improvement. Before proceeding to the questionnaire, stepwise guidance was provided on how to use the tool. It was required to fill out all the questions in order to be able to submit the form; thus, there were no missing values.

For the data analysis, the qualitative outcomes emerged from the free texts of participants and generated corresponding explanations, whereas statistical analysis for the close-ended questions and SUS was carried out.

4.2 Evaluation Results

Demographic Data

The participants who completed the questionnaire comprised 36 educators from 6 different countries and different types and education levels. 58% came from secondary education, 17% were primary school teachers, 11% were pre-school teachers, and 14% were from non-formal or lifelong learning education. In terms of STEAM teaching experience, 83% had previous experience. More details on the demographic data are illustrated in Table 2.

Table 2. Number and percentage of participants per background characteristics.

Educators' characteristics	Survey Respondents	
	n	%
Gender		
Female	32	89
Male	4	11
All	36	100
Country		

(*continued*)

Table 2. (*continued*)

Educators' characteristics	Survey Respondents	
	n	%
Greece	23	64
Turkey	2	6
Bosnia and Herzegovina	1	3
Italy	4	11
Romania	4	11
Spain	2	6
All	36	100
Current Occupation		
Pre-school Teacher	4	11
Primary School Teacher	6	17
Secondary School Teacher	21	58
Educator in non-formal education	2	6
Educator in adult education/lifelong learning education	3	8
All	36	100
STEAM expertise		
No experience	6	17
Some experience	20	56
Experienced	9	25
Expert	1	3
All	36	100

System Usability Scale and Overall Impression from Using the Tool

Results showed that the tool had a usability score of 76%, indicating that it is considered acceptable as having "good" usability levels; however, some improvements could enhance the users' experience while using this tool. The results of the positive tone questions for the STEAMEdu SAT tool have fewer "strongly agree" scores (see Fig. 6 and 7). Looking at the results of SUS(7), 16.7% of the respondents answered "strongly agree", while looking at the negative tone question SUS(8), 19,4% of the responders answered "strongly disagree"; from these, we can deduce that uses may need some time to learn how to use this tool. However, from the results of SUS(4) presented in Fig. 6 and SUS(5) shown in Fig. 7, it can be deduced that the usability issue of the tool concerns its efficiency. Regarding the organization of the tool's questions, 89% of the participants answered positively (Fig. 8).

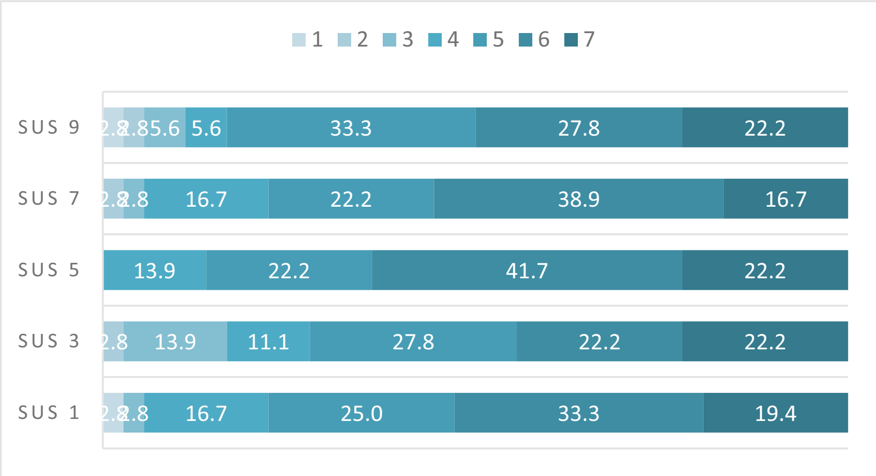

Fig. 6. SUS Positive tone questions for STEAM SAT tool

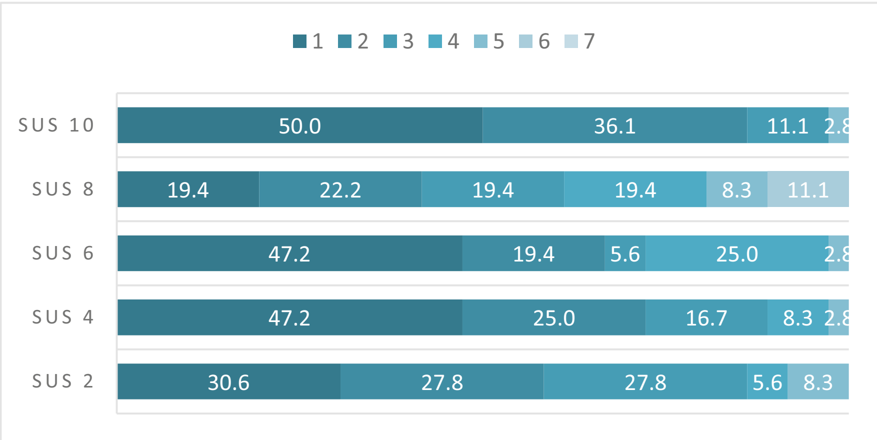

Fig. 7. SUS Negative tone questions for STEAM SAT tool

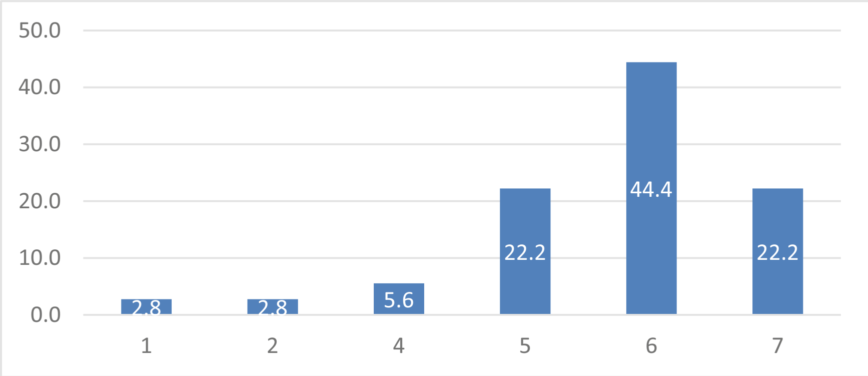

Fig. 8. Results from the statement "The questions were organized (structure, examples) in a manner that helped me understand the underlying concepts"

Open-Ended Comments and Recommendations

Comments from the users posted on the open-ended questions included general responses to STEAMEdu SAT tool. More importantly, the tool was characterized as helpful in reflecting on the various roles of educators and on how they could improve their roles.

The stronger point of the report was the structure and the multi-modal presentation of summarizing results, while, regarding the weak points, participants commented on issues regarding the non-availability of the tool in more languages than English and the long length of the report.

In addition, participants proposed some improvements, including translating the tool into other languages, implementing a version for mobile devices, and creating a history page to track the user's progress. Furthermore, educators proposed diversifying the questionnaire based on educational level and including questions for students. Finally, educators proposed to include specialized recommendations based on the results of the produced reports.

5 Conclusion and Next Steps

This paper presents the design, development, and assessment of a self-assessment tool for STEAM educators. Based on its first pilot test, educators expressed their opinions on their experience with the tool while describing its design and content improvements. The majority of educators find the tool helpful and usable. At the same time, they proposed to be translated into other languages to be accessible to more educators. The following steps include improvements based on educators' comments. More specifically, we will adapt it to self-evaluate educational organizations, where students, educators, and directors have to answer different questions. In this case, the produced report will be provided to assess the educational organization's capacity to offer STEAM education and identify improvement gaps.

The STEAM SAT tool can be freely accessed at https://steamonedu.eu/settool/.

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A Systematic Literature Review on the Learning Technologies Implemented in Organizations

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Abstract. Many organizations' performance and survival challenges need dynamic capabilities and technology to speed the development of those capabilities. Companies are constantly visiting the strategies used in learning as a crucial element in preparing their workforce for the accelerated changes. Learning Technologies stand as a facilitator of these challenges, which is why they are so important. There is still a good margin of exploration in the field of the learning technologies. The reality is that a reduced number of studies explore the technology as important in accelerating innovation, performance, and competitiveness. The present research will focus on the strategic implementation of learning technologies. The approach we chose to solve this problem is to develop guidelines that support the strategy for implementing technology in the learning field. The approach will allow us to relate the strategy with the challenges and the impact the organization is expected to achieve.

Keywords: Learning organizations · Technologies · Learning & development

1 Introduction

Nowadays, organisations operate in a transforming context, guided by a changing and accelerated environment. In their efforts to quickly pivot for a more agile operating model, they understood that enabling collaboration and leveraging enriching experiences to their human capital is important. This is needed to create the conditions for continuous learning and the rise of the needed capabilities. L&D teams are gradually shifting to the spotlight of the organizations' strategies to lead this vision and prepare the workforce for rapid changes and demands. The transformation faced at the business level is transversal to the L&D operations. Currently, plenty of new learning technologies can accelerate this mission and, in some cases, guide the evolution of the learning strategy itself. It is not an easy action. Learning Technology becomes much more massive every day, and we may find several cases where huge investments are made without clear evidence of the added value to the organization [1]. A Market Report from Grand View Research, presents that he global education technology market size was valued at USD 106.46 billion in 2021 and is expected to expand at a compound annual growth rate (CAGR) of 16.5% from 2022 to 2030. Education technology (EdTech) includes hardware and

A. Reis et al. (Eds.): TECH-EDU 2022, CCIS 1720, pp. 241–252, 2022.
https://doi.org/10.1007/978-3-031-22918-3_18

software technology used to educate students on a virtual level to improve learning in classrooms and enhance students' education outcomes [2]

While it is easy to point the finger at technology, it is not software which is the problem but how it has been implemented [3]. One KPMG study into project failure concluded that only 7% of project failure was due to hardware and software issues. The study mentioned that 17% was due to failure to define project objectives, 20% was attributable to poor communications, 32% to poor project management and 17% to poor management in the transition of issues [3].

Technology implementation and it connection with the business, need to appear in parallel and inform one another. An organization should not prepare a new strategy without assessing the real potential of new technologies that they may consider, and in the opposite organizations should not adopt new systems without a closer look at the strategy planning [4]. Strategy implementation (SI) is therefore a crucial component of why some organizations outperform others as even a well-formulated strategy cannot guarantee success until it is effectively implemented [5].

2 State of the Art

2.1 Learning Culture

Learning culture is an environment that encourages and where we observe individual and collective learning. The acquisition and the sharing of knowledge is prioritized, valued, and recognized. It's part of the organization's ecosystem [6]. In organizational learning cultures, team members have the time and space to continually grow their knowledge and develop new skills. The learning aims to improve employee performance and support personal and professional growth [7].

More and more organizations are willing to become learning organizations because it's an imperative to continuously adapt, learn, retain and transfer new skills and processes to stay ahead of the competition [8]. Because learning is essential for employees to develop new skills and find fulfilment in their work, companies that foster a learning culture and offer development opportunities are laying the groundwork for long-term success with a team of engaged employees who do their jobs well. A learning culture is a particularly important element of sustainable success in business because it positively impacts strategy, innovation, employee engagement, employee retention, and many other elements of an organization [7].

However, for the majority of organizations, the ideal of the learning organization has not yet been realized. Over the past two decades, organizational research has revealed three broad factors essential for organizational learning and adaptability: a supportive learning environment, concrete learning processes and practices, and leadership behavior that provides reinforcement [9].

2.2 Learning Technologies

In order to narrow down the research, we selected the following learning technologies:

- Learning Management System (LMS), is a software application or web-based technology used to plan, implement and assess a specific learning process [10].
- Learning Content Management System (LCMS) that allows users to create, manage, host and track digital learning content [11].
- Social Learning Platforms (SLP), are solution that organizations can use to create, manage, and deliver employee training programs. They enable learners to interact based on the model of social media platforms like Facebook, LinkedIn, or Instagram [12].
- Learning Experience Platforms (LXP), are user-centric learning software built for businesses and consumers to learn, grow skills, discover new information, and engage with peers and leaders across the organization [13].

3 Systematic Literature Review

In this work we performed our Systematic Literature Review (SLR) guided by Kitchenham's Procedures for Performing [14] (see Fig. 1).

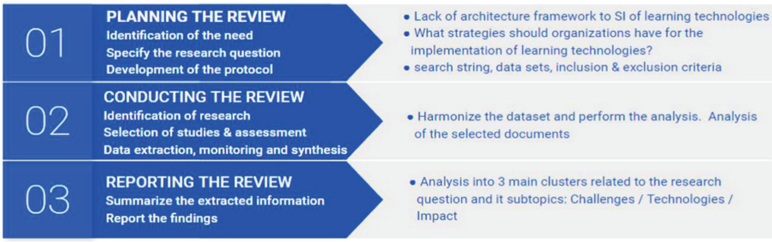

Fig. 1. Systematic Literature Review Phases adapted to this research

The section is divided into the three phases of the SLR - Planning, Conducting, and Reporting.

3.1 Planning

In this section, the SLR planning is detailed. Motivation and review question is specified, protocol review is presented and inclusion and exclusion criteria are identified.

Research Motivation
Implementation of learning technologies is an ongoing practice done in several organizations. We are in a context where learning technology is evolving faster and learning strategies are closely connected with the technologies selected. However, since the implementation of technologies is a combination of different areas (IT, Management, Talent) there is a lack of reference models that can guide this implementation to succeed. This work intends to get information regarding the challenges that organizations are facing, the technologies being implemented, and their impact on the organization's field.

Research Questions (RQ)
The aim of this systematic review is to answer a basilar question:

RQ1 - What strategies should organizations have in consideration for the implementation of learning technologies?

In order to achieve this objective, we proceed with an analysis on 3 areas:

- *The most important challenges recognized by the companies*
- The learning technologies implemented
- *Impact of implementing that specific learning technologies*

Review Protocol

Given the research goals of this review, Population, Intervention, Comparison, Outcomes and Context (PICOC) was defined, using the following components:

- Population: Organizations,
- Intervention: Technology, Systems and Platforms
- Comparison: not applicable
- Outcome: Learning Strategies

Based on the PIPOC analysis the search string used to perform the search are listed below.

Search String: organizat* AND ("learning management system*" OR "content management system*" OR "knowledge management system*" OR "learning experience platform*" OR eContent OR "mobile learning" OR mlearning) AND (technolog* OR system* OR platform* OR "learning strateg*") AND ("learning culture" OR "learning organizatio*") NOT ("high* education" or "universit*" or "college*" or student*)

The chosen datasets were SCOPUS and EBSCO. The "*" sign was used at the end of some keywords to expand the range of possible studies. In SCOPUS instead of operator NOT it was used AND NOT.

Inclusion and Exclusion Criteria

In order to filter the obtained papers after the search string application, different inclusion and exclusion criteria were defined.

The criteria for inclusion considered are records:

- Related to organizations and learning technologies, revised by peer review, from
- Academic Magazines, Journal, Articles, Reports, and Books, related to high education, university.
- Related to projects focus on TQM (Total Quality Management), not in English nor fully available, and published before 2015

The review protocol process is illustrated in Figure 2 (see Fig. 2).

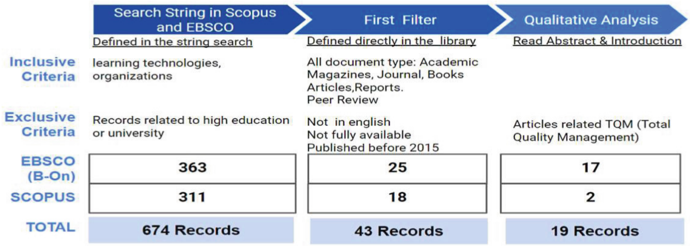

Fig. 2. Review Protocol

3.2 Conducting

This Section concerns the second phase of the Systematic Literature Review Methodology. The documentation management of all studies reviewed was done on Mendeley, an open- source desktop application to search and organize all references.

Selection of Studies

As a first action, the search string was used in EBSCO and Scopus Database. An exclusion criteria was defined in the search string due to the high volume of records found in the first results. Secondly, the exclusion and inclusion criteria were applied directly in the databases to perform the first filter. Afterward, a qualitative analysis was performed and all abstracts and introductions were screened in order to decide their relevance to the research. A final set of papers was obtained which is the final selection of studies to perform the review.

Data Extraction Analysis

Considering the 19 resources selected we analyzed the year that the records were published. An almost gradual increase of articles published is observed since 2015 but with a substantial decrease in 2021 (see Fig. 3).

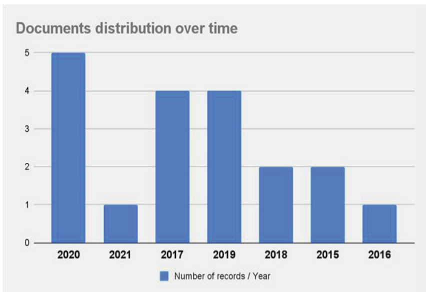

Fig. 3. Documents Distributed over time

In order to help us identify the areas from which the documents were selected, Figure 4 presents the distribution of underlying theories (see Fig 4).

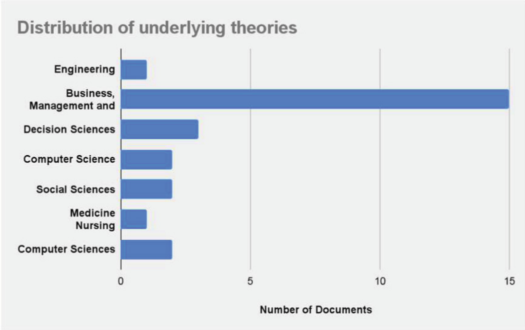

Fig. 4. Distribution by Underlying Theory

We can analyze that the subject is common to different areas, having a stronger highlight in Business and Management Theories. Considering that the implementation of technologies is also an important subject in the field of computer science, it's surprising that this domain does not have a higher number of documents.

3.3 Reporting

This Section concerns the last phase of a Systematic Literature Review. In this section, we present the answers to our Research Questions. Table 1 shows an overall view of the documents, and the created cluster of the findings per Research Questions (see Table 1.)

Table 1. Comparison of QRs and number of cited findings

Research questions	Findings	Number
1.1 Challenges	Knowledge as a cycle/Upskill/Reskill	11
	Employee's engagement and growth	4
	Technological: System Integration	1
	Great Resignation	1
	Technological Accelerated Evolution, Continuous4 Change, Competition	4
1.2 Technologies	Social Learning Platforms	2
	Knowledge Management System (theoretical)	3
	Learning Content Management System,	2

(*continued*)

Table 1. (*continued*)

Research questions	Findings	Number
	Learning Experience Platform	3
	Learning Management System	3
1.3 Impact	Diversity in the type of content	1
	Decision Data-Driven (Report)	3
	Increased efficiency	4
	Easily convert and share knowledge	4
	Cost reduction	2
	Building knowledge communities,	1
	Curation, Advanced search, Skills framework, User-	2
	generated content (UGC)	2

The analysis will now detail the findings for each Research Question.

Challenges Addressed by Organizations
All the challenges presented in this document were analyzed from a learning & development perspective.

Knowledge as a Cycle/Upskill/Reskill
This is a challenge that affects the different layers of the organizations and areas. In Macuglia Spanemberg (2020) we find the importance of knowledge management to the shop floor: *"The literature recognizes the importance of managing shop floor knowledge and capabilities as a means to create a long-term competitive advantage. Organizations need to adopt a strategic approach to manage the knowledge of workers, because high performance connects to tacit knowledge, to keeping employees that possess this knowledge, and to the ability to continuously reap their knowledge and skills (Kiessling and Harvey, 2006)."* [15]

The same tendency is found in the Knowledge Intensive Companies (KICs). For such organizations, their intellectual capital, people, is often their only or most precious and valuable asset. A key priority for leaders of KICs, therefore, is to maximize the creative value of their employees, stimulating innovative and creative behavior and creating new knowledge. Organizational leaders are also challenged with ensuring that their intellectual capital, their knowledge talent, is retained – that competitive edge is kept within their organizational boundaries [16].

– Employee Engagement and Growth

  "Developing a learning culture is no longer just another fanciful idea. It is becoming more imperative for companies to cultivate learning if they wish to stay in business" [17]. Inefficiency in the knowledge management system is the result of the knowledge workers' different perspectives regarding the value of those systems. A consolidated

process to share, and/or is knowledge hiding part of the way they work would be more efficient [16]. Employees are putting in ever shorter tenures in positions and showing general growing impatience with typical learning technology solutions in an always-on, wired world [18].

– Technological: System Integration

  It can be challenging for learning professionals to manage and tell a convincing story about the digital tools part of the learning ecosystems of the organization. Therefore it may be an issue to the employees to understand how to create world-class learning experiences, to enable teams to rapidly build and iterate content, and measure the outcomes [19].

– Technological Accelerated Evolution, Continuous Change, competition

  Recent decades have seen a dramatically accelerating pace in the development and adoption of new technologies, even though various gaps persist in terms of adoption in different parts of the world, especially in the least developed countries. This rapid technological change is affecting almost every area of the economy, society and culture [20] (UNCTAD, 2022). In the way we work, this technological advancements brings digitization of work that enabled employees to connect to each other from one location, something not possible before [16].

– Great Resignation

  The Great Resignation, a term coined in May 2021, describes the record number of people leaving their jobs since the beginning of the pandemic. After an extended period of working from home with no commute, many people have decided their work-life balance has become more important to them [21]. A Pew Research Center survey found that who quit a job in 2021 say low pay (63%), no opportunities for advancement (63%) and feeling disrespected at work (57%) were reasons why they quit, according to the Feb. 7-13 survey. At least a third say each of these were major reasons why they left [22].

Learning Technologies Implemented

From the literature review, we identified that not all challenges have addressed a learning technology implementation. A systematic map to understand the impact of investing in knowledge for a production line, and correlations between the main variables were defined when looking for knowledge management [15]. The same was done in Müller et al. (2021) where it described factors influencing the transfer of operational knowledge and what a conceptual framework might look like in this context.

– Learning Management System (LMS)

  Three LMS implementations were analyzed. Balavadze & Zhgenti, explorer the Moodle- based Learning Management System (LMS) as a learning technology where employees can share knowledge and experience in the Bank of Georgia [17]. John Palmer, the Vice President at AT&T shared that to follow a strategy to reskill their employees, the companies decided for a implementation of an LMS [23].

– Social Learning Platform

  Social platforms are technological knowledge management designed to capture both explicit, or documented knowledge through the documentation of knowledge in an organizational repository, and implicit, or undocumented knowledge, through the development of databases, or knowledge maps which are designed to replicate social networks [16].

– Learning Content Management System

  In practice, an e-learning system is often utilized to foster professional development as it is capable of delivering information and knowledge to individuals across organizations. More than half (63%) of corporations in South Korea implemented an e-learning system in 2011. [24]. In 2013, AT&T offered an online master's degree in computer science, that represented an investment of $2 million, with the objective to develop future tech talent. The initiative also pursued equip their employees with crucial skills for their business. More than 4,000 students were enrolled [23].

– Learning Experience Platform (LXP)

  eLearning Industry had enumerated the following advantages by implementing an LXP:

– Advanced content and social tracking to manage performance
– Increased rates of employee and customer retention
– Improved levels of engagement and productivity
– Consistent and direct forms of communication
– More powerful brand voice and brand loyalty
– Builds successful cross-functional teams and relationships

An LXP has the ability to store and monitor data and analytics, which leads to a more advanced interface and the ability to track data. Employers can use this data to see how their employees are performing and learning in order to maximize their ROI and adjust their learning and developmental goals accordingly [25].

Impact of the Implemented Learning Technologies

As a result of the implementation of learning technologies, we identified the following impact:

– The Moodle in the Bank of Georgia, brought better productivity, efficiency, and profit. From a user perspective, employee are now taken part in the process of knowledge sharing and the sense of being accountable for the organization's accomplishments increased. There are new ways of learning with videos, procedures or instruction as well as tutorials. From an admin perspective, the reporting capabilities are also a benefit [17].
– In terms of the implementation of Learning Content Management System, we identified that in average 15% of the learners complete a MOOCs (massive open online courses). Being this a low average training budgets can be seen as a wasted and expensive resource[26]. Anyway, we find positive impact. E-learning leverage learning across organizations while making possible to update capabilities worldwide in a consistent and diverse way (various formats) [24].
– eLearning Industry had enumerated the following advantages by implementing an LXP:

  • Content more advanced and social tracking

- Better rates of employee retention
- Improved levels of engagement and productivity
- More direct ways of learning communication
- More powerful brand voice and the possibility to create a brand loyalty
- Builds successful cross-functional teams and relationships

An LXP can store and track data and analytics, which contributes to a more advanced interface. L&D professionals can use this data to see how their employees are performing and learning in order to maximize their ROI and adjust their learning and developmental goals accordingly. This contributes to better data driven decisions [25].

4 Conclusion

L&D teams are gradually shifting to the spotlight of the organizations' strategies to lead this vision and prepare the workforce for rapid changes and demands. The transformation faced at the business level is transversal to the L&D operations. Currently, plenty of new learning technologies can accelerate this mission and, in some cases, guide the evolution of the learning strategy itself. It is not an easy action. Learning Technology becomes much more massive every day, and we may find several cases where huge investments are made without clear evidence of the added value to the organization.

In the Systematic Literature Review, 3 main dimensions came to light when we looked at the implementation process. Learning technology implementation to be successful needs to go beyond the technology alone. It must be aligned with the business needs and what the employees (users and learners) value. The second dimension is to identify how the technology can best support those objectives. The third dimension is the Impact, expected and achieved. Structured and strong planning is crucial, and it starts even before the decision on the best technology. A proper strategy is required that facilitates the analysis of the 3 dimensions of successful implementations: Challenges, Technologies and Impact.

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Integrating Video Production in Early Ages to Promote Motivation for Mathematics and Transversal Competences: Examples from ViduKids Project

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Abstract. Aiming to develop a whole approach education for mathematics in early ages that involve video production by children, in this paper it is described the Erasmus + project ViduKids no. 2020–1-NO01-KA201–076442 aims, pedagogical approach and activities developed. The tasks developed in the scope of the project involve children exploring how to use images and videos to illustrate mathematical concepts, as shapes, numbers, and space. At the same time, children must get familiar about how to use cameras and other devices in order to develop their ideas and projects and learn about videos techniques production as one-shot video or stop-motion. When producing their own videos, children visualize and reflect on mathematical concepts, and at the same time it is expected that they develop transversal competences as communication, cooperation, creativity, and problem solving. Examples of activities developed so far are presented, namely 'an explorer mission', 'a story with mathematical with content', 'problem solving with stop motion', and 'playing a game and reporting'.

Keywords: Video · Early ages · Mathematics · Motivation · Transversal competences

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1 A Whole Approach to Education

The challenges of contemporary education, referred by Delors [6] constitute a classic but also current reference. In this context, some of the challenges are the development of competencies and skills to deal with permanent change and to rapid development of knowledge. For this, and continuing to refer to Delors, it is important to promote knowledge in a perspective of deep understanding, involving learning to learn but also knowing how to do, the development of a cohesive and secure sense of self, and the ability to live together (ibid.). Taking into account the role that technologies assume in all dimensions of life today, the development of skills at this level has emerged as a priority, fundamental for full social and educational inclusion [9]. It is also fundamental that the development of ICT skills is done in a reflexive and critical perspective, with educational intentionality.

In order to face the objectives and challenges mentioned above, it is important to develop educational strategies that allow the integrated and integral development of diversified competences, academic and technical but also transversal competences that enhance personal and social development and the collective well-being, elected by OECD [22] as the "north" of the compass for education 2030. In this, 'the integral development of the child is currently one of the objectives of education, which implies the use of activities and strategies that involve the various dimensions of the human being in an articulated manner' [33, p. 352].

In this scope, the challenge is to plan and implement activities that address different dimensions of the child development and child individuality, differentiated competences in respect also the abilities of each child. This implies to challenge the child to interact in different groups, presenting their ideas and being able to listen to others' ideas, learning to communicate effectively, dealing with complex problems and different points of view.

There are several designations that can be used for educational approaches aimed at the integral development of the human being, e.g. whole approach education, 3H pedagogy, which encompasses Heads-on, Hands-on and Hearts-on and is characterized by 'take a whole-child perspective to engage students' cognitive, social, communicative, physical, and psycho-emotional skills' [12]. The core idea is to implement pedagogical approaches that involve and promote different competences at the same time and that are implemented with educational intentionally.

2 Searching for a Whole Approach for Mathematics Education

The development of mathematical skills is considered fundamental in both in educational and social terms. Mathematical knowledge may contribute significantly to the global learning process [7, 8, 10], to the development of intellectual autonomy, reasoning, critical thinking, logical thinking, interpretation, argumentation, social and affective relationships, as well as, when necessary, making interventions in the environment in which one lives [15]. Being one of the fundamental dimensions for the integral development of the children, mathematics should make sense in their learning and in their daily lives [15]. However, this view contrasts with the results obtained in the meantime by children and young people, e.g., Pisa results [23], their lack of motivation to study the subject or to choose courses or jobs involving mathematics [9, 25]. There is some evidence that this poor engagement and interest in mathematics starts in early stages of development and schooling [1, 24] thus putting early childhood mathematics in the international spotlight [26] and justifying the need to develop educational strategies to change the situation.

The Erasmus + project ViduKids no. 2020–1-NO01-KA201–076442 contributes to this discussion as it aims to promote mathematics motivation and learning in early ages in a whole educational approach, developing innovative pedagogical methods taken from the ideas within the rich technology ecosystem that surrounds video production.

3 ViduKids Erasmus Project Aims and Scope

The potential of using videos for educational purposes has been extensively explored. (e.g. [16, 19, 21, 27]). Videos can be used in different contexts and with different educational aims and target groups (e.g. [17, 32]). Previously, Thiel et al. [30] have shown that video production in primary school classrooms helps mathematics learning. By producing videos, children experience mathematics in an engaging and enjoyable way. ViduKids carries this over to younger ages. Video production in early childhood is possible, but still controversial [14]. In this project, the children become an active part of the video production process in order to support mathematics understanding and promote competences such as communication, cooperation, autonomy, creativity, and problem solving [18].

The ViduKids project's target group are preschool children and their educators or teachers. The aim is to explore how video production by the children contributes to visualize and reflect on mathematical concepts, to using video to explore mathematical contexts (ibid., p. 229). The images can help to illustrate mathematical concepts and can connect them with the real world [28]. The mathematical concepts are taken from three content areas space, shape, and number, which are related to four of the six fundamental mathematical activities proposed by Bishop [2]: Locating is exploring one's spatial environment. It includes spatial relations (left, right, front, rear, top, bottom, in front, behind, outwards, inwards, though, up, down, outside, inside, …) and spatial imagination (to visualize how parts will fit together). Designing is creating a shape for an object. It is about shapes (circle, triangle, rectangle, square, …) and their properties (round, pointed, oblong, symmetrical, corner, side, …). Counting is a systematic way to compare and order discrete phenomena. It involves tallying, using objects to record, compare and order discrete phenomena, and using number words (e.g., five wooden sticks, four cars, three stones, two animals). Measuring uses numbers to quantify qualities for the purposes of comparison and ordering (longer, shorter, as long as, twice as long as, …).

We used three different approaches: exploration, storytelling, and problem-solving.

1. According to the theories of Dewey, Bruner, Piaget, and Vygotsky (cf.[11]), children have to explore the world to construct their own concepts. Even though mathematical concepts are abstract, they are often related to structures of the physical world, which children can explore [28].

2. Play supports children to engage naturally with mathematics [4]. One way to engage children in mathematical play is to start with a story. It can be a traditional fairytale [5] a modern children's book [18], or a narrative that the children create by themselves.
3. Problem-solving is not only an important goal of mathematics lessons but also one of the most important methods of learning mathematics [20]. Even young children learn in kindergarten that mathematics can help them solve a variety of problems [3].

There are different video techniques that can be used. In the ViduKids matrix, we propose three main techniques [29]:

1. recording video in one-shot – without any video editing, or taking pictures and letting the software app automatically create a slideshow,
2. stop-motion animation – a basic type of video animation where still images are put together in a software app or video editing software. Objects are moved slightly and a freeze frame is taken after each motion. The images are put on a video timeline with a short duration between each. In the final video, it looks like as if the objects are moving automatically. The video gives us the idea of a cartoon. To give an idea of 'in motion', Stop-motion is a great tool.
3. creative explorations – this technique is open to different video production ideas and requires 'proper' video production including camera work and video editing.

In the following, we present some examples of tasks developed so far.

4 Examples from ViduKids Erasmus Project

4.1 Example 1: An Explorer Mission

An explorer mission challenges the children to observe and analyze the context and identify mathematical content, e.g., shapes, numbers and space. Examples of tasks that we tried in the project are 'Find round shapes!' (Fig. 2, https://youtu.be/cILBDHog_QA) and 'How many leaves are on the ground?' (Fig. 1).

Fig. 1. 'How many leaves are on the ground?' (Authors A.M., A.S., C.C., C.R.)

Fig. 2. ‘Find round shapes’

4.2 Example 2: A Story with Mathematical Content

In Figs. 3, we present ‘The house of the three pigs’ as an example.

Fig. 3. Making a stop-motion video about the ‘three pigs houses’

First, the children did a puzzle about the story. Following that, they choose the pieces to make the scenes, combining and recombining them and taking photos at each step. The task involved manipulating different geometric shapes of different sizes, exploring how to combine them in order to construct the houses. Counting was also involved.

4.3 Example 3: Problem Solving with Stop-Motion

As a mathematical problem, we chose 20 divided by 4 and 20 divided by 5 as described by Justnes [13, p. 8], but with rubber ducks. The activity had four phases.

1. Anne playfully presented the mathematical problem.
2. Supported by Anne, the children produced a Stop motion video that shows the solution to the problem.
3. The children watched the final video and added sound to it.
4. The whole kindergarten group watched the video together and reflected on it.

Our observations show that the method allows children to engage with the same problem four times naturally and playfully when (1) solving the problem, (2) filming (see Fig. 4), (3) adding sound, and (4) watching the video. In each phase, the children can have new experiences, recognize other possible solutions, and gain deeper insights in each phase [31].

Fig. 4. Solving- problem task example: ducks divide money

4.4 Playing a Game and Reporting

In the example presented in Fig. 5, the children explore the geometric shapes game. Children worked in groups of five persons. At the beginning, each group had a similar shapes. They had to exchange shapes with other groups to finally have only different shapes. The next task was to make constructions with the shapes, to find more shapes in the room or even create their own shapes. Children documented this process on video, namely in several one shot videos.

Fig. 5. Playing the geomtric shapes game and reporting

Children were actively engaged in the task, either in the shape task or the filming task. Each child made their own construction and made a one-shot video or took some photos. Children expressed joy and reported having appreciated all the process. When asked ‘Which did you like more, making the constructions or doing the videos?’, they said ‘both’. The educator referred that the activity promoted children’s engagement, attention and comprehension as well as collaboration and coordination among children.

5 Conclusions

The children’s interest and curiosity through contact with ViduKids allowed creative thinking and the search for solutions to problems through an autonomous, critical, and collaborative posture.

The resources developed by the ViduKids project promote improvements in engagement and learning. As soon as the video task was introduced, it immediately caught the children attention and interest. In order to produce their own video, children had to develop a mental representation of the task, and also imagine how to represent it in images. Children also have to find or produce resources for the video scenes, to readjust them according to the storyboard. Therefore, we can say that they enable the development of transversal skills such as creativity, curiosity and collaboration, thus acquiring new knowledge and the development of each children's skills in the area of mathematics.

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ICT and Critical Thinking in Higher Education

Teaching Critical Thinking– A Task-Based Approach: Work in Progress

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Abstract. While there is large body of literature devoted to teaching critical thinking (CT) in higher education, there is no consensus on what educational approaches and instructional methods are best for developing CT in students. Although many scholarly studies have explored various methods for teaching CT, there are still no conclusive findings about their impact. This study proposes a task-based educational approach that aims to teach both domain-specific skills and CT skills and dispositions. This approach integrates the teaching of CT into the subject instruction and can be applied across disciplines. To evaluate the impact of this approach on the development of CT skills in students, two educational experiments were conducted. For these experiments, two modules "Innovation management" and "Scientific seminar" were developed according to this approach and deployed at the University of Applied Sciences Emden/Leer. The Critical Thinking Assessment Tool, developed as part of the Think4Jobs project and proven in terms of validity and reliability, was used to measure students' CT skills and dispositions. At the time of writing this paper, this tool has been used to record students' self-assessments at the beginning of the experiments. As this study is still in progress, further data collection, data analysis and presentation of the findings will be published later.

Keywords: Teaching critical thinking · Task-based teaching approach

1 Introduction

1.1 Definition of Critical Thinking and Its Importance

Critical thinking (CT) is considered one of the key skills that citizens need in the globalized, digitalized societies. Although CT is frequently mentioned in society, business, research, and education, there is no consensus among experts on its definition. According to Lai [1], the definition of CT depends on the field in which the phenomenon of CT is researched and can be from psychological, philosophical, and educational backgrounds. However, several authors agree that CT includes both cognitive skills and dispositions [1, 2]. In this work, the definition of Facione [2] has been adopted which represents a framework with skills and dispositions characteristic of CT competency. This framework lists as CT skills 1) interpretation, 2) analysis, 3) inference, 4) evaluation, 5) explanation, and 6) self-regulation, and as CT dispositions 1) truth-seeking, 2) open-mindedness,

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3) analyticity, 4) systematicity, 5) self-confidence, 6) inquisitiveness, and 7)cognitive maturity. This definition is most appropriate for the purpose of this work, as these listed CT skills and dispositions can be easily used to define intended learning outcomes and assessment criteria of modules.

Society and business require higher education (HE) graduates to develop CT skills during their university studies in order to be able to use them in their profession [3] and as citizens. National and governmental organizations and initiatives, such as the Bologna process for education in Europa, have defined the development of both domain-specific and transferable skills, which include CT skills, as a goal for HE. As the development of CT skills is not necessarily accompanied by the acquisition of domain-specific knowledge and skills [4], additional efforts by HE institutions are required to provide students with these skills. Moreover, CT and higher order cognitive skills (see Bloom's taxonomy [5]) are more complex and require from students more efforts than the acquisition of domain-specific knowledge [6].

1.2 Challenges of Teaching Critical Thinking in Domain Specific Courses

EnniS [7] distinguishes four approaches to teach CT: 1) the general approach which attempts to teach CT separately from the presentation of domain-specific content, 2) the infusion approach which integrates teaching CT skills in the domain-specific content and makes CT principles explicit, 3) the immersion approach which is similar to infusion but does not make CT principles explicit, and 4) the mixed approach which combines the general approach with either the infusion or immersion approaches. In their meta-analysis of studies aimed at teaching CT and published between 1960 and 2005 [3], Abrami et al. have identified that the mixed approach was the most effective strategy for teaching CT, followed by the infusion and general approaches. The immersion approach had the smallest effect.

Teaching CT has been the subject of numerous programs and initiatives in both schools and HE institutions since the 1930s. Abrami et al.'s meta-analysis of relevant studies published between 1930 and 2009 [4] has revealed that two teaching methods - dialogue (or discussion) and student engagement with authentic problems – are particularly helpful for developing CT. These methods are especially effective, when combined with mentoring (e.g. teacher feedback).

Studies published after 2009 report various educational interventions aimed at teaching CT. In nursing education, multiple approaches are used to promote the development of CT, for instance problem-based learning, concept mapping, simulated clinical scenarios, and case studies [8]. Values and knowledge education approach, in which students are confronted with a moral dilemma, namely a conflict situation in which they must argue for or against a solution, has been recognized to be an effective approach to teaching CT in an undergraduate Psychology course [9, 10] reports that schoolteachers integrate teaching CT into their own subjects by focusing on the core concepts of their subjects, presenting students with examples that help them more easily understand new topics, showing students subjects-specific inquiry methods, and getting students to apply the acquired knowledge and skills in practice. In [11], the authors integrated rigorous performance tasks and a common rubric with corrective teacher feedback into a problem-based learning environment in three different fields: teacher education, social sciences, and life sciences. In the life sciences class, a performance task was organized as a research-based inquiry in which students practiced in making claims or hypothesizing, analyzing, evaluating, and integrating or synthesizing. The principles of critical thinking and the criteria in the rubric were made explicit to the students (approach 2 of Ennis [7]). The authors collected quantitative and qualitative data in their educational experiments. While quantitative data showed some limited statistically insignificant improvement in CT skills and dispositions, qualitative data of student reflections demonstrated positive changes in the development of CT skills and dispositions. They have concluded that their methodology could have a substantial impact if performance tasks are integrated into every module. Duron et al. (2006) [12] emphasize that CT takes place at the higher levels of Bloom's taxonomy [5] and propose a framework for encouraging students to think critically that includes the following five pieces of advice: 1)explicitly define learning outcomes, 2) use questions when teaching, 3)promote active learning, 4) monitor activities and collect feedback from students, and 5)provide feedback and organize self-assessment.

The studies reviewed integrate teaching CT into domain-specific modules and use teaching approaches and methods that promote active student participation and learning such as discussions, concept mapping, problem solving, use case studies, and written assignments, which is consistent with the findings of Abrami et al.. However, there are some deficiencies in these studies. Values and knowledge education approach with moral dilemmas is a specific approach applicable for teaching social sciences rather than engineering. Several studies do not provide guidance for teachers on integrating CT instruction into their modules and classes(e.g. [10, 12, 13]). Some studies ([11]) integrate teaching CT into the research-informed approaches such as problem-based learning. However, according to [14], problem-based and project-oriented learning has been found to have deficits in teaching domain-specific skills and fostering independent work skills in engineering programs.

To address the identified deficiencies, this study proposes a task-based educational approach that integrates the teaching of domain-specific skills and CT and provides guidance for teachers to develop their modules and classes. The proposed approach is based on the T-CHAT educational approach that addresses the development of both domain-specific and transferable skills in students [15]. The T-CHAT approach combines five pedagogical approaches: 1) perceptional learning, 2) face-to-face teaching, 3) problem-based learning, 4) research-based learning, and 5) project-based learning in a learning process, as they fill the gaps of each other, and a holistic/synergetic outcome is achieved through their combination and linkage. Findings from the literature review have lent support to the development of this educational approach.

This paper is organized as follows. Section 2 describes the proposed educational approach. Section 3 presents the evaluation methodology for the proposed approach. Section 4 concludes and outlines future work. As this study is still in progress, no results will be presented.

2 The Proposed Educational Approach

The proposed educational approach operates at the module level and is based on the following main pillars:

1. The mixed approach (see Ennis [7]), which combines the infusion and the general approach, is adopted. This means deep subject-matter instruction, which encourages students to think critically and makes general principles of CT skills and dispositions explicit, and general principles of CT are explicitly taught.
2. Tasks are the central points to address the development of domain-specific skills and CT skills and dispositions in students. These tasks have to be authentic problems, which contain various aspects of both domain-specific content and CT skills and dispositions.
3. Domain-specific content and general principles of CT are taught to the students in lectures and presentations. This teaching is combined with the task solving activities.

Figure 1 illustrates the structure of a module developed using the proposed educational approach. The module contains two parallel integrated strands: 1) teaching of subject-specific content and concepts, and general principles of CT, and 2) working on tasks. The first strand lays the foundation for the learning activities in the second strand. Since the ability to think critically and see an issue from multiple perspectives only works if students have deep domain-specific knowledge and skills [16], the first strand aims at acquiring these skills. In this strand, students are also introduced to the general principles of CT. The deep understanding of domain-specific concepts provides the basis for solving tasks and developing and practicing thinking strategies. In the second strand, students are given opportunities to apply the new knowledge and skills in solving tasks.

To ensure a deep understanding and to promote the ability to think critically, both strands adopt student-centered strategies and encourage students to actively participate in the learning process. In the first strand, teacher introduces the subject matter in small portions throughout the module, since lectures and presentations are an efficient approach to transmit theoretical content [17]. These short presentations are followed by group and plenary discussions during which students can deepen their understanding and reflect on their learning experiences in solving tasks they have collected in the second strand. The teacher does not introduce the general principles of CT directly at the beginning of the module but engages the students to critically deal with the domain-specific content through asking them provocative critical questions. These questions aim to create an intuitive understanding in students what critical thinking is and how it can be implemented in solving issues and tasks. This intuitive understanding plays an important role in student perception of both CT and subject matter and, consequently, in their learning (see [18]). After the students have practiced answering critical questions in problem solving and discussions, the teacher introduces CT general principles. The students get thus the opportunity to link these principles to their initial intuitive understanding of CT.

The aim of the second strand is that the students apply the domain-specific knowledge and skills and their understanding of CT for solving specific tasks. The proposed educational approach provides that there are several tasks in a module. Each task addresses a limited number of domain-specific and CT aspects. CT aspects in the tasks are made explicit to the students only after the students have been introduced to general principles of CT. The next task is presented to the students after some domain-specific concepts necessary for solving this task have been presented, discussed and reflected upon. After a task has been solved, the students reflect on their solution strategies and acquired skills.

Two strands are tightly intertwined thematically: the domain-specific topics which are presented and discussed in the first strand are included as individual aspects in the task that is being solved in the second strand. CT aspects are gradually introduced to the students and included in the tasks.

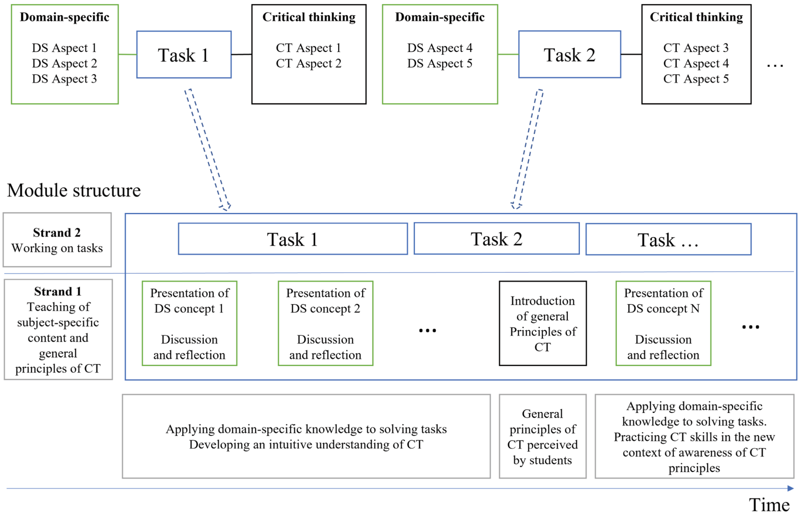

Fig. 1. Module structure (DS = discipline-specific)

3 Evaluation of the Approach

3.1 Research Methodology

This study uses the mixed methods concurrent triangulation approach [19], which consists of collecting both quantitative and qualitative data and comparing them to determine if there are similarities, differences, or a combination thereof. The quasi-experimental nonrandomized approach [20] and the one-group pretest-posttest design [21] are used to measure the impact of the proposed educational approach on the improvement of students' CT skills and dispositions. Based on this design, the following educational experiment has been designed:

- The students participating in the module selected for the experiment will be observed at the beginning of the module (pre-test).
- This module will be delivered according to the proposed educational approach.
- The students will be observed at the end of the module (post-test).

We have focused only on measuring students' CT skills and dispositions in this study, as previous research has shown that the T-CHAT approach, on which the proposed educational approach is based, develops both domain-specific and transferable skills [15].

During the observations, quantitative and qualitative data will be collected through student surveys. Quantitative data (pre- and post-test) aim to examine how students self-assess their CT skills and dispositions. Qualitative data (post-test only) aim to examine students' perceptions of both their CT skills and their participation in the experiment. Pre- and post-test quantitative surveys make it possible to investigate whether the students' CT skills and dispositions changed during the experiment. In this study, it is assumed that this change is caused by this experiment and not due to other reasons, such as maturation and participation in other modules.

- a 60-item questionnaire based on [22] assesses students' perception of their CT skills, and
- a 21-item questionnaire based on [23] assesses students' perception of their CT dispositions.

To collect qualitative data, a questionnaire with seven open-ended questions has been developed (see Table 1). Based on this questionnaire, students reflect on their learning and experiences in the experiments.

Table 1. The questions used for student reflections.

Scale	Questions
CT: definition and process	1. Critical Thinking: definition and process
	2. Describe what you do to solve a problem. Explain the steps
Professional and personal development	3. What have you learned for your professional and personal development by participating in this module?
Understanding of CT and CT skills	How have your understanding and skills changed due to this module? Consider the following **aspects**:
	4. Understanding of the subject 5. Understanding of critical thinking 6. The link between theory and practice 7. The ability to solve problems

3.2 Educational Experiments

Two modules at the University of Applied Sciences Emden/Leer (Germany) were selected for the educational experiment and developed using the proposed task-based approach: (1) the "Innovation management" module in the Master program "Industrial

Informatics - Specialization Industrial Cyber-Physical Systems (ICSP)" and (2) "Scientific seminar" in the Master program "Media informatics". Both modules, every of which has 5 ECTS points, were deployed in the summer term 2022. Various students participated in these modules.

The "Innovation Management" module consists of two parallel parts. The first part, "Innovation processes for ICPS" addresses the innovation paradigm and methods for its implementation. It focuses on topics such as Open Innovation [24], industrial patent process that combine innovation and patentability, and understanding and managing the process of generating research and innovation actions. In the second part, "Creativity techniques and scientific writing", students learn techniques for creative thinking, for selecting ideas, and for creative group processes; they study and practice the methods for writing scientific papers. As both parts run in parallel, they are linked in terms of content and pedagogy. According to the proposed educational approach, the subject matter of these both module parts and general principles of CT are presented and discussed in the first strand (see Fig. 1). The tasks in the second strand combine specific aspects of both module parts and some CT aspects. For example, the students have to 1) analyze the structure and quality of writing of papers dealing with innovation processes, 2) apply methods of creative thinking to generate innovative ideas in groups, and 3) write a reflection on the application of these ideas in their own study.

The mixed approach to teaching CT was used to prepare the students to carry out the tasks. Theoretical aspects of CT were briefly introduced before each task to ensure that the students focused on the CT aspects. The students were trained in the active reading method, in which comments and questions that arise during reading were made about the text. Then the task set was discussed, and it was ensured that the students understood the task and its objectives. The students were again reminded to keep the CT aspects in mind. For example, to analyze the structure and quality of scientific publications as reviewers, not only published scientific papers were used, but also papers submitted to scientific conferences and journals but not accepted. In this way, the students were able to see the difference between high-quality and low-quality publications based on the criteria of scientific conferences and journals. Following the in-class assignment, a similar but more extensive assignment was given as homework. In the next class, each student was asked to briefly describe their own solutions. Each student also received brief individual feedback from the teacher on their solution. Students participated in the group discussion. Homework was formatively assessed. Completion of homework and participation in the class work were included in the grade.

"Scientific seminar" is thematically similar to the "Creativity techniques and scientific writing" part of the first module. In this seminar, students get familiar with the research process in their discipline, learn writing research findings in a scientific paper, and writing the final thesis. According to the proposed educational approach, the subject matter is presented and discussed in the first strand. In the second strand, students have to critically analyze their own scientific text (usually their own bachelor thesis) and scientific publications of other authors in their discipline. The analysis of students' own writing is self-reflective activity to answer the questions "What would I do differently now?" and "What would I advise myself to do better?" When analyzing scientific publications, the students use quality criteria used by conferences and scientific journals to evaluate scientific papers. The students present their views in a plenary discussion. This learning activity have been formally assessed by giving feedback to the students.

According to the research methodology, both modules were developed according to the proposed educational approach and were delivered in the summer term 2022. The pre-module student surveys were conducted resulting in the sample sizes of 10 respondents for the "Innovation management" module and 10 respondents for the Scientific seminar. The small sample sizes present a limitation for statistical analysis of the data.

4 Conclusion and Future Work

The purpose of this study is to introduce a task-based educational approach that integrates the teaching of CT skills into the domain-specific modules. This approach adopts a combination of the deep subject-matter instruction that explicitly addresses CT skills and explicitly introduces general principles of CT to students. Both teacher presentation of content and student-centered learning activities are the important instruments used in this approach. The most student-centered activities are encouraged by a collection of tasks that address the development of both domain-specific and CT skills of students. This study also presents the methodology to evaluate the impact of the proposed approach on the development of students' CT skills and dispositions. For the evaluation, two different modules were developed according to the proposed approach and student surveys were conducted at the beginning of the modules. To complete this study, the following research activities are planned: 1) recording students' assessments at the end of the experiments, 2) collecting qualitative data in the form of student reflections on the development of CT skills and dispositions; 2) analyzing both quantitative and qualitative data to obtain results and draw conclusions.

As future work, the proposed pedagogical approach will be implemented and evaluated in the teaching of other subjects and disciplines.

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Developing Critical Thinking Skills Through Work-Based, Blended Apprenticeship Curriculum for Business Communication

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Abstract. The development of students' critical thinking skills through the teaching process is a key factor that reveals the performance and effectiveness of the educational act. Moreover, the demand in the labor market for graduates who have good communication skills and who can logically analyze certain situations and make relevant arguments has increased. Thus, this paper describes the curriculum for the Business Communication course carried out within the project "Critical thinking for successful Jobs (Think4Jobs)", which was designed in such a way as to develop students' ability to think critically. During the course, students will analyze different case studies in which they will have to logically research and organize certain information, data, notions according to their relevance and significance in order to be able to propose appropriate conclusions. Therefore, this paper suggests that critical thinking can be integrated as a component part of any discipline, given the increased interest in this area. As a sequel to this paper, is proposed a statistical analysis of the impact of critical thinking on students following the implementation of the Business Communication course.

Keywords: Critical thinking · Business communication · Pedagogy

1 Introduction

One of the main objectives of the educational process in the university environment is the development of critical thinking among students, respectively the ability to ask questions and to analyze logically the opinions and assumptions of others. Critical thinking is a process of reflection, of continuously verifying the truth value of information, as well as its relevance, in order to adopt decisions in a reasoned and rational way. Today more than ever critical thinking is a learning outcome valued by the workforce and higher education institutions [1]. In fact, critical thinking is considered one of the most significant outcomes of higher education courses [2–4]. Thus, through the Business Communication course, students will have the opportunity to explore the concept of "critical thinking" in addition to the information they will learn about how to carry out an effective communication process with the stakeholders of an organization in order to achieve the company's objectives through all the notions taught and the activities in

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which they will participate. In fact, the scope of all disciplines in the field of education, from elementary to college is the development of students' ability to think critically [5, 6]. In recent times, the interest in approaching critical thinking in education has grown as a basis for various educational interventions concerned with the development of cognitive skills and curriculum [7]. Employers also want the graduates they are going to hire to have the ability to understand the interdisciplinary nature of business, to have good communication and problem-solving skills [8].

In order for students to become better critical thinkers, they need to be taught how to evaluate each argument about a particular piece of information so that they in turn become able to create convincing arguments [9]. Therefore, in designing the curriculum for the Business Communication course, were approached the following topics (main types of communication, intercultural areas in communication, barriers in communication, analysis and elaboration of business proposals, etc.) by highlighting the elements of critical thinking. After the presentation of the subject and a brief analysis of the literature on the promotion of critical thinking in educational disciplines, the paper presents the structure of the Business Communication course, following in the part of discussions and conclusions to be presented the next areas that can be approached in the future within the course curricula.

2 Literature Review

In the literature, the definitions of critical thinking are numerous. The notion of critical thinking is Deweyan [10]. Dewey presents a theoretical approach that provides an understanding of the influencing factors for transformative learning, highlighting the importance of a critical-reflective view in the learning process [11]. Critical thinking refers to the cognitive skills used in solving problems, calculating probabilities, formulating deductions and making decisions in order to increase the probability of obtaining the expected outcome [7]. Critical thinking is a tool to facilitate the decision-making process in order to solve problems that arise in everyday life and in business [12–15].

The WSU guide presents the main stages of the critical thinking process: identifying the problem, the analyzed subject, establishing a clear perspective on the approached topic, recognizing and researching alternatives, locating (placing) the analyzed problem in an appropriate, identifying, verifying and evaluating the evidence on the analyzed subject, determining the hypotheses for the representation of the analyzed problem, drafting and researching the potential conclusions [16, 17]. Paul and Elder [18] consider that a critical thinker evaluates problems, asks questions, formulates them clearly and concisely, gathers and analyzes relevant information, verifies information, decomposes processes into subprocesses, using abstract information, reaches conclusions and well-founded solutions by testing them against certain criteria. Considering the important role of Dewey in approaching critical thinking in the context of pedagogy, as well as his contribution to education practices [19], in order to identify the most used terms together with the concept of "critical thinking", a search for the keywords "critical thinking" and "pedagogy" was carried out in the Web of Science database, resulting in a number of 2236 papers. The justification for choosing the Web of Science database is that this platform contains the most relevant studies in the researched fields, being recognized as the most appropriate source, being composed of the most renowned journals. After eliminating the papers that are not articles and do not fit in the researched fields, respectively "Education Educational Research" and "Education Scientific Disciplines" in the period 2018–2022 resulted in a number of 648 articles. Thus, after studying the appearance of keywords in the 648 articles, the main terms and groups of words used together with the concept of "critical thinking" were obtained (these are represented according to their intensity in Fig. 1).

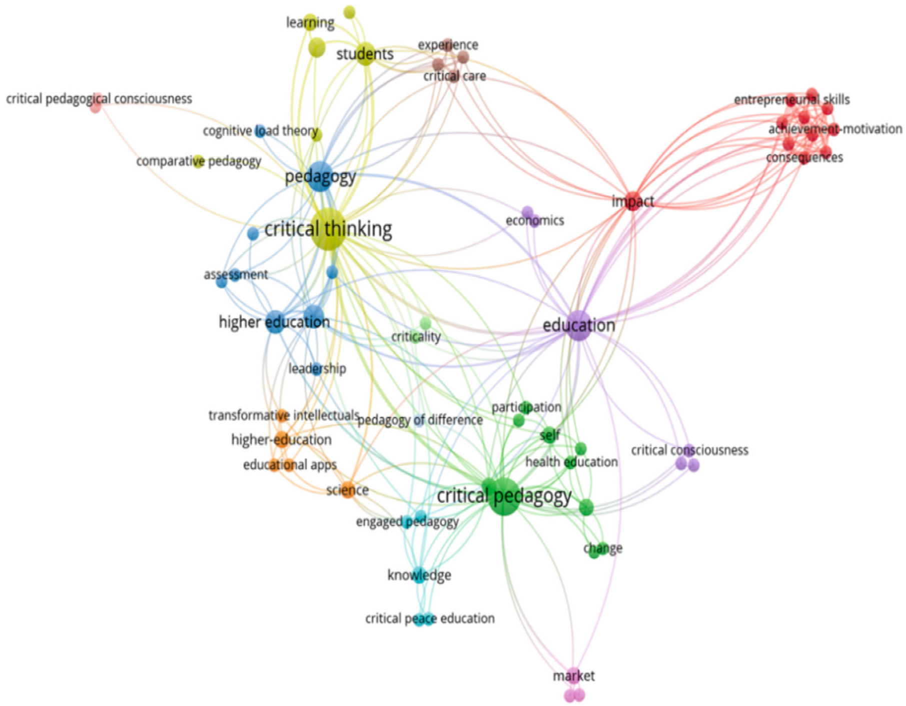

Fig. 1. Keyword co-occurrence critical thinking Source: the authors' own contribution

As can be seen from the Fig. 1, the most common terms include: "higher education", "critical pedagogy", "education", "entrepreneurial skills", "students", "science" and "knowledge". The most rarely encountered words are: "critical consciousness", "market", "transformative intellectuals". Regarding the definition of critical thinking in the context of business and professional communication courses Morrison [20] argues that there is still much to be done for the ideas presented to focus on developing the ability to think critically. It is noteworthy that among the most common terms along with the concept of critical thinking are entrepreneurial skills, which are specific to the Business Communication course. Linina & Vevere [12] also considers that the ability to think critically is one of the most important business skills, which can make the difference between failure and success. At the same time, the study of Moshiri and Cardon [21] based on the research conducted by Pascarella and Terenzini [22] reveals several approaches through which critical thinking can be promoted in Business Communication courses: identifying central hypotheses and making assumptions about a researched topic, searching for relationships and links with other topics in order to deduce the first conclusions from the information collected, evaluating the evidence and justifications, in order to make self-corrections and solve problems. Taking into consideration all the critical events that are occurring in organizations more and more often, and the totality of quick decisions that employees of companies must make to counteract the negative effects of a particular activity that has occurred, critical thinking is an essential skill that all students participating in the Business Communication course should obtain it.

3 Description of the Course

Business communication refers to the process of transmitting information and data, both, externally and internally of a company [23]. The learning process can be achieved by watching, observing others, analysing information about their behaviour in certain situations and using this codified information as a starting point in similar or different contexts [24, 25]. The structure of the course is summarized in the diagram below (Fig. 2).

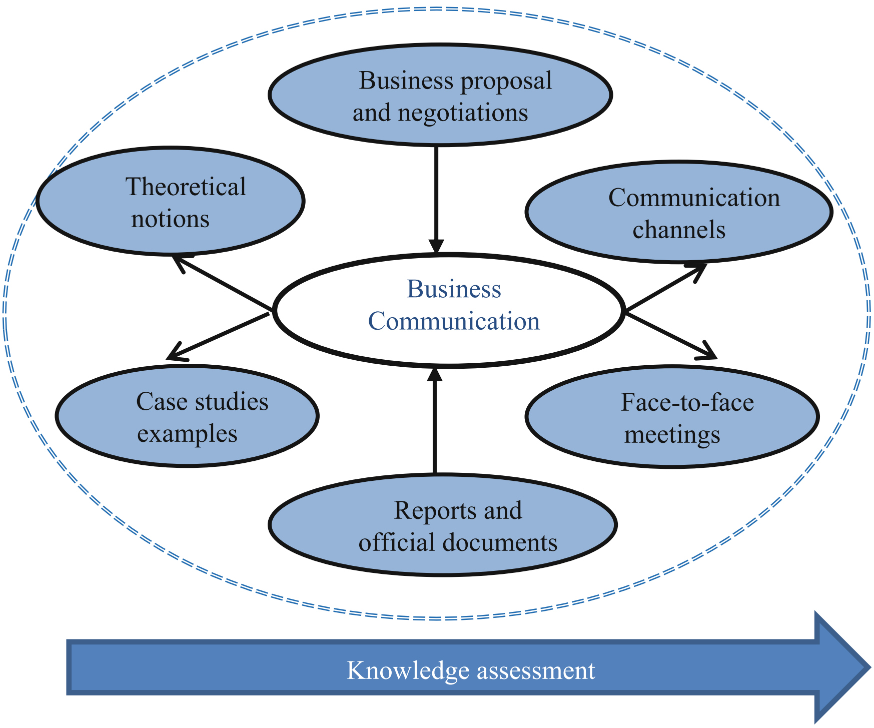

Fig. 2. The structure of business communication course Source: adapted from Mäkiö et al. (2022) [23]

Regarding the teaching methods used, these are: case study, experimentation, debate, brainstorming, lecturing and simulation [23]. Students react to different environmental situations so they can actively and proactively construct cognitive and noncognitive solutions to different situations [25, 26].

During 13 weeks of courses (2 h/week), students will acquire and develop their communication and ethics skills in business Also, they will develop, in a practical way, their business communication and critical thinking skills. The critical thinking skills and dispositions that will be addressed in this course are described in Table1.

Table 1. Critical thinking skills approached in the course

Learning scenario	Syllabus	Critical thinking skills
Analysis of the communication process from a project carried out in an organization	- introduction in the concept of business communication; - theoretical notions regarding business communication; - communication techniques, communication channels; - ethics in business communication; - types of communication & current channels – the golden rules; - argument building in business communication.	• interpretation; • analysis; • evaluation; • open-mindedness; • analyticity; • systematicity.
Identifying communication errors and prevention methods	- reports and official documents (different documents specific to an organization (contracts, offers, etc.) will be analyzed and studied by students, in order to identify possible errors;	• analysis; • evaluation; • open-mindedness;
Identifying and specifying possible solutions to the given communication problem	- analysis of case studies regarding the business communication process; - writing a business proposal and simulating negotiations, analyzing non-verbal communication techniques.	• explanation; • truth-seeking; • open-mindedness; • self- confidence; • systematicity.

Source: adapted from Mäkiö et al. (2022) [23]

Students will be able to acquire these skills through case studies and examples that will be explored throughout the course [23]. Also, in some case studies, students will be put in certain situations and they will have to adopt decisions in order to improve the communication process [23]. The scenario consists of the following activities: students are divided into teams of 4–5 people, each team receives the case study/problem/situation that needs to be solved, students analyze the assigned case study/problem/situation and answer the questions/solve the corresponding applications. In order to identify the most relevant answers/solutions for the assigned case study each group presents the possible solutions found [23]. The assessment of students' competences will consist of: systematic observation of students' work/observation matrix, oral assessment during the semester (students will be asked to formulate their own points of view on specific situations), writing an essay on business communication (arguing and detailing a specific topic of business communication), creating/improving a business proposal [23].

4 Discussion

Business Communication courses should contribute to facilitating the labor market integration of students through the development of skills and competences. The new competencies that students will acquire at the end of this course are: understanding and knowledge of the concepts of "business communication" and "critical thinking", capturing and maintaining the attention of a group of people, improving communication skills needed in a business environment, identifying the main means of influencing (from an ethical point of view) employees in an organisation, understanding the principles of communication, applying "business communication" in writing (drafting analyses, sending messages, writing reports), critical use of relevant sources of documentation for writing business proposals [23]. Approaching critical thinking skills and dispositions (for example analysis, interpretation, open-mindedness, analyticity) the business communication course aims to present to the students an image on the communication processes established between the employees of a company in order to accomplish the organizational objectives.

Considering the innovative aspects of the Business Communication course organised within the Think4Jobs project, 3 assessments were established (one at the beginning of the course, one in the middle of the course and the last one at the end of the course) regardering student's critical thinking skills, in order to study how their skills were improved after attending the course. The learning activities depend directly on each case study that will be used in the learning scenario: problem-based learning, discussions, group work, individual work, hands-on learning, reciprocate teaching, cooperative learning, flipped classroom, heuristic conversation, debate.

Also, through the Business Communication course, students will acquire new skills in through of all the activities in which they will be involved: team working skills (students will work in groups of 4–5 people), business writing skills (students will analyze different business proposals in the case studies approached during the course), presentation skills (in the case studies of the course each group of students will have to present their opinion on a given situation), transferable skills (management, organization, coordination, critical thinking), ability to communicate in a professional way in the business environment, ability to communicate ethically through digital instruments in business, ability to communicate with assertiveness.

5 Conclusions

Critical thinking is the disciplined process of analyzing, evaluating and synthesizing information gathered or resulting from observation, reflection, experience, reasoning and implicitly from the communication process. The key critical thinking ability is based on several features, such as: clarity, precision, relevance, well-founded justifications, good reasons for selecting one decision option over the other, fairness.

In the Business Communication course students will analyze various case studies through which they will gain new skills, including critical thinking, a skill that will help students integrate faster into the labor market. The course of Business Communication aims to provide students an overview of the concept of "business communication" by paying special attention to aspects specific to critical thinking. Professional communication in the business environment refers at the whole process, respectively both verbal and nonverbal communication.

Considering the information presented above on critical thinking and its influence on the business environment, it is recommended to pay more attention to the concept by incorporating it into educational disciplines. Regarding the next steps, after the implementation of the Business Communication course within the Think4Jobs project, will be carried out a statistical analysis of the data obtained following the 3 assessments regarding the critical thinking abilities of the course participants. The interpretation of the results will allow to assess the effectiveness of the integration of critical thinking issues into the curriculum, taking into account the fact that these skills are increasingly pursued by employers.

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Better Teacher — Better Critical Thinker. Good Practices for Pre-service Teacher Training Students in Economics in Synchronous Online Classes

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Abstract. Teacher training/education is problematic in every country, and it was puzzling across historical epochs. There were questions and preoccupations about the perfect teacher or how to educate a better teacher for our children, although the quest for such a teacher was not always scientifical or sustained by proof. But starting with the early twentieth century the search for the better teacher became scientific and serios. Many theories have been developed. Starting from some of them, this paper, propose an innovative approach for the best adaptation of students to labour market. Our domain is teacher education in Business and Economics. The aim is to put together the labour market organizations (LMO), in our case, trainers form a commercial bank, with higher education (HE) teachers to construct joint activities from which students (the future teacher of Economics) become better critical thinkers. The reason is that in recent years, critical thinking (CT) was listed among the most desired skills for twenty-first century jobs. Hence, our project is aiming to enhance this skill in student-teachers and bring labour market in the university to create a more adapted curriculum to job needs. In the following we shall present a curriculum for Pedagogy of Economics and concrete examples of blended, work-based learning scenarios in an online synchronous environment (a condition determined by the Covid-19 pandemic).

Keywords: Critical thinking · Pedagogy of economics · Higher education curriculum · Blended apprenticeship · Work-based learning scenarios

1 Introduction

Higher education has had as a long-lasting goal the development of critical thinking. Teaching the student how to think, or to reason is also an expectation from persons who apply to a university. Critical thinking represents a key feature in job applications or in job specifications [1]. It represents recommendations for the future job applicant as career counsellors or human resources websites show [2]. In these materials, critical

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thinking (CT) is named as such or has close relatives like reasoning skills, problem solving skills, decision making, etc.

This reality motivated us to create a project that embeds CT into specific domains, but also invites employers to introduce apprenticeship into everyday classes in higher education. This is how the European project *Critical thinking for successful jobs – THINK4JOBS* was born. It is a consortium of ten partners, five universities and five labour market organizations, from five countries, organized in pairs, resulting in five pairs for the respective domains: Teacher Education, Business and Economics, Business Informatics, English as Foreign Language, and Veterinary Medicine. The motivation was even deeper, "it is suggested that despite HE and LMO instructors' willingness to promote CT, they both might lack conceptual as well as procedural knowledge regarding CT" [3]. The project started with empirical research, followed by training of teachers and LMO partners. The third step was to create new teaching-learning activities using LMO experience and needs, the result being a collection of 13 higher education curricula, by domain. The present paper is a short presentation of the new curriculum for Pedagogy of Economics, a field that concerns both Economics, Financial Accounting and Teacher Training. The students were second year, enrolled in the non-mandatory teacher education program, accompanying the bachelor program. There are several research papers showing different methods aiming CT development in Economics students or Economics classes [4]. Some authors have encouraged higher education teachers to include CT module when teaching Economics principles classes [5]. The present research will try to add yet another perspective on teaching CT in Economics, using labour market trainers' experience.

2 Grounding. Literature Review

2.1 Critical Thinking Definition

Since Socrates, the definition of critical thinking has changed, bearing the mark of the famous ancient philosopher. Strictly speaking, Socrates did not use the term CT, which is a late twentieth century addition from Dewey [6]. Dewey used the term "critical thinking" or "reflective thinking" or just "thinking". For him, the term CT is used to describe an educational objective [7]. But in the revised edition of *How we think* [8] Dewey deletes all entries of the term "critical", settling on the term "reflective" or "reflection". However, "critical thinking" continued to be used by his contemporaries interchangeably with "reflective thinking" [7].

The current paper assumes a more recent definition, known as the Delphi project consensus definition. Facione [9] gathered around fifty scholars and experts, from many domains, for a multi-round Delphi method to obtain CT consensus definition, which was used as goals of a lower-level undergraduate course in critical thinking. For Delphi panellists CT was an ability identified by skills (interpretation, analysis, inference, evaluation, explanation, self-regulation) and dispositions (truth-seeking, open-mindedness, analyticity, systematicity, self- confidence, inquisitiveness, cognitive maturity).

Paul and Elder [10] propose intellectual standards of the critical thinker, standards which can be used to guide and assess the quality of teaching critical thinking (clarity, accuracy, precision, relevance, depth, breadth, logic, significance, fairness).

The THINK4JOBS uses the sum of standards proposed by Paul and Elder in the project's outputs, including the empirical research which stood as the basis for the present proposal of Pedagogy of Economics curriculum.

Regarding the association between Pedagogy and critical thinking, as we have said, Dewey mentions it as an educational objective. Presently, we are finding it in the mandatory curriculum (first ten years) in State of Victoria, Australia, under the category of general capabilities aimed at, clustered with creative thinking [11].

The curriculum for Pedagogy of Economics aims to develop critical thinking using infusion approach, an embedded teaching strategy which includes CT explicitly into Economics classes [12, 13].

2.2 Critical Thinking in Economics Classes

Recently, many researchers were preoccupied to emphasise the role of CT in education [14, 15]. Due to increasing interest of different economic entities, such as World Economic Forum or OECD [16], for CT and problem solving many employers wish that their staff to hold such skills. Some models of conceptualizing a curriculum containing CT were proposed, such as Siegfried J, Colander D [17] proposing a "big-thinking" and a "little-thinking". Teaching Economics mean that some well-known works must be taken into consideration, such as D. Kahneman [18], a psychologist who was awarded the Nobel prize for Economics in 2003. Getting students from thinking fast to thinking slow (using Kahneman's words) is a good piece of advice not only for Economics [19, 20], but for all students alike.

In our paper we try to bring in Pedagogy of Economics classes (a mandatory class for students in pre-service teacher training program) a teaching model based on dual-processing theory also used in other papers [17, 19, 21], but also an inquiry-based model proposed by other authors [22, 23].

The pandemic conditions forced us to propose an online, collaborative teaching and learning model [24, 25]. The collaborative teaching approach was proposed by the labour market partner, a multinational bank, with many years of training experience.

Adding labour market input is an original approach, brought by the THINK4JOBS project. HEI and LMO agreed that the trainers cannot explain pedagogical specific concepts to fulfil the curricular requirements of Pedagogy of Economics classes. But they can provide actual training sessions and, based on them, the students and HE teacher can develop a metacognitive/reflective session from which students can infer diverse teaching approaches, methods, techniques, and content selection methods. The HE teacher was a facilitator of learning-by-discovery teaching strategy. Students were discovering teaching techniques from their experience as trainees and the teacher named and explained them in depth.

Nevertheless, the previous research conducted in THINK4JOB mapping work package showed that Economics students need more divers teaching strategies, a more interactive teaching style and a constructive pedagogical approach [3, 26].

Concluding, the approach to Pedagogy of Economics class to enhance CT is conceived to be online, collaborative, inquiry-based and metacognitive.

3 Description of the Course

Students will acquire knowledge related to the education system, school curriculum, design and evaluation of educational activity. They will have the opportunity to learn how to maintain the audience's attention, how to manage difficult situations, how to trigger change and how to maintain their energy throughout a course while in the same will acquire a better understanding of basic Economics and financial accounting.

The class has 14 meetings of 2 h each, one class per week. The scenarios are 4 h each, so there are 7 learning scenarios. We shall present two scenarios as examples: one which is held by the LMO trainer together with HEI teacher, and the other scenario which is held by the HEI teacher alone keeping the link with labour market real cases. The structure of the course is summarized in the diagram below (Fig. 1).

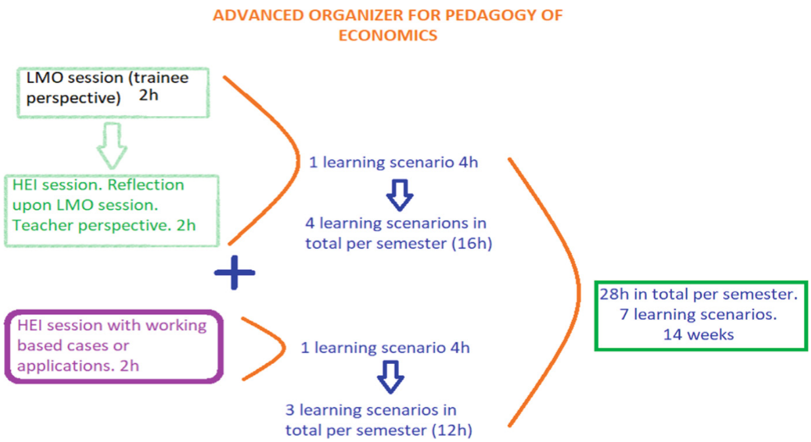

Fig. 1. Advanced organizer for Pedagogy of Economics curriculum (source: author's representation)

The overall objectives for the 28 h dedicated to this class were:

- Development of thinking skills specific to the educational field, which should serve to understand and correctly evaluate the educational opportunities and risks in teaching Economics.
- Improving adaptive thinking for teaching in Economics.
- Correct use of conceptual tools specific to education sciences.
- Critical use of relevant documentation sources for solving pedagogical problems in teaching Economics.
- Design and correct use of teaching strategies in educational activities concerning teaching Economics.
- Design and correct use of evaluation tests in teaching Economics.
- Designing Economics educational activities.

3.1 Social- Constructivist and Metacognitive Teaching Strategy. Higher Education and Labour Market Collaboration

The first example of a work-based, blended learning scenario was led by the LMO trainers and has a duration of 4 h per scenario (2 classes). The LMO presents a training session where the *students are in trainee roles*. The next 2h are dedicated to the *teacher perspective*. The students discover methods, teaching approach, materials, instruments used by the trainer. The trainers have selected social–constructivist [27] and cognitivist teaching approaches [28, 29]. The HE teacher also used a cognitive approach but used metacognition as the primary source of teaching and learning. CT teaching approach is infusion (see [13]). Due to the Covid-19 pandemic, the learning environment had to be online, synchronous, using an application for video conferences.

In the first 2 h, LMO trainer have presented in a constructivist, interactive approach a session about savings and investing savings.

A Canva presentation was used and students, in the role of trainees, follow each step interpreting, understanding, and applying knowledge about what saving money is, why it is better investing than keeping money home or in a savings account, what annuity means and how to take wise decisions interpreting widely available economic data.

In the second part, the next 2 h, students had a template/table for commenting on the previous training activity as in Table 1. This approach used a collaborative strategy, which is also social-constructivist, but with an emphasis on the need to put together different or divergent ideas and to reach a consensus. The activity was online, using Google form in real time.

Table 1. Collaborative document in Google Drive that facilitates students' discovery of teaching methods, materials, concepts used by the LMO trainer (the students were in the role of trainees)

What can you **remember** from the training session?	Which was the **direct experience** that led to this?	Try to identify the methods, procedures, strategies entailed (use your own words)	Try to identify instruments and materials used by the trainer	The actual concepts from the course (with teacher's help)

Students filled in the table in a collaborative Google Drive text editing document during the seminar, online, synchronous. The link of the completed document was uploaded in the Moodle platform of the class, for future consultation. Students had access to a class in a Moodle (e-learning platform) dedicated to THINK4JOBS where they had to upload all homework. Teachers and trainers created presentations and tasks that were also shared in the Moodle class.

The assessment was included in the final examination. The students wrote a short essay inferring and applying in new settings what has been taught in the class: students should indicate contents, strategies, methods, materials, evaluation form and instruments in an Economics training session presented as case study.

3.2 Inquiry-Based CT Teaching Approach

The second example of a worked-based learning scenario is more detailed. It uses a case study from every day pedagogical practice, as teacher, meaning how *to select the content that will be taught* in an Economics lesson (11th grade). Choosing which content is relevant is difficult because students think that everything is important. They cannot evaluate and make an informed choice on what pupils absolutely must know and what they can learn by themselves.

Choosing which content is necessary is difficult because the content is in the syllabus and in the textbook (hence, "everything" is important). Moreover, students learnt the same things when they were pupils, and they learn the same in the faculty. This adds up to their bias. They do not question content. Why are they learning exactly that information and no other. Or if there are other perspectives?

This class aimed the following CT skills/dispositions:

- Interpretation and analysis of the prescribed curriculum, content, and suggested methods;
- Evaluation of the current situation (who are the pupils in their class, what do they want and what are they able to learn?);
- Self-evaluation and open mindedness.

The skills and dispositions are gradually evolving from reading and opinionizing on class content.

The learning scenario is unfolding through **four learning settings, 4 h (two classes), the teaching approaches are cognitive and collaborative, using an infusion approach to CT teaching (make CT concepts visible)**. The settings are inspired by a cognitive approach to teaching and learning used by several authors [20, 30, 31].

Setting 1. Reading and Selecting Content (Approx. 30 min.)

- Students are selecting a lesson from the 11th grade Economics manual, they are reading, analysing and selecting a particular text which is supposed to be taught in a 50-min lesson.

CT skills involved in this part are interpretation, analysis and explanation.

Setting 2. Re-evaluation of Selected Content (Approx. 30 min.)

- From the HE teacher, the content is too rich. Students are selecting almost all the text from the lesson, and they are asked to compose a teaching scenario, when and what to teach. They soon realize that the content cannot be well prepared in 50 min.
- Students re-evaluate the amount of selected content. They should focus on what is needed for the students to be independent and understand the subject themselves.
- Students must provide reasons for their choices. This is a recurring task.

The CT skill involved is evaluation.

Setting 2 was followed by evaluation activity through validation by colleagues (collaborative work and making the consensus). Students made the *concept map of the selected content*. The whole class participated in the activity of designing the concept map of the lesson. This map demonstrated logical accuracy on representing the main concept of the lesson, logical links between the main concept and supported key concepts.

Setting 3. Matching Methods and Content (Approx. 30 min.)
In setting 3 the students had to select a proper teaching method or strategy for the selected content from setting 2. They had to make decisions and to justify their choices to the other colleagues. *The CT skill involved is problem solving.*

Setting 4. Possible Scenarios of Content Delivery (Open-Mindedness) (Approx. 30 min.)

– In setting 4 students had to provide different lesson scenarios. They realized that there is more than one way to teach a lesson and each scenario can have different benefits.

In addition, students had to answer the following questions addressed by the teacher: what can go wrong with the selected scenario? What does "wrong" mean in the context of selected content? What can be done to minimize the downsides of the provided scenario? *The CT skill involved is Open-mindedness.*

3.3 Feedback and Assessment for Inquiry-Based Learning Scenario. Systematic Observation Ranking Sheets

The assessment of the second learning scenario was made through systematic observation [32, 33], a holistic evaluation concentrating on the CT skills involved in the activity. The author proposed an original observation sheet based on placing the indicators in order of importance, which is the most prominent CT skill or disposition in the respective class. The result is a set of ranking sheets as displayed in Tables 2 and 3. For example, Table 2 proposes a ranking sheet for the CT skill named Analysis [9]. The most prominent feature of this CT skill is "Identify the intended & actual inferential relationships among statements". The sheet continues with three other indicators of the Analysis CT skill.

The teacher distributed the ranking sheets to the students at the beginning of the activity, to raise students' awareness. The teacher evaluated by observing the student's behaviour during the classes and at the end of the activity the teacher communicated the results, namely how well they have performed.

The ranked sub-skills or sub-dispositions were displayed in the order of importance given by the teacher.

The assessment was for the whole activity, it is a qualitative assessment, made by the teacher, and not an assignment for the students (not self-evaluation). The teacher checked the following criteria:

For assessing CT disposition, the teacher used a ranking evaluation sheet which contains criteria in the order of importance for the teacher:

Table 2. Systematic observation sheet. Ranking evaluation sheet for CT skill - Analysis (qualitative, observational)

Skill: Analysis		
Ranking (importance)	Description and criteria	Check
1	Identify the intended & actual inferential relationships among statements	☐
2	Make judgments	☐
3	Write questions, concepts, descriptions, or other forms of representation intended to express belief	☐
4	Make observations about the general idea or the general purpose of the lesson	☐

Table 3. Systematic observation sheet. Ranking evaluation sheet for CT disposition - Open-mindedness (qualitative, observational)

Disposition: Open-mindedness		
Ranking (importance)	Description and criteria	Check
1	Sensitivity to personal bias	☐
2	Tolerant of divergent views	☐
3	Valuing tolerance	☐
4	Understanding of the beliefs of others	☐

4 Discussion

The curriculum of Pedagogy of Economics, consisting of 14 activities, each having 2 h, had the purpose to enhance critical thinking skill in a work-based environment, with the help of trainers from a commercial bank. It aimed to lead and monitor the process of training and instruction of students, to evaluate students and educational activities, to achieve professional cooperation at school level. The class build up also on the development of communication skills for teaching and increasing the competence of basic Economics.

The proposed activities structured in tandem with the labour market equally contributed to the teaching skills construction and to the better knowledge of general Economics and financing. The students were able to critically consider the multi-aspects in creating the materials, using teaching methods and the process of teaching in an understandable, facile and structured way.

CT skills/dispositions involved in the proposed class of Pedagogy of Economics (interpretation and analysis of the prescribed curriculum, content, and suggested methods; evaluation of the current situation - who are the pupils in their class, what do they want and what are they able to do; self-evaluation; open mindedness; self-regulation; metacognition) are gradually evolving by reading and opinionizing about class content.

Educational experience is coming from learning by discovery and self-reflection, students are trainees and after this they reflect with guidance provided by the HE teacher to discover pedagogical aspects of the training session.

Learning activities developed by the HE teacher are also in the spirit of Think4jobs project: embedding critical thinking in disciplinary knowledge (student-teachers of Economics curriculum), using work-based scenarios (e.g., selecting appropriate content for an Economics lesson) in an online environment. Diverse learning materials are used, collaborative online documents, collaborative applications, synchronous conference platforms. Materials and homework resolved individually by the students are uploaded in the Moodle platform dedicated to Pedagogy of Economics class.

5 Further Development

The concept of Pedagogy of Economics curriculum is based on a set of hypotheses considering the works of consecrated authors [12, 34, 35]. They presume that embedded critical thinking skill development and worked-based apprenticeship [19, 22–24, 36, 37] are a better, enriched environment for successful teaching. The alliance with labour market organizations meant to make teaching more adapted to work, thus student-teachers will have the right needed skills for creating Economics lessons for their pupils.

The program presented in Sect. 3, Fig. 1, was tested through a quasi-experimental design, involving second year students, at a bachelor program in Economics which takes initial teacher training classes as well.

Subjects were tested three times, at the beginning, in the middle of the program and at the end, being pre-, intermediate and post-test evaluation. The global evaluation used 81 closed questions, originating from in two different scales: The critical Thinking Self-Assessment Scale (CTSAS) [38] and The Student-Educator Negotiated Critical Thinking Dispositions Scale (SENCTDS) [39]. The results will make the issue of another paper.

In addition, every class was evaluated with an evaluation form, such as the systematic observation ranking sheets presented in Sect. 3.3. It represents a feedback form designed to help the teacher and the students to monitor and regulate the teaching/learning process.

Preliminary results showed that students responded well to the experimental curriculum and the results will be presented in a future research article.

Critical thinking is one of the most wanted skills in labour market, and it appears in many job announcements or in resume recommendations. Thus, we consider the present paper to be a good opportunity for teachers and trainers alike to find new ideas to reach the objective of having CT as active, real-life skill.

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Using Socially Relevant Projects to Develop Engineering Students' Project Management, Critical Thinking, Teamwork, and Empathy Skills: The UTAD-REFOOD Experience

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Abstract. Teaching project management to engineering students demands real-world experiences in which they can apply and develop work-ready skills, such as critical thinking, empathy, and teamwork. While a shortage of these skills in new graduates is frequently claimed by engineering companies and educational bodies, there is still a lack of higher education research studies on how to foster them through teaching practice. This paper intends to contribute to filling this gap by presenting an exploratory case study research of a Project-Based Learning (PjBL) experience aimed at designing and implementing a professional (re)integration plan for social and economic deprived people (e.g., long/short-term unemployed), who depend on external food supply provided by a non-profit organization called REFOOD. The experience was carried out in Portugal, from February to June 2021, with 7 MSc mechanical engineering students from the University of Trás-os-Montes and Alto Douro (UTAD). We firstly describe the PjBL experience in terms of the key driving question, the learning goals, the educational activities, the collaboration among students and stakeholders, the scaffolding activities, and the tangible learning artefacts produced. We further discuss the preliminary results of the study from data collected through documental analysis, participant observation, and self-completion questionnaires on students' perceptions of the PjBL experience. Data analysis shows that this experience positively impacted the development of students' project management, empathy, critical thinking, and team-working skills, by mainly having challenged their personal belief systems and biases related to the real-world scenarios they dealt with. Finally, we outline implications for the teaching practice concerning the development of similar PjBL experiences, as well as future research directions.

Keywords: Engineering education · Social responsibility · Project management · Empathy · Critical thinking

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1 Introduction

The problems that engineers face today are becoming more complex, with an increasing potential to impact society for many generations (e.g., global warming, nanotechnology, artificial intelligence, sustainable energy). Therefore, one of the major goals of engineering education is to cultivate social responsibility in new graduates, a foundational disposition that informs how engineers relate to many professional skills, including ethics and the impacts of engineering on society [1]. Whereas different stakeholders have been incorporating this perspective into their discourse (e.g., faculty, higher education institutions, professional bodies and societies, policy-makers), an integrative, hybrid learning approach for engineering education has been recently proposed [2]. It consists of a mix of scientific education and practical training in technical skills with the cultivation of a broader socio-cultural understanding of the implications of science and technology, on one hand, and self-reflection on one's role as an engineer in particular, on the other hand.

In this context, core competencies that engineering educators must seek to promote in students are communication and empathy. Empathy is commonly referred to as a cognitive and affective process fostering the capability of having a keen understanding and valuing the feelings, thoughts, and experiences of others [3, 4]. It has been linked to students' ability to understand the perspectives of other stakeholders and integrate them into engineering design and decision-making processes, by connecting inter and intrapersonal skills with enhanced abilities to understand and productively work in multidisciplinary environments. While incorporating empathy into undergraduate engineering education is more complex than simply adding it to the curricula, students need explicit training to offset the analytic cognitive bias of undergraduate engineering degree programs, by actively fostering their social reasoning and concern for public welfare [5].

This is also the case of project management education. Despite the increasing labor market demand for project management graduates and their role in promoting engineering students' social skills [6], universities still struggle to train these professionals effectively [7]. Educators often neglect the importance of 1) developing students' critical thinking for dealing with project complexity, 2) developing "softer" parameters for managing projects, especially interpersonal skills and leadership as opposed to just technical skills, and 3) preparing project managers to be engaged in the context of real-world projects, and 4) considering empathy in their practice to improve project manager wellbeing and tackle social needs more effectively [8, 9].

Different pedagogies have been debated in higher education literature with these goals in mind, including PjBL [10, 11]. As an inquiry-based strategy, PjBL engages students in knowledge integration, application and construction, by having them accomplish meaningful projects and develop real-world products [12, 13]. PjBL is distinct from other teaching methods to the extent that it builds upon a specific driving question, learning goals, and educational activities, expecting a higher level of collaboration among students and stakeholders, the use of scaffolding technologies, and the creation of tangible artefacts [14]. It thus requires learners to work together in finding solutions to authentic problems within a socio-constructive environment in which educators and other stakeholders (e.g., customers, partners) normally act as facilitators, providing formative feedback and support.

In engineering education, PjBL is typically implemented according to the following principle: the use of small working groups of students to solve open-ended, ill-structured, real-life problems through self-directed learning [15]. Experiences aimed at developing students' practical capabilities and design-based skills, with the use of assessment strategies like oral team presentations, project written reports, self and peer-assessment, meeting records, and/or other process control tools such as SCRUM are the most frequently reported ones in the literature [10]. Overall, studies have shown positive impacts of PjBL in the development of both engineering students' knowledge and skills, learning motivation, and product quality [16, 17].

Nevertheless, not only students but also engineering educators are facing challenges in terms of a heavy workload, and limited time and resources, essentially due to the lack of pedagogical training on PjBL [18]. Additionally, course isolated implementations may limit the long-term effectiveness of PjBL on student learning, especially when it comes to transferable skills development, such as communication and critical thinking [19]. This demands a supportive policy and resources at the institutional level, providing faculty with more opportunities to share and learn about PjBL pedagogy, choose effective assessment tools, and improve their facilitation skills. Finally, at the course and teaching program levels, there is a need for a structured PjBL implementation plan and design, considering specific learning objectives and activities within different, congruently aligned stages across the curricula [13].

This paper presents an exploratory case study research involving a PjBL academic experience consisting in the development of a professional (re)integration plan for socially and economically deprived people (e.g., long/short-term unemployed), who depend on external food supply provided by a non-profit organization called REFOOD [20], the main stakeholder of this project. The experience was carried out in Portugal, from February to June 2021, with seven Master of Sciences (MSc) mechanical engineering students from the University of Trás-os-Montes and Alto Douro (UTAD), who have applied real-world project management, statistical data analysis and industrial optimization concepts (e.g., project charter, WBS, Gantt), methodologies (e.g., SCRUM), and tools (e.g., Zoom, Google Drive, Padlet, Trello, ProjectLibre, IBM SPSS Statistics).

The goal of this paper is thus to answer to the following research question: to what extent a PjBL experience with this scope and characteristics could successfully be implemented to enhance students' project management, critical thinking, teamwork, communication, and empathy skills? The results and implications from the study herein discussed may encourage and support other engineering educators and stakeholders in delivering academic experiences with similar purposes.

2 The 'Industrial Management I' Project-Based Learning Experience

The PjBL experience herein described took place in the 'Industrial Management I' course, which is part of the MSc degree in Mechanical Engineering at UTAD [21]. It is a semester, 1st-year course with 5 ECTS (135 total hours), aiming to deeply engage students in key knowledge areas of industrial management, namely project management and optimization. Three main modules integrate the course: 1) industrial management optimization (e.g., material requirement planning, modelling and solving linear optimization problems, graphic methods); 2) current challenges for industrial companies (e.g., industry 4.0, ecology, globalization, marketing, logistics, ecology); and 3) project management (e.g., critical factors of a project, knowledge areas and processes (conception, planning, execution, control, closure).

For the design of this PjBL experience, the six hallmarks proposed by [7] were used, which include a) the driving question, b) the learning goals, c) the educational activities, d) the collaboration among students and stakeholders, e) the use of scaffolding technologies, and f) the creation of tangible artefacts.

2.1 The Driving Question

The whole PjBL experience was built upon the following driving question, to be answered by students: How can future engineers contribute to re(integrate) socially and economically deprived people into the labor market? Ultimately, the final goal was to support a group of 10 beneficiaries from REFOOD by helping them in seeking a job and/or guiding them into a professional development path according to their profiles and needs.

2.2 The Learning Goals

The EUR-ACE Standards and Guidelines for Accreditation of Engineering Programs (EAFSG) [22] served as a basis for the establishment of specific PjBL goals:

- Knowledge and Understanding: Students should be able to apply in-depth knowledge and understanding of the current industrial and project management main challenges areas;
- Engineering Analysis: Students should be able to identify, formulate and solve real-world problems taking into account their implications at different levels (e.g., economic, social, technical, environmental);
- Engineering Design: Students should be able to creatively design and develop a project that requires integrating knowledge from different fields and considering non-technical constraints by using project management and data processing skills;
- Investigation: Students should be able to identify, locate and obtain required data for project management and data analysis;
- Engineering Practice: Students should be able to apply up to date approaches, methods and tools for project management and data analysis in a real-world project context;
- Making Judgement Skills: Students should be able to develop critical thinking skills within problem-solving and decision-making situations, by studying different possible solutions and implications, and by recognizing their own thinking biases and limitations;
- Empathy and Teamwork Skills: Students should learn how to communicate clearly and unambiguously their knowledge and conclusions to specialist and non-specialist audiences, to active listening, and collect the needs of different stakeholders (e.g., customers, partners), while collaborating in a team as members and/or leaders of a meaningful project that use different face to face and/or digital (synchronous and asynchronous) communication tools.

2.3 The Educational Activities

The development and execution of a plan to professionally re(integrate) REFOOD beneficiaries into the labor market - namely, by helping them to seek a job and/or by providing them professional guidance - were the backbone of the PjBL activities. Different small-hint discussion sessions for each content-specific teaching module were performed by groups of 2 or 3 students and mediated by the teaching team of 2 teachers, using explicit instruction and different supportive resources (e.g., PMBOK). The teaching team had a key facilitator role by modelling students' high order thinking with the application of think-aloud strategies, and by promoting a cooperative learning atmosphere in which empathy, communication, and shared leadership were continuously enhanced. Students worked in and outside the classroom, either to establish and strengthen the relationships with the different stakeholders or to perform the needed tasks for project achievement. Among all the PjBL activities carried out by the participating students, the most important ones within the course timeframe, and taking into account the main PMBOK knowledge areas [23] were:

1. **Project Conception**

   a. Delivery of a kickoff meeting with the REFOOD representatives to collect insights on how to approach the driving question, analyze similar projects, and identify technical resources available at UTAD and/or other potential stakeholders (e.g., UTAD Social Responsibility Office, training and professional development centers and agencies);
   b. Establishment of the main project goals, milestones and outputs.

2. **Project Life Cycle and Processes**

   a. Visit a local mid-size enterprise in the metalworking sector which adopts project management approaches, methods and tools within its daily processes, to analyze their real-world application in terms of benefits and limitations.
   b. Review of the literature and other course materials.

3. **Project Management**

   a. **Scope**

      (1) Development, presentation and discussion of the project charter with the teaching team, the UTAD Social Responsibility Office (identified as a project key stakeholder), and the REFOOD representatives;
      (2) Elaboration of the project Work Breakdown Structure (WBS) (see Fig. 1) in small groups of 2 or 3 students, which was then discussed and assessed by other team members to achieve a final project WBS, reviewed afterwards by the teaching team and REFOOD representatives;
      (3) Design and conduction of a survey with the REFOOD beneficiaries, followed by a phone call, to collect their professional profiles and needs;

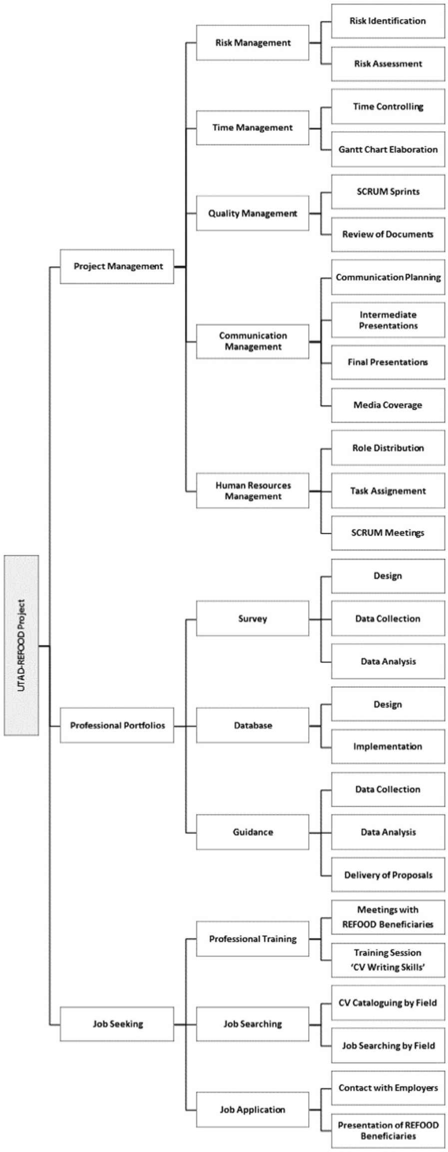

Fig. 1. The UTAD-REFOOD project work breakdown structure.

(4) Elaboration of a professional portfolios database, by cataloguing the REFOOD beneficiaries' CVs according to their profiles and needs;
(5) Development and delivery of a short training session for the REFOOD beneficiaries on 'Curricula Vitae (CV) writing skills (e.g., What is a CV? What is the best way to write and present a CV? Which templates are more

appropriate?), followed by the provision of professional guidance (e.g., the suggestion of training courses, job hunting advice);

(6) Establishment of a list of potential employers for the different REFOOD beneficiaries, followed by informal and formal contact concerning job offers and application processes;

(7) Development, presentation and discussion of the preliminary and final project plan and reports with the teaching team, the UTAD Social Responsibility Office, and the REFOOD beneficiaries and representatives.

b. **Time Management**

(1) Development, presentation and discussion of the project Gantt chart with the teaching team by allocating the different project activities and optimally managing their dependencies and timing.

c. **Quality Management**

(1) Application of quality planning and control processes to achieve plan acceptance and compliance to requirements through SCRUM sprints and meetings [25], by using explicit criteria for self-/peer- and group assessment;

(2) Cooperative review of the project documents and intermediate reports on the process (e.g., team coordination, conflict resolution, shared leadership, team SWOT analysis), and outputs (e.g., goal compliance, practical application and results).

d. **Human Resources Management**

(1) Role distribution and task assignment to different members according to a SWOT analysis of the team, followed by shared monitorization, decision-making and leadership according to their performance indicators and developed skills.

e. **Communication and Stakeholders' Management**

(1) Elaboration of an internal and external communication plan, its monitoring and control;

(2) Delivery of SCRUM team meetings and reports, intermediate and final presentations on the project activities and results to the different stakeholders (e.g., teaching team, UTAD Social Responsibility Office, REFOOD beneficiaries and representatives);

(3) Elaboration of a press release about the project to be distributed by the local and national news media community and participation in media interviews.

(4) Intermediary and final oral presentations to share the project results and outcomes to the teaching team, and the REFOOD representatives and beneficiaries;

(5) Communication management with the different stakeholders (regularity, formal and informal means).

f. **Risks Management**

(1) Identification, analysis and assessment of the project risks, handling their impact (e.g., lack of participation and/or availability to cooperate by the REFOOD beneficiaries and local companies).

2.4 The Collaboration Among Students and Stakeholders

Similar to real-world projects, the success of the current PjBL experience strongly depended on the effective collaboration among students, occurring in both the small and the large groups. In this sense, the SCRUM agile project management methodology [24] was adopted for quality monitorization, planning and control processes, role distribution and task assignment, as well as for the internal communication and team performance, all together in compliance with explicit criteria for self-/peer- (e.g., participation in group discussions, creativity, search and writing skills, availability to help others) and group-assessment (e.g., group performance, autonomy, conflict management, quality of the artefacts produced). These criteria were also taken into account by the teaching team, not only for grading purposes but to continuously provide formative feedback on students' learning and achievements.

Different SCRUM sprints, meetings and roles were thus assigned to the 7 participating students every week, consisting of a rich opportunity to practice shared leadership and experience the performance of different tasks (e.g., leading the group towards the sprint achievement, coordinating the writing of a team report, managing time and deadlines). Additionally, the collaboration between the participating students and other project stakeholders was an essential part of the PjBL experience, on several occasions, namely 1) at the very beginning of the project, with the UTAD Social Responsibility Office, which trained students on job hunting and professional guidance, empowering them to be able to delivery subsequent training for the REFOOD beneficiaries, 2) at the project requirements stage, with the REFOOD beneficiaries and representatives, which not only participated in the survey about their professional profile and needs, but also in the training session on job hunting and professional guidance, and 3) at the end of the project, with the local and national news media community, to deliver the project press release and participate in media interviews.

2.5 The Scaffolding Technologies

In order to support the PjBL educational activities and the collaboration among students, different technologies were used, such as 1) Zoom - for the delivery of some synchronous classes (this semester had a hybrid format with face-to-face and online classes according to the pandemic situation), practical hints sessions, discussion activities, and meetings with stakeholders, 2) Padlet - for the management of course activities, resources and deliverables, 3) Trello - for the monitorization and quality control of SCRUM sprints, meetings, and outputs, 4) WhatsApp - for the internal communication, 5) ProjectLibre - for the development of project WBS, Gantt chart, and Earned Value Management (EVM), and 6) Google Drive - for the collaborative writing of the project reports, multimedia presentations, spreadsheets, and surveys.

2.6 The Creation of Tangible Artefacts

Among the tangible artefacts co-produced during the PjBL experience by the participating students involving the development of the professional (re)-integration plan for the REFOOD beneficiaries (e.g., multimedia presentations, written reports, surveys, online and SCRUM meeting records, project charter, WBS, Gantt, professional portfolios), some were of utmost importance for the learning assessment. These included the intermediary and the final written reports and oral presentations delivered to the teaching team, the UTAD Social Responsibility Office, and the REFOOD representatives, as well as the 2 job positions achieved for 2 of the 10 REFOOD beneficiaries.

3 Materials and Methods

A qualitative, exploratory case study research was carried out within the scope of this PjBL experience [25]. The main research goal is further outlined, followed by the sample included in the study, the instruments, the procedures adopted for data collection and analysis, and the ethical considerations. An overview of the data collection methods and techniques - teachers' participant observation, documental analysis, and questionnaires on students' perceptions - used to assess the overall impact of the UTAD-REFOOD PjBL experience is presented in Fig. 2.

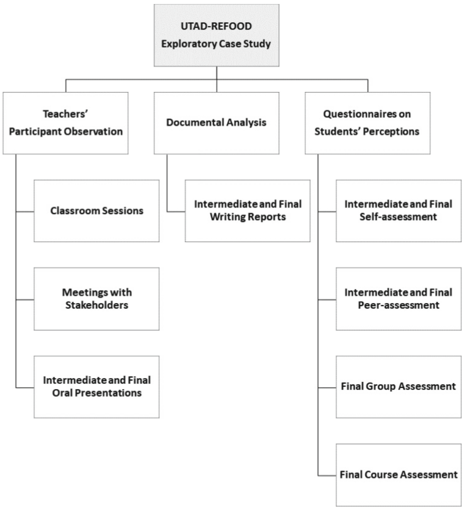

Fig. 2. The UTAD-REFOOD exploratory case study overview.

3.1 Research Goal and Design

The main research goal of this study was to explore how the PjBL experience affected the participating students' perceptions of their learning process and development. Specifically, we aimed at answering to the following question: to what extent a PjBL experience with this scope and characteristics could successfully be implemented to enhance students' project management, critical thinking, teamwork, communication, and empathy skills ?

3.2 Research Sample

A convenience sample of 7 graduate students enrolled in the 'Industrial Management I' course of the Mechanical Engineering MSc degree at UTAD was included in the study. The sample was constituted of 6 male and 1 female participant, aged between 21 and 23 years.

3.3 Research Instruments and Procedures

The impact assessment of the PjBL experience took into account the quality of the professional (re)integration plan for socially and economically deprived people who depended on external food supply provided by a non-profit organization called REFOOD, since this was the main tangible learning artefact produced by the participating students in response to the initial driving question. In order to measure its quality, different quantitative and qualitative indicators were defined, namely: 1) the number of REFOOD beneficiaries with a job at the end of the project, 2) the quality of the professional portfolios of the REFOOD beneficiaries catalogued by their type of profiles and CV, 3) the media coverage of the project by local and national media companies, 4) the feedback provided by the REFOOD representatives and beneficiaries on the project oral presentations, writing plans and reports, 5) the quality of students' intermediate and final written reports, and 6) the quality of the project-related documents produced by students (e.g., WBS, Gantt, EVM, SWOT analysis, SCRUM reports).

By having in mind these indicators, teachers' participant observation was carried out during the whole PjBL experience, especially during the classroom sessions, the meetings with stakeholders, and the intermediate oral and final presentations. Although an unstructured, naturalistic type of participant observation [26] was adopted by the teaching team, special attention was paid to the feedback provided by the different stakeholders on the project outputs, the student's engagement with the activities, as well as to the overall students' learning development in terms of knowledge and skills. Documental analysis of the intermediate and final project writing reports delivered by students was performed by the teaching team using a direct approach to content analysis [27, 28], taking into account the development of students' project management, critical thinking, empathy and teamwork skills. Moreover, data were also obtained and analyzed from four different self-completion questionnaires on students' perceptions about the PjBL experience, previously designed by the teaching team, namely, 1) an intermediate self- and hetero-assessment questionnaire, 2) a final self- and hetero-assessment questionnaire, 3) a final global assessment questionnaire about the group performance, and 4) a final global assessment questionnaire about the course experience. Perception questions differ from other types of survey questions focusing on knowledge, attitudinal, or demographic dimensions since they allow respondents to provide information on how they perceive such matters as the effectiveness of the learning experience [29].

Both the intermediate and final self- and hetero-assessment questionnaire consisted of a 4-points Likert scale instrument covering 11 dimensions: 1) project execution, 2) cooperative work, 3) work preparation, 4) conflict resolution, 5) creativity, 6) critical thinking, 7) punctuality, 8) digital competence, 9) writing communication competence, 10) deadlines, and 11) leadership. Similar to these two questionnaires, the final global assessment questionnaire about the group performance was built using a 4-points Likert scale with 12 dimensions: 1) autonomy, 2) punctuality, 3) conflict resolution, 4) cooperative work, 5) oral communication competence, 6) writing communication competence, 7) communication between elements, 8) digital competence, 9) creativity, 10) deadlines, 11) mutual help, and 12) overall effort. Ultimately, the final global assessment questionnaire about the course experience included 9 open-ended questions and 15 4-points, Likert scale questions. This questionnaire covered the following dimensions: 1) learning goals, 2) course satisfaction, 3) course structure, workload and assessment, 4) group work and technologies, 5) course positive aspects and suggestions for improvement, 6) learning difficulties and suggestions for improvement, and 7) developed competencies. All the participating students answered the questionnaires, either via mobile devices or personal computers. Their responses were collected and saved immediately after completion. Data were then analyzed using statistical measures such as the minimum, the maximum, the mean, and the standard deviation values. Different bar charts and box-plot diagrams were elaborated using the SPSS Statistics software; one could have thought of performing independence tests, but the small sample size limited the statistical treatment of the data.

3.4 Ethical Considerations

The ethical requirements of the European Federation of Psychologists' Associations (EFPA) were followed [29]. All ethical principles were respected, ensuring that all participants knew and accepted the principles of informed consent, voluntary participation, and confidentiality of their responses.

4 Results

Results on the impact assessment of the PjBL experience are presented below according to two different types - the tangible outputs achieved by the participating students, and the intangible outcomes generated by the data collection and analysis using the four questionnaires on students' perceptions, the teachers' participant observation, and the documental analysis of the intermediate and final project writing reports.

4.1 Tangible Results

Different tangible results were achieved by the participating students within the project lifetime activities, including:

- The professional portfolios - a digital database with the CVs of the participating REFOOD beneficiaries catalogued according to their profiles and needs. This output required the development of students' resilience and empathy skills, not only due to the difficulty experienced in reaching and contacting some of the beneficiaries but also because of the challenge of establishing a social and emotional connection with them;
- The professional development plans - a concrete training proposal for the REFOOD beneficiaries consisting of professional guidance with practical recommendations for job hunting. This output was jointly co-developed with the UTAD Social Responsibility Office (i.e., as key stakeholder and supervisor), requiring the students' assertive communication skills to cooperate with all involved stakeholders;
- The project management documentation - different project management learning artefacts (e.g., WBS, Gantt, EVM, WBS, SWOT, SCRUM reports) developed by students, used to support the development of the whole PjBL experience activities. These learning artefacts implied the use of students' project management skills, like quality, time, communication, and human resources planning, through the application and use of different techniques and tools;
- The successful job hunting cases - 2 REFOOD beneficiaries got a job successfully;
- The public presentations and reports - three public oral presentations and two writing reports discussed with different stakeholders (i.e., UTAD Social Responsibility Office, REFOOD representatives and teaching team) about the project status and outputs;
- The media coverage - one press release followed by one interview about the project with a national media company, and five media articles published in local and regional media companies.

4.2 Intangible Results

4.2.1 Students' Perceptions About Their Self- and Peers' Performance

Comparative results generated from the intermediate and final self- and hetero-assessment evaluation questionnaires are displayed in Fig. 3, according to the questions presented in Table 1. These questions were specifically related to students' overall performance within specific dimensions, based on the research goal and the impact assessment indicators initially outlined by the authors. Therefore, students' responses were collected using a 4-point Likert scale; in all the questions, the value 1 was the lowest level (i.e., the group members contributed little or nothing to this dimension), and the value 4 was the highest one (i.e., the group members' contribution was excellent, doing everything as expected or even more). Although the Likert scale corresponds to categories represented as numbers, we analyzed the mean and standard deviation values to get the overall perception of the responses' questionnaires.

Table 1. Questions from the intermediate and final self- and hetero-assessment questionnaires on students' perceptions about their self- and peers' performance.

Question number	Dimension (description)
Q1	Project execution ('I/he/she performed the tasks of my/his/her responsibility to help achieve the defined goals')
Q2	Cooperative responsibilities and teamwork ('I/he/she helped to accomplish the team goals, asking for help or supporting the others when needed, by active listening and respecting the different points of view')
Q3	Individual preparation ('I/he/she dispensed the needed time and brought the supportive material requested for the group work activities')
Q4	Conflict resolution ('I/he/she listened and accepted suggestions for improvement from the others, especially in conflicting situations of disagreement, by proposing alternatives to reach a consensus or solve the situation')
Q5	Creativity ('I/he/she brought creative ideas to the group work activities')
Q6	Critical thinking ('I/he/she sought to question things and see different points of view, being curious and justifying my/his/her positions with valid, relevant and clear arguments')
Q7	Group work meetings' punctuality ('I/he/she was always punctual')
Q8	Digital skills ('I/he/she mastered or sought to learn and/or consolidate my/his/her digital skills')
Q9	Writing skills ('I/he/she successfully articulated and synthesized ideas by relating the factors between them in a clear way')
Q10	Deadlines ('I/he/she met the deadlines for tasks in which I/he/she was responsible')
Q11	Leadership ('I/he/she played a leadership role with commitment to the team, leading its members to do what was needed on time and according to the established goals')

Figure 3 shows the comparison between the mean values corresponding to each question presented in Table 1. The blue bars relate to the students' answers to the intermediate questionnaire, and the orange ones to the final instrument. The standard deviation for each question and instrument is indicated by the segment above each bar.

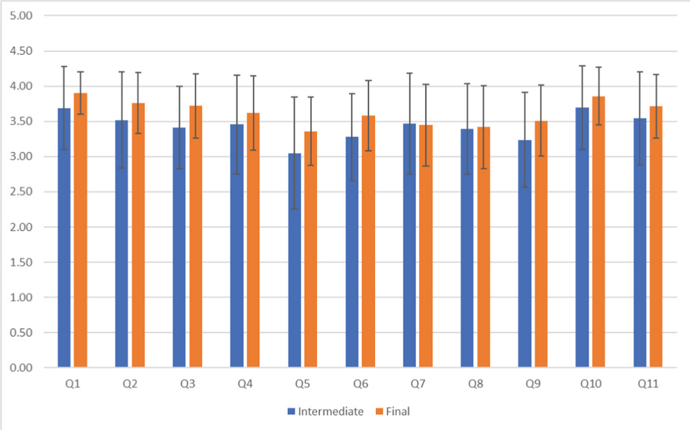

Fig. 3. Mean and standard deviation of the students' perceptions about their self- and peers' performance.

All the mean values are positive, situated above 3 and, except for Q7 (Punctuality), and have increased between the intermediate and the final questionnaire. A possible explanation for this might be related to the overall increase of the learning assignments prevenient from other MSc curricular units and typically experienced by the participating students during the last weeks of the academic semester. The highest increment was verified in Q5 (Creativity) and Q6 (Critical thinking). Standard deviations are low and of a similar range between the intermediate and final questionnaire. The highest-scoring questions are Q1 (Project execution) and Q10 (Deadlines), in both the intermediate and final questionnaires.

4.2.2 Students' Perceptions of the Group Performance

Results generated from the final group performance questionnaire are displayed in Fig. 4, according to the questions presented in Table 2. These questions were specifically related to the group performance levels within specific dimensions. Therefore, students' responses were collected using a 4-point Likert scale; in all the questions, the value 1 was the lowest level (i.e., insufficient performance), and the value 4 was the highest one (i.e., very good performance).

Figure 4 shows the mean values corresponding to each question presented in Table 2. The standard deviation for each question is indicated by the segment above each blue bar.

The majority of the mean values were equal to or above 3, which shows a very positive students' appreciation of the overall group performance, and standard deviations range between 0 and 0.8. It is interesting to note that the highest mean values observed were strongly related to key teamwork skills and spirit, such as conflict management (Q3), rapport (Q4), and mutual help (Q11). Contrastingly, students rated lower in the group performance related to the oral presentations (Q5) and creativity (Q9). Despite students being aware of the importance of this PjBL to the improvement of their communication

Table 2. Questions from the final assessment questionnaire on students' perceptions about the group performance.

Question number	Dimension
Q1	Autonomy
Q2	Punctuality
Q3	Conflict management
Q4	Rapport
Q5	Oral presentations
Q6	Writing skills
Q7	Communication between members
Q8	Digital skills
Q9	Creativity
Q10	Deadlines
Q11	Mutual support
Q12	Group effort

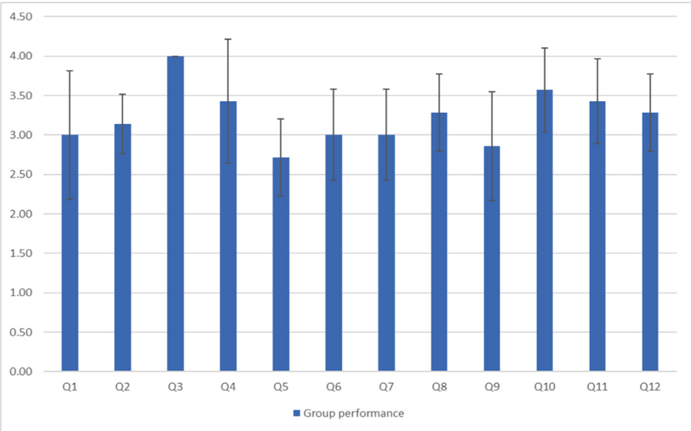

Fig. 4. Mean and standard deviation of the student's perceptions about the group performance.

and creativity skills, these results were reinforced by the responses to the open-ended question regarding the main difficulties that students experienced as a team and ways to overcome them, like as an example:

- '(…) we need to improve our communication, the way we present our ideas, either between us or to the public. The ways we can overcome this vary from person to person, but projects like this help a lot to overcome these barriers' (student 2);

- '(…) communication; express what we want to say/communicate, but as we interact with the teacher things improve '(…) concerning the technological aspect, for example, it was difficult to communicate using Zoom and Word due to lack of practice' (student 4);
- '(…) the main group difficulty was to communicate, and to overcome this we probably need more public presentations and/or activities like debates, which promote the critical spirit and argumentation capacities' (student 6);
- '(…) sometimes things could be done with a greater quality but because of other curricular units, we try to do the tasks quicker, and probably they are not so good' (student 7).

4.2.3 Students' Perceptions About the Course Experience

Results generated from the final questionnaire about the overall learning experience are displayed in Fig. 5, according to the questions presented in Table 3. These questions, specifically selected for analysis, were related to the students' agreement on different course-related dimensions. Students' responses were collected using a 4-point Likert scale; in all the questions, the value 1 was the lowest level (i.e. totally disagree), and the value 4 was the highest one (i.e., totally agree).

Figure 5 shows the mean values corresponding to each question presented in Table 3. The standard deviation for each question is indicated by the segment above each blue bar. The mean values range between 1.7 and 3.9, while the standard deviation values range between 0.58 and 0.79. All students expressed that the teaching module about project management was of extreme importance for their professional careers as future mechanical engineers (Q1; $\bar{x} = 3.9$), considering that the challenges faced within the PjBL experience are similar to those faced by a mechanical engineer at the workplace (Q2; $\bar{x} = 3.6$), even though the project, more than technical, had a strong social strand.

Moreover, while they felt some difficulties in the use of digital tools to elaborate the GANTT chart (Q3; $\bar{x} = 2.3$), they ended up having more confidence in both developing a project plan and controlling it (Q4 and Q5; $\bar{x} = 3.3$). In this context, the scaffolding strategies implemented by the teaching team seem to have been relevant - formative feedback (Q6; $\bar{x} = 3.4$), small-hint discussions and modelling sessions (Q7; $\bar{x} = 3.6$) supporting the development of students' readiness to engage with project management.

While most students found that the work outside the classroom involved an extra workload, requiring additional time and effort (Q8; $\bar{x} = 1.7$), they all enjoyed working as a team (Q9; $\bar{x} = 3.9$), highlighting this aspect as crucial to the learning of project management (Q10; $\bar{x} = 3.8$). In line with this, students agreed on the overall usefulness and ease of use of most of the scaffolding technologies that supported the group work (i.e., Padlet, Whatsapp, Google Drive), except of Trello and Zoom, which sometimes challenged their ability to be more participative in the teamwork debates. Notwithstanding, they all pointed out that communication was one of the most developed skills during the project lifetime, followed by teamwork, critical thinking, and leadership, and this was also evident from the final open-ended questions' data on the most positive and negative aspects of the whole course experience.

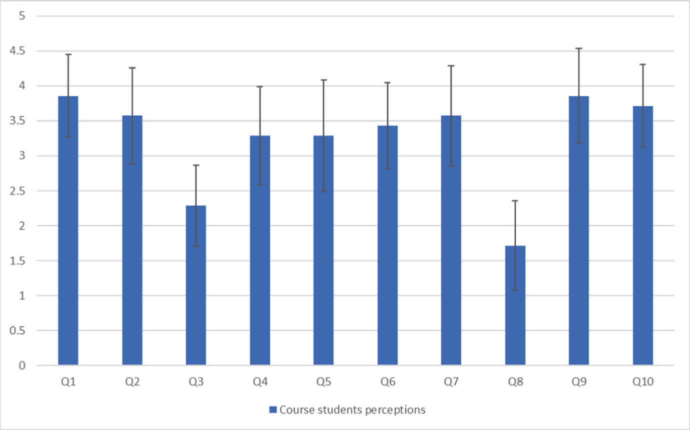

Fig. 5. Mean and standard deviation of the student's perceptions about the course experience.

Table 3. Questions from the final questionnaire on students' perceptions about the course experience.

Question number	Description
Q1	'I consider that what I learnt in this course is important to my professional career as a future mechanical engineer'
Q2	'I consider that the challenges faced during the PjBL activities are similar to the ones that a mechanical engineer will face at the workplace'
Q3	'I know how to use a digital tool to create a GANTT diagram'
Q4	'At this point, I feel that I can develop a project plan'
Q5	'At this point, I feel that I can control a project'
Q6	'The teaching formative feedback on students' assignments was useful'
Q7	'The preparation classes for project monitoring and follow up with the teaching team were useful to develop the PjBL activities'
Q8	'I consider that the study/work in and outside the classroom was balanced'
Q9	'Overall, I enjoyed working in a group'
Q10	'I think that I learnt more because of the possibility to work in a group during the project management'

4.2.4 Document Analysis of the Final Writing Project Report

The final writing project report consisted of a document collaboratively written by all students about the project's processes and outputs. Therefore, students were asked to reflect together upon three key components of the PjBL experience: the project (e.g., objectives, achieved and non-achieved results, suggestions for improvement), the group work (e.g., SWOT analysis, leadership, success factors), and the personal development (e.g., difficulties, achievements, impact).

Regarding the project, students felt that although the EAP took time and workload to be developed, it was one of the most important outcomes of the experience, identifying logically all the tasks that need to be performed, giving a path to more effective project execution. On the other hand, the communication plan was not found as being an important tool for the project execution, since students did not need to consult it during its lifecycle. They even mentioned that in projects like this one, performed in a small team and involving a small number of stakeholders, there is not so much need to formalize communication channels. Students recognized that they failed in establishing long-term partnerships between the project stakeholders for the continuity and sustainability of the project, especially with the companies. In this sense, as suggestions for improvement, they pointed out to the need for a commitment analysis of all the stakeholders from the very beginning of the project, to better assure its successful development and execution.

Concerning the group work, students noted slight improvements in the team's internal communication and self-confidence, recognizing a continuous need of having more experience in project management to training these aspects. They pointed out "team spirit, coordination, organization, respect, persistence, ambition, communication, cooperation and trust" as the drivers for the success of the group work. They felt they demonstrated these qualities often over the project lifetime, and even when "there was a divergence between team members' opinions in the Zoom meetings", they "were organized and persistent (…) having improved this aspect thanks to the regular meetings". In this context, students reflected on the importance of experiencing the exercise of shared democratic leadership, in which "different ideas, suggestions and critiques were taken into account for decision-making", enhancing the mutual trust, collaboration and help among the team members.

Finally, at the personal level, students found that the project allowed them to "develop and grow not only as future project managers and engineers but also as persons since we had to establish a continuous relationship with people within different social and economic situations", which provided "a broader perspective about society". Among the aspects for improvement, students mentioned that the different time availability, low technological literacy and oral communication skills challenged them to seek strategies of self- and group development, like the pre-schedule of SCRUM meetings, the increase of the communication with the stakeholders, or even the enrollment in training courses about digital tools and/or languages.

4.2.5 Teachers' Participant Observation

As key facilitators of the PjBL experience, teachers acted as participant observers who continuously analyzed the students' learning development. There was an incremental students' participation in the PjBL discussion activities (e.g., posing questions, intervening by providing constructive feedback), in which teachers' regular and constant feedback was felt like a very powerful tool for students' engagement. An important aspect was to allow students to lead the project and to be autonomous while taking their own decisions and learning paths, within an open, democratic environment, which constantly enhanced the relationship established with the different stakeholders.

Due to the difficulties felt by students in terms of external communication (e.g., shame and lack of confidence when communicating with UTAD Social Responsibility Office, REFOOD representatives, beneficiaries, and media), it was important to challenge them in writing a press release for media coverage and to respond to a media interview, as well as giving them more confidence in their capacity of communicating with different stakeholders. A specific small-hint, classroom discussion on groups' dynamics and assertive communication dynamized by the teaching team was essential for this purpose.

During the oral presentations, students manifested their biased assumptions and beliefs regarding the REFOOD beneficiaries at the very beginning of the project (e.g., by judging that they were in that socially and economically deprived situation due to their lack of motivation and effort to change, preferring to live under social aids instead of looking for a job). During the project, students were asked to deeply engage and be involved with the REFOOD beneficiaries, by trying to empathetically understand their situation. This resulted in a change in their belief systems and assumptions manifested orally in the final presentation (e.g., by realizing that society labels them and gives them few opportunities for professional re(integration)). This PjBL experience had a double effect at this level. That is, also the REFOOD beneficiaries gained a different perspective about the value and importance of this kind of PjBL experience, which are crucial to empowering the University-Business-Society triad.

5 Discussion and Conclusion

The PjBL experience herein presented has impacted the students' personal and professional lives, contributing to their growth as future project managers and as individuals, by offering students a real-world scenario to develop the necessary knowledge and skills needed for their professional careers in the engineering management field, in line with previous studies [17, 30]. More specifically, the characteristics of the socially driven scenario at stake stimulated students' communications skills development, leading them to a more empathic attitude towards the main beneficiary stakeholders who were in economically and socially deprived situations. This, in turn, made students question their pre-conceived, biased assumptions, namely the one that the beneficiaries were lazy and subsidy-dependent people. They thus took conscience that whatever the project they will have at hand in the future, assumptions and beliefs must be identified and questioned to not become an obstacle. On the other hand, the beneficiaries had low expectations regarding the initiative's success, perhaps because they were not used to being the focus of other individuals' concern for better living conditions. The fact that a job was found for two of them made everyone more enthusiastic and expectant about their future.

Among the project's contributions, we highlight improvements in communication, empathy, teamwork, project management, and critical thinking skills. These main results were possible thanks to the consideration of the six hallmarks proposed by [7] for PjBL in a collaborative learning context, with shared leadership and constant feedback and reflexive moments. In this context, as students gain more control of the project, in an environment in which they have the freedom to discuss different perspectives, make decisions and fail, they progressively gain a sense of self and group empowerment, transforming the teaching team into a role of moderators, thought-provoking elements, resources providers, mediators between different stakeholders. In that way, the teaching team has to become more creative, and resilient and be able to adapt, to think critically about the project development, its success/inhibitors factors. It requires giving autonomy to students, making them proactive and responsible for their learning while educators dissociate themselves from their typical role of the transmitter of knowledge.

The solution developed by the participating students to this economic and social problem (in close collaboration with the stakeholders), its execution and control, proves their efforts and work, synthesizing and reflecting all the knowledge and skills acquired during the course activities, having been rewarded with a very positive appreciation from all stakeholders. As it is clear through the analysis of results, and reinforcing the literature [19], one-shot experiences like this one are not sufficient. As students were able to convey to the investigation elements, the path for successful communication and empathy is a long one and needs constant improvement. Thus, a shift is needed to drive additional and common efforts to rethink the teaching program. Time constraints need to be addressed to effectively meet the learning goals. Competencies like teamwork, project management, critical thinking, and oral communication need to be explicitly, continuously and congruently allowed across the engineering curricula, otherwise, the short-term efforts are likely to be limited [18, 20].

6 Limitations and Future Work

Although this socially driven PjBL for engineering students might inspire other engineers (and not only) educators to strongly embed social and economic problems in the curriculum to effectively help develop communication and empathy skills, it has some limitations. First, the small sample size of 7 participating students, which does not allow to make any generalization of the results. Second, a more refined qualitative analysis of students' tangible artefacts (e.g., project WBS, Gantt chart, oral presentations, written reports), as well as the application of a quasi-experimental research design with pre-/post-assessment of the students' competencies, is likely to be taken into account by the teaching team in the next course editions.

Another reflection worth having is on the challenges of this approach for large classes with many students and different projects, especially what concerns teachers' workload. It also questions the freedom of the curriculum, since this kind of approach does not always guarantee to find real-world projects which include the possibility to apply all the components of the syllabus (in this case, for example, less need for the optimization component). What, then, should be privileged, and assessed? Finally, is it possible to gradually increase the level of complexity of the projects for students to be prepared for our VUCA (Volatile, Uncertain, Complex, and Ambiguous) world? Would then it be possible to focus more on some key skills (like empathy) rather than others? How to assess success in this kind of projects?

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Designing Critical Thinking Blended Apprenticeships Curricula to Promote Reflective Thinking in Higher Education

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Abstract. Higher-order thinking skills, such as critical and reflective thinking, are essential for Higher Education graduates' employability. Particularly for the teaching profession, reflective thinking has been highlighted by theorists, such as Schön, as a necessary skill for regulating various aspects of the profession. The literature demonstrates that critical and reflective thinking, both higher-order thinking skills, share common ground. Still, instruction is required in order for students to develop them after attending studies in Higher Education. In addition, the transformation of Higher Education curricula to promote higher-order thinking skills might be a demanding task. Following theoretical presuppositions regarding instruction for critical thinking and blended learning, two Critical Thinking Blended Apprenticeships Curricula for Teacher Education were designed. The study aimed to examine whether the curricula could promote reflective thinking. Seventy-one undergraduate student-teachers participated in the study, which followed a pretest-posttest design. Paired sample t-tests revealed minor differences in student-teachers' reflective thinking, which were nevertheless insignificant. However, when the two curricula were examined separately, a significant increase in student-teachers' dimensions of reflective thinking was revealed. Results are discussed in light of the super complexity of learning and teaching in Higher Education.

Keywords: Critical and reflective thinking · Higher education · Curricula

1 Introduction

Policymakers such as OECD [1] stress the need for educational systems to go beyond factual knowledge and unreflective learning, equipping students with tools necessary to understand the contemporary world, such as higher-order thinking skills, procedural knowledge, and cross-disciplinary thinking. Particularly for the teaching profession, higher-order thinking skills, such as Critical and Reflective Thinking, have been considered essential qualities for 21st-century teachers [2]. However, the design of Higher Education (HE) curricula promoting higher-order thinking skills, such as Critical and

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Reflective Thinking, can be demanding and challenging for educationalists and instructors. The current work is carried out within the European Erasmus + funded Project "Think4Jobs", which aims to design, develop and evaluate Apprenticeships Curricula in various disciplines in order to foster graduates' Critical Thinking and bridge a skills mismatch [3] between the ones cultivated through HE curricula and those required by labor market stakeholders. In particular, the current work presents results regarding the development of student-teachers' Reflective Thinking during a semester of attending courses implementing blended apprenticeship curricula aiming at student-teachers' development of Critical Thinking.

1.1 Critical and Reflective Thinking

Critical Thinking (CT) is a controversial concept, and a literature review reveals the lack of consensus among scientists regarding its nature and definition. Halpern defined CT as "the use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal-directed […]" [4, p.8]. In that sense, CT involves structured judgment towards a specific end and identifying pitfalls and mistakes in argumentation [5]. CT is considered as a compound of a set of skills (such as interpretation, evaluation, inference, and verbal reasoning) and dispositions (such as truth-seeking, open-mindedness and flexibility) [4, 6]. However, CT is usually activated as "an integrated skill" [7, p.669], thus being something more sophisticated than a simple conglomeration of separate skills and dispositions [8].

Reflection, on the other hand, is defined as a "conscious, active process of focused and structured thinking" [9, p. 338], which scaffolds the identification of complex or ill-structured problems [10] through contemplation over knowledge, understanding, and prior experience [5]. Initiating from Dewey's theory [11], Reflective Thinking (RT) or critical reflection -as it is also called- is considered a vital component of learning and also appears to be significant in the work field of various domains since professionals have to practice reflection on a daily basis [12]. However, contrary to what was expected, reflection is not habitually activated as a daily professional attitude but arises in cases of mishaps or crises [9].

Older research supported the idea that CT and RT are orthogonal (are not interrelated to each other) and are approached as two separate entities [13]. However, current research findings suggest that there is an interplay between them. At the same time, the interaction of CT and RT, as higher-order abilities, seem to promote academic performance [5, 14]. The strength of this approach is also supported by Facione [6], according to whom the concept of reflection is introduced in the CT field: "Critical Thinking is judging in a reflective way what to do or what to believe" (p. 61). Other research suggests that there is common ground between these two concepts and metacognition in that a focal point in the thinking process is detected through deliberation. This particularly applies in the problem-solving area in social sciences when students are presented with real-life tasks requiring holistic approaches. Especially in teacher education, student-teachers must be familiarized with designing and constructing lesson plans and activities that can actively engage pupils. Besides, their educational decisions and choices in the classroom settings should combine knowledge, pupils' perceptions, and beliefs by guidance offered through formative assessment [15]. Therefore, it is assumed that contemporary approaches to teaching in the light of constructivism indicate the interaction between CT and reflection [16].

Based on the above, we can claim that there is a need for a combination of high-order skills that can lead future teachers to quality teaching but graduating from Higher Education Institutions (HEI) does not necessarily guarantee the acquisition of such skills since disciplinary knowledge as well as skills and dispositions should be combined by offering student-teachers opportunities for reflection [17]. Therefore, the way that the skills mentioned above and dispositions can be explored and taught in HEI is to be traced and explicitly analyzed, especially since university attendance, per se, does not seem to promote students' creative and CT skills [18].

In the field of teacher education, the need for reflective practitioners [19] seems to be a constantly emerging theme due to the nature and the demands of the occupation, which is not only restrained to aiming at pupils' mere acquisition of knowledge but extends further to the concepts of Values Education [20, 21] and Critical Pedagogy [22] identifying teachers and pupils as active members of a society striving for reconstruction and transformation [23]. In detail, future teachers should be aware of the importance of reflection and committed to it since it is necessary when tracing and analyzing their pupils' needs and preferences to support their learning [24]. Besides that, reflection in the classroom is also needed in classroom management in the light of democracy [25]. Additionally, critical incidents, which commonly arise in classroom settings, also set the stage for critical reflection [26]. Therefore, a crystallized and explicit understanding of reflection is needed and should consequently be infused into the HEI curricula in the field of teacher education.

1.2 Instruction for Critical Thinking

Instruction for CT could benefit if certain theoretical presuppositions are met. First, Ennis [27] proposed four CT instructional approaches, namely the general (i.e., CT is taught independently from content), the infusion (i.e., CT is taught explicitly within a specific subject-matter or content), the immersion (i.e., CT is taught implicitly within a particular subject-matter or content) and the mixed approach (i.e., the general approach is combined with either infusion or immersion). In their meta-analysis, Abrami, Bernard, Borokhovski, Waddington, Wade, and Persson [28] reported that the mixed approach has the most positive impact on students.

Second, previous research [28, 29] has indicated that teaching strategies such as engaging students in dialogue, higher-order questioning, authentic or situated problems, and mentoring positively affected CT skills. Moreover, mentoring, which is perceived as one-on-one interaction between an expert and a novice [30], and types of mentoring such as apprenticeships/internships/placements are indicated as valuable approaches for labor market stakeholders [31]. In particular, apprenticeships are work-integrated learning interfaces allowing students to adapt and apply theoretical knowledge in real-world learning contexts [31]. Later, we describe how these theoretical presuppositions are met in the current study.

1.3 Blended Learning in Higher Education

The COVID-19 pandemic had a broad and immediate impact on the digitalization of HE, forcing HEI to make a transition to online teaching and learning through the exploitation of Learning Management Systems (LMSs). As the pandemic recedes and the HEI return to physical campuses and face-to-face instruction, Blended Learning (BL) is becoming new normality in HE instruction and/or design of learning environments [32]. BL is the combination of face-to-face and technology-mediated instruction in a pedagogically thoughtful manner [33]. The effectiveness of BL is widely studied in the literature, revealing its positive impact on students' learning outcomes in HE [34, 35]. Still, a question arises regarding the level of institutional adoption of BL and its actual implementation in HE [36], which can be related to the abstract definition of BL and how instructional designers perceive it. Alammary, Sheard, and Carbone [37] conducted a review and reported three approaches regarding the implementation of BL in HE: (i) the low-impact blend, namely adding extra online activities to an existing face-to-face course; (ii) the medium-impact blend, where some face-to-face activities are replaced with online activities in an existing course and (iii) the high impact blend, that is, building the blended course from scratch. Later on, we describe how BL was exploited in the current study.

1.4 Designing Blended Apprenticeships Curricula for Critical Thinking

According to a phenomenographic study by Fraser and Bosanquet [38], "curriculum" means, among others, the subject matter content and structure of delivery at a course level. HE curricula are undergoing significant changes in order to meet the needs of the labor market [39]. Thus, we will present the design procedure followed in the research presented here to transform two HE Curricula for the discipline of Teacher Education in order to meet the needs of the labor market regarding the development of graduates' CT. The Critical Thinking Blended Apprenticeships Curricula (CTBAC) at a subject matter content level aims to prepare student-teachers for the design of Teaching Learning Sequences (TLSs) in Early Childhood and Elementary Education. Notably, one CTBAC focuses on Science Teaching, while the other one focuses on Teaching Biological and Environmental Concepts.

For the design process of the CTBAC, we employed the ADDIE [40] instructional design model, which follows five interconnected steps, namely: i) requirements analysis, ii) design, iii) development, iv) implementation, and v) evaluation.

Considering the theoretical presuppositions regarding CT instruction, as well as the fact that BL is a common feature in the post-Covid-19 era, five main requirements emerged for the design of the CTBAC. First, the mixed approach for the instruction of CT was exploited along with the infusion approach. Infusion instead of immersion was preferred due to previous research suggesting that explicit instruction of CT can prove beneficial for students' CT development [41]. Second, the curricula were to be implemented in the context of teacher apprenticeships. This requirement was grounded on: (i) the fact that apprenticeships as a form of mentoring facilitate the development of CT; (ii) the fact that mentoring can benefit apprentices [42]; (iii) apprenticeships allow student-teachers to implement their theoretical knowledge in real-life settings.

Third, considering the literature for CT instruction, HE Instructors exploited teaching strategies that promote CT, such as dialogue, higher-order questioning and problem-based learning. Fourth, although BL was deemed an appropriate approach to follow in the post-Covid-19 era, HE Instructors adopted a low blend approach for the design of the CTBAC due to a lack of previous experience in the design of BL Environments. Finally, the fifth requirement was related to the identified expected learning outcomes of the CTBAC. Apart from the content-related, outcomes regarding CT skills and dispositions were identified. For that purpose, a bottom-up procedure was followed, as stakeholders from the Labor Market identified CT skills (i.e., inference, interpretation, explanation, analysis, evaluation, reflection, self-regulation) and dispositions (i.e., flexibility, open-mindedness, analyticity, systematicity, inquisitiveness, intellectual courage) that they considered essential for future teachers. For more information regarding the procedure followed to identify the CT skills and dispositions, the reader can refer elsewhere [i.e., 43, 44].

In the second step of the ADDIE instructional design model, the content and the materials for the CTBAC were designed, and specific learning scenarios were prepared to ensure that they meet the requirements set in the first step of the design process.

Next, the development step followed, where the designed content, activities, and materials for the CTBAC were created. For the online mode of the CTBAC, the Moodle platform was employed. MOODLE is an open-source LMS that can be developed according to users' needs. In addition, it offers a user-friendly interface and a variety of tools allowing the design and implementation of constructivist activities [45]. Both CTBAC included online activities that allowed interaction among the student-teachers (e.g., chat, forum), interaction with the mentors (e.g., chat, assignments, feedback), as well as activities for student-teachers evaluation (e.g., assignments). The courses differed on the exploitation of explicit and implicit reflection strategies. The developed CTBACs were peer-reviewed by experts in the field of CT and refined accordingly (for more information, see [46]). More information about the fourth and fifth steps of the ADDIE instructional design model will be provided in the following section focusing on the methodology.

1.5 Aim of the Study

There is an interplay between CT and RT [e.g., 14, 5], while some theorists [e.g., 4, 6] suggest that RT is an integral part of the development of CT. Still, higher-order thinking skills are not byproducts of attendance in HE, and direct instruction is required for their development [18]. Moreover, RT is of high value to the teaching profession [47]. In the current study, we have presented HE curricula designed to foster CT. A review of the existing literature about ways to promote CT as well as RT in HE reveals that the same or similar approaches (i.e., engaging students in dialogue, higher-order questioning, exposing students to authentic or situated problems, and mentoring) can be used for the promotion of both CT and RT [48]. Thus, we wondered whether CTBAC could also indirectly promote the development of student-teachers' RT. Therefore, in this exploratory study, we aimed to examine whether the design of the CTBAC can promote the development of student-teachers' RT, mainly in the conditions explicit or implicit RT strategies are exploited during the courses.

2 Method

2.1 Participants

Seventy-one student-teachers (62 females) participated in the present study. Participants were undergraduate students at the University of Western Macedonia's School of Education, preparing for a career in Early Childhood or Elementary Education. The majority of participants (83.1%) were in their 20s (aged between 19 and 30, $n = 59$), while 11.3% ($n = 8$) were in their 30s (aged between 31 and 40 years old). Finally, 5.6% were older than 40 years old ($n = 4$). Student-teachers were enrolled in one out of two courses on the design of TLSs in Science Education, namely Science Teaching (ST) ($n = 35$, 28 were in their 20s, 5 were in their 30s, and 2 were older than 40 years old) and Teaching of Biological and Environmental Concepts (TOBEC) ($n = 36$, 31 were in their 20s, 3 were in their 30s and 2 were older than 40 years old) during the winter semester 2021.

2.2 Research Design and Data Collection

In order to measure possible changes in student-teachers' RT through their participation in courses designed to promote CT, a pre-test – post-test study was designed. At the beginning of the semester, the HE instructors participating in the Erasmus + program informed the enrolled students about the study and asked them to consider participating. The study was approved by The University's Research Ethics Committee (No 11/18–10-2021). Participation in the study was voluntary, and data were collected anonymously. Students that consented to participate were asked to complete the pre-measurement of RT. During the semester, student-teachers were introduced to CT theory and related concepts alongside content knowledge, and they also engaged in numerous in-class as well as web-based activities designed to promote CT and content knowledge for 6 weeks. On the one hand, student-teachers attending the ST course designed their TLSs and implemented them in schools while explicitly reflecting on the design and implementation. They also received feedback from the instructor and the mentors fulfilling in that way the requirements for their apprenticeships for the next seven weeks of the semester. Student-teachers attending the TOBEC designed, presented, received feedback and refined their TLSs for the next seven weeks of the course. Reflection was supported implicitly. Mentoring was an integral part of both courses. Afterwards, student-teachers were asked to complete the post-measurement of RT. For the pre- and the post-measurement of RT, the same questionnaire was used (see Material section). Questionnaires were administered online, and students were asked to complete them during class, in the first lecture (pre-measurement) and the last lecture (post-measurement).

2.3 Material

For the measurement of RT, the Reflection Questionnaire [10] was used. The Reflection Questionnaire was designed to measure the level of RT in HE, consisting of 4 subscales with 4 items for each one of them: Habitual action (e.g., *When I am working on some activities, I can do them without thinking about what I am doing.*), Understanding (e.g., *I need to understand the material taught by the teacher in order to perform practical* *tasks.),* Reflection (e.g., *I sometimes question the way others do something and try to think of a better way.*), and Critical Reflection (e.g., *As a result of this course, I have changed my normal way of doing things.*). Habitual action refers to tasks performed with little thought, typical for experienced employees in the work field. Understanding relates to learning and comprehending knowledge without further reflection on the value of the content. Reflection concerns judgment over content relating to problems potentially leading to new perceptions. Critical reflection is defined as deeper reflection with a view to beliefs transformation [10, p. 384–385]. Participants were asked whether the statements characterize their thinking and acting during classes using a 5-point Likert scale (1: *"totally disagree"* and 5: *"totally agree"*). IBM SPSS 23 was used for further analysis. Cronbach's alpha in previous studies for the four subscales ranged from 0.62 to 0.76 [e.g., 49, 10]. In the present study, Cronbach's Alpha ranged between 0.70 and 0.80. For further analysis, an aggregated score was computed. The aggregated score was calculated by adding the response score for each of the four items per scale. Thus, the score per scale could vary from 4 (strongly disagree) to 20 (strongly agree).

3 Results

3.1 Descriptive Statistics

Table 1 presents the median and interquartile range (IQR) for each subscale pre- and post-assessment by course (Science Teaching-ST & Teaching of Biological and Environmental Concepts-TOBEC).

3.2 Changes in Student-Teachers' Thinking and Acting

In order to identify possible changes in students' RT as a result of the implementation of CTBAC, four Wilcoxon signed-rank tests were conducted to identify changes in pre- and post-measurements of student-teachers, one for each subscale. Results suggest a statistically significant improvement in Habitual Action ($Z = -3.506$, $p < .000$) ($M = 11$, $IQR = 9;14$ and $M = 14$, $IQR = 11;15$ for the pre and the post-test respectively). No other significant change was found (all ps $> .05$) (Fig. 1).

Furthermore, to investigate whether changes in thinking and acting differentiate between the two courses or if the pattern is similar in both courses, Wilcoxon signed-rank tests were conducted by course. Concerning student-teachers that attended *Science Teaching*, *the* Wilcoxon tests indicate a significant improvement in Habitual Action, $Z = -2{,}085$, $p < .05$, ($M = 11$, $IQR = 9;13$ and $M = 13$, $IQR. = 11;15$ for the pre and the post-test respectively). Moreover, a significant improvement was also found in Critical Reflection, $Z = -2{,}340$, $p < .05$, ($M = 15$, $IQR = 13;17$ and $M = 17$, $IQR = 15;18$ for the pre and post-test, respectively). No other significant change was found (all the other ps $> .05$) (Fig. 2).

Student-teachers enrolled in the Teaching of Biological and Environmental Concepts showed a significant improvement in Habitual Action, $Z = -2{,}716$, $p < .01$ ($M = 12$, $IQR = 9.25;15$ and $M = 14$, $IQR = 11.25;16$ for the pre-and the post-test respectively). No other significant change was found (all ps $> .05$) (Fig. 3).

Table 1. Median and interquartile range for each subscale of the reflective thinking questionnaire [10].

Reflective thinking questionnaire	Pre-test			Post-test		
	ST	TOBEC	Total	ST	TOBEC	Total
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Habitual action	11 (9;13)	12 (9,25;15)	11 (9;14)	13 (11;15)	14 (11,25; 16)	14 (11;15)
Understanding	17 (16;19)	17 (15;19)	17 (16;19)	17 (15;18)	17 (15;19)	16,50 (15,25; 18)
Reflection	18 (16;18)	16 (15; 17,75)	17 (15;18)	17 (16;20)	16 (15;19)	17 (15;19)
Critical Reflection	15 (13;17)	15,50 (14; 17,75)	15 (14;17)	17 (15;18)	16 (13;18)	16 (14;18)

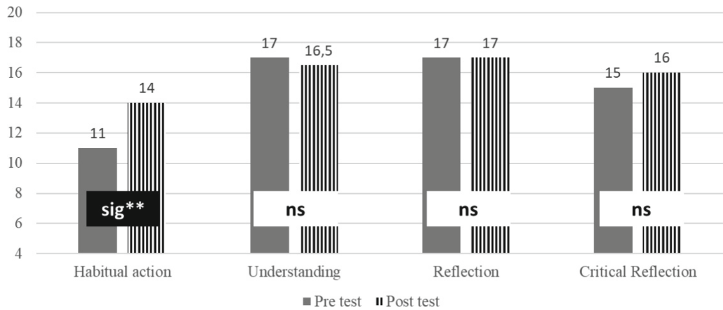

Fig. 1. A pre-post comparison of student teachers' thinking and acting based on Reflective Thinking Questionnaire.** $p < .001$.

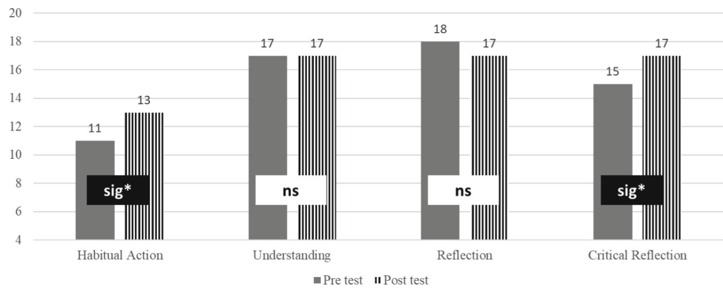

Fig. 2. A pre-post comparison of Science Teaching students thinking and acting based on Reflective Thinking Questionnaire. * $p < .05$.

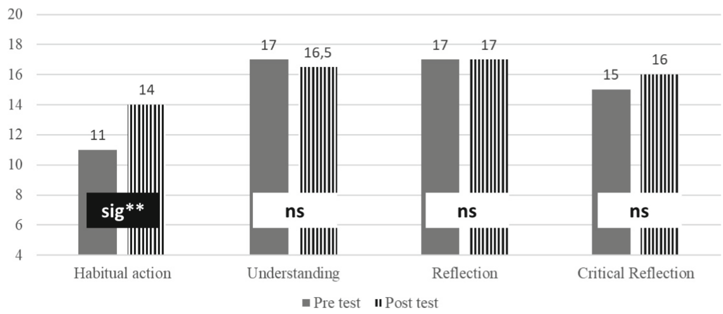

Fig. 3. A pre-post comparison of Teaching of Biological and Environmental Concepts students thinking and acting based on Reflective Thinking Questionnaire. * $p < .01$.

4 Discussion

The current study aimed to examine whether the design of two CTBACs fostered the development of student-teachers' RT, which besides CT, is another essential higher-order skill for the teaching profession. In order to meet this aim, 71 undergraduate students were engaged in a pre-test – post-test study. Multiple Wilcoxon tests were conducted for analysis of the data.

One expected finding was that student-teachers, after the end of the CTBAC, reported greater levels of habitual action, namely, a knowledge that, through frequent use, becomes an activity taking place automatically or with little consciousness [50]. This finding can be attributed to the content and structure of the course. Regarding HEI, habitual action relates to an automated process of daily activities probably involving well-defined problems that lead to sole answers (i.e., in our case the design of a TLS). Student-teachers are also familiarized with structured steps regarding their TLSs design without activating themselves in the direction of differentiation [51].

Further, when student-teachers' RT was examined in both courses, we observed some small positive changes in student-teachers' RT, which nevertheless did not reach statistical significance. Interestingly, the analysis revealed a significant increase in student-teachers' critical reflection when the CTBACs were examined separately. Critical reflection is a dimension of RT, which according to Mezirow [52], indicates that a person is becoming aware of how one perceives, thinks, feels or acts in a specific context. The increase was observed in favor of student-teachers attending the ST course. This encouraging finding could be attributed to the design differences between the two CTBACs. For instance, student-teachers in the ST course implemented their TLSs in a real-life context (i.e., school), and after the implementation, they prepared a written reflection upon their experience suggesting what they perceived as successful or less successful in their TLSs, and whether or not, they would choose to refine their TLSs after their in-class-experience. In that sense, explicit strategies for supporting reflection were employed in the particular course. Thus, we could argue that student-teachers were more aware and conscious after the end of the course regarding their instructional design actions. The implementation of the TLSs and the explicit reflection upon the designs rendered student-teachers aware of the importance of reflection for ensuring the TLSs quality.

Teaching critical reflection in HEI is challenging since it asks for cultivating conditions where objective-content knowledge is there alongside the uncertainties following it. It asks for a constructivist framework of cooperative and open-minded approaches taking into consideration the multiple perspectives that the professional field encompasses as well as students' awareness that critical reflection is a personal and self-constructed entity [53].

This study strengthens the idea that using CT curricula in HE might benefit the enhancement of RT. One would expect that in the absence of a relationship between CT and RT, RT would not improve through CT instruction. Still, this is not the case with the current study. Our study could imply support for previous research [e.g., 5, 14] indicating an interrelationship between CT and RT, under the condition that explicit instruction on CT and RT is implemented.

Overall, a HE curricula transformation aiming at developing graduates' high-order thinking skills, such as RT, is a challenging and time-demanding process [54]. Hence, we argue that a systematic and holistic commitment from faculties or HEIs are required to ensure that higher-order thinking skills will be promoted across the majority of the curricula of a study program [18], maximizing in that sense the impact of the curricula transformation.

5 Limitations and Future Steps

The current study presents some limitations. First, the sample was relatively small, limited to only one discipline, and with high discrepancies in terms of age representativeness. Although gender is disbalance among the participants, the teaching profession in Greece is dominated by female teachers. Thus, we consider gender representativeness acceptable for the current study. Therefore, future research could engage more participants, compare different disciplines as well as ensure equal representation of age among the participants. Finally, participants were asked to follow a different way of studying using web-based and in-class activities that differed from those typical in HE. Thus, some students might have shown some resistance to active participation, instead preferring a more passive role, which eliminated possible improvements. This research project targeted students that have come to class after two years of synchronous online teaching. Hence, the semester the study was conducted might have also been a period that at least some students struggled to readapt to the post-pandemic face-to-face teaching. These changes might also have affected students' way of thinking and acting.

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Developing Critical Thinking in Higher Education: Is There a Reason to Change?

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Abstract. Competency-based veterinary education has been proposed for long, but its implementation accelerated in recent years. It endorses the development of specific abilities, that are identified, and needed for a wide range of professional tasks. Nevertheless, the University's adaptation to the proposed competency-based framework is not always easy. It often depends on economic and administrative constraints and requests some time until the completion of the reforms. This time-lapse foster the skills mismatch existing between Academia and the labor market. Think4Jobs project organized focus groups interviews with Veterinarians with experience across many professional areas (e.g., clinical, food production and food safety, research), pre-graduate students and teachers, to identify core critical thinking-related competencies deemed crucial by the labor market. Triangulating the beliefs of Stakeholders and University detected some differences in the importance of competency domains, sustaining the need to change the pedagogical approach during learning and during the traineeships to enhance autonomy, self-regulation, and self-confidence in students' clinical reasoning and decision-making skills. Based on the identified differences, the framework presented herein was proposed to strengthen the acquisition of those competencies across existing curricula.

Keywords: Competence-based curricula · Critical thinking · Clinical reasoning · Labor market · Soft skills development · Veterinary medicine

1 Introduction

Albeit not new, closing the claimed gap between newly graduates competencies and the competencies expected by employers remains a challenge and a concern for European

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countries, particularly on respect to required critical thinking (CT) and other soft skills [1]. The impact may differ across countries, and across fields of education [2, 3] since these skills are differently understood or applied according to the professional context [4].

Because of the acceleration of technology and knowledge in the past decades, which rapidly changes the workplace, along with their stiff adaptation ability, higher education institutions policies seem to always run after the damage. Therefore, adjusting the educational offer to the expectations of the labor market, whether on knowledge or competencies, remains a crucial goal for Higher Education Institutions (HEI). According to Barnett [5], to skip this tendency, HEI should focus in developing not only in terms of knowledge or skills on their students, but also invest in human qualities and dispositions – ensuring a higher level of transferability, as requested by a world of uncertainty. Following Barnett´s opinion, the ERASMUS project Think4Jobs (https://think4jobs.uowm.gr/), endorsed by a consortium of five HEI and five Labor Market Organizations (LMO), from five countries (Germany, Greece, Lithuania, Portugal and Romania), seeks to identify and mitigate perceived gaps or mismatches in critical thinking skills needed to the successful employment and transition of new graduates from the university to the labor market. The Veterinary Medicine graduation was the field analysed by the Portuguese partners.

In Europe, a list of day one competencies, perceived as "the knowledge, skills and attributes required of veterinary students upon graduation to ensure that they are prepared for their first role in the profession and safe to practice independently" [6] has been identified and was recently actualized to endorse the growing requirements of the Veterinary professionals. Nevertheless, the University's adaptation to the proposed competency-based framework is not always easy. It often depends on economic and administrative constraints and requests some time until the completion of the reforms, and this time-lapse foster the skills mismatch existing between Academia and the labor market. This presentation intends to understand the methods used at HEI and labor-market organizations in apprenticeships and training courses in the field of Veterinary Medicine, to explore perceived mismatches at the transition from academic to work contexts and to identify existing convergent or divergent assumptions regarding desirable critical thinking traits.

2 Methods

2.1 Participants

The study involved 32 participants: 10 teachers, 6 intern students, 6 recent graduates and 10 senior tutors. All participants signed an informed consent and agreed with the publication of the focus group (FG) data.

2.2 Procedure

Embracing a qualitative empirical research approach, six focus groups were organized to map the differences between critical thinking understanding and possible mismatches between HEIs and LMOs concerning critical thinking needs and expectations.

The focus group enrolled representatives form HEI teachers [n = 10, two FG], students in curricular traineeships [n = 6], young graduates (less than 2 years in the category) [n = 6] and senior tutors [n = 10, two FG]. The focus groups were carried on in Zoom platform, because of the pandemic conditions, during January and February 2022 (during mandatory confinement). The sessions were recorded for posterior analysis of the discussions. Focus groups involving more than 6 participants were divided in two sections. Table 1 presents the questions presented to the different focus groups, that lasted less than 90 min each.

Table 1. Questions presented to the focus groups.

	Questions
1	What does CT mean to you?
2	[Teachers & Senior Tutors] How do you teach it? (aims, content, methods/strategies, time) Do you communicate CT specific concepts to your trainees? [Students] How it is taught in your university? Can you give some examples? (aims, content, methods/strategies, time) [Young graduates] How is CT taught in the classes you attended? Can you give some examples? (aims, content, methods/strategies, time)
3	[Teachers] How do you know your students learnt CT? (assessment, methods, instruments?) Is CT necessary for passing the exam? [Senior Tutors] How do you know your trainees learnt CT? (assessment, methods, instruments?) Is CT necessary for completing the course/traineeship? [Students & young graduates] How do/did you know you acquired CT skills? I/wass it assessed by self-evaluation, peer evaluation or teacher evaluation?
4	[Teachers & Senior Tutors] Which materials you provide to students/trainees that support or reflect CT learning? (syllabi, documents produced for students or given in class) [Students & young graduates] Which were the materials supporting CT learning that you received? (syllabi, hand-outs, other documents produced for trainees)
5	[Teachers & Senior Tutors] Do you believe a gap exists regarding CT between what you teach and what is needed on labor market? [Students & young graduates] Do you believe a gap exists regarding CT between what you learnt in university and what you believe is necessary on labor market?

2.3 Data Analysis

The discussions of each FG were transcribed by the authors, and the speakers identified using the following system: FG identifier [TCH/Teachers; VET/Senior tutors; YG/Young graduates; STU/students] + sequential number of the participant. Transcriptions were prepared for analysis, coded, and analysed by two independent analysts, using NVivo software. The categorization procedures followed a mixed approach: initially, an analysis matrix was used (top-down approach), based on Facione framework for critical thinking skills (interpretation, analysis, evaluation, inference, explanation) and dispositions [7];

hereafter, with the development of the exploration procedures, it was possible to find links between the different categories that led to the creation of new categories and adaptation of the previous ones (bottom-up approach). The clipping phase produced 330 registration units (RU), which were grouped into a system of categories of meaning that initially did not show good intracoder reliability. Sorted out the number of disagreements, intersubjective agreement was reached (test-test consistency), and Cohen's kappa was calculated, with the value of $k = 0.812$ which can be considered very good, and not by chance [8].

3 Results

After performing the content analysis, five tables were elaborated, to organize the information in a systematic and quantified way, allowing us to understand which categories of meaning emerged from the analysis and the frequency with which they emerged. Table 2 presents the terms or phrases that were most associated with the question «What does CT mean to you?»

Table 2. What does CT mean to you?

Categories of meaning	Teachers	Students	Professionals
Analytical skills (analysis and decision-making)	5	5	6
Ability to question	1	1	7
Scientific evidence as support (informed decision)	2	3	3
Divergent thinking (addressing multiple perspectives)	5	2	0
A structured way of reasoning	0	1	4
Autonomous thinking	2	3	0
Problem solving	1	2	1
Openness to new ways of thinking (out of the box)	1	3	0
Reflecting	2	1	0
Adaptability (ability to adapt to different settings)	2	0	0
Apply and mobilize knowledge	1	0	0
Reasoning	1	0	0

In total, 65 registration units (RU) were registered (Teachers 23 RU; Students 21 RU; Professionals 21RU), divided by 13 categories of meaning.

Teachers, students, and professionals define critical thinking as the ability to analyze data to decide (16 RU), having the «ability to question» (9 RU) (questioning the quality and reliability of the information). The third most mentioned aspect was «Scientific evidence as support» (8 RU). These perceptions are evident in these sentences:

> "It has to do with the ability to make an objective and dispassionate analysis of the things, that is, of a given situation. In any case, from a clinical point of view,

my area of intervention, critical thinking takes place in the context of clinical practice, that is, it has to do with an analysis of variables whose interpretation may have a subjective component and that leads to decision making. In the context of professional activity, it has to do with being able to analyze each situation and our own performance. Critical thinking requires reflective activity as well" (TCH_10)

"It is a judgment of a situation in which we see ourselves, we see others and what surrounds us, I think it reflects a little on what we think things are and the way we interpret and think that we can solve the problems around us" (VET_8)

"[it´s the] capacity that we have, when faced, for example, with a problem, a question, to have the ability to think about that question, to find our own answers, our own methods to deal with that question or that theme. To think outside the box. To find a way to reach an end" (STU_5)

"It is not just questioning, it is also looking for, studying, obtaining information on a certain subject, to be able to substantiate and create a point of view with basis. To have an informed opinion" (YG_6)

The definition of critical thinking is very much supported by the idea of having the ability to rigorously analyze information and decide based on its quality and reliability, supported by scientific evidence. Professionals also emphasize that this reasoning must occur in a structured way, and they are also the group that most values the importance of the ability to question:

"I would say that it is a little bit regarding the capacity for self-questioning. (…) and to not be afraid of questioning ourselves or to be questioned by those on the other side" (TCH_3)

It is also interesting to note that professionals define CT as «A structured way of reasoning» (4 RU), while professors prefer to highlight «Divergent thinking» (5 RU). This aspect will certainly be related to their functions, for a professional it is very important to have a systematized, well-structured process that facilitates the clinical diagnosis, while teachers, more focused on the teaching process, want their students to be able to approach a problem from multiple perspectives:

"It implies having the skill of flexible reasoning; an adaptability and the capability of analysis that in Veterinary Medicine and what concerns the clinical aspects, which is where I focus on, must always be based on scientific evidence" (TCH_5)

"It is putting the "if", seeing things from the end to the beginning. So, we know what we have (…) but what if it is not? What other possibilities do I have to analyze this issue? It is not easy" (TCH_6)

"it is a way of systematizing (…) analyze and draw conclusions" (VET_1)

"it is a structured analysis of information, from a given information, we have to have the ability to evaluate it, analyze it and ultimately we can question how true this information is" (VET_2)

Students refer that in addition to these multiple perspectives (2 RU), more conventional, it is also necessary «Openness to new ways of thinking» (4 RU). They also highlight the importance of the process occurring autonomously (3 RU). It should be noted that the authors decided to place the category «Problem solving» (4 RU) separate from the category «Analytical skills (Analysis and decision-making)». Although problem solving requires analytical skills, the sentences given by the interviewees strongly suggested that they referred to analysis as a competence, and to problems as a strategy.

Table 3 presents the terms that were most associated with the question «How do you teach it?/How is CT taught?».

Table 3. How do you teach it?/How is CT taught?

Categories of meaning	Teachers	Students	Professionals
Problem/case-based learning	6	12	5
Questioning	5	4	2
Promoting critical reflection	2	1	6
Promoted only at the traineeship	0	7	1
Active search/study (additional knowledge)	5	0	3
It is poorly developed	0	7	0
Attitudinal contents	4	1	2
Analog thinking (inversion of perspective)	4	0	1
Self-regulation and autonomy	2	1	0
Not penalizing the error	2	0	1
Cooperative learning	1	0	2
Demand/work in small groups	3	0	0
Debate	1	1	0
Relationship between concepts	2	0	0
Creative controversy	0	0	2
Feedback	1	0	0
Significant learning	1	0	0
Peer feedback	0	0	1
Proximity between teacher and student	1	0	0

The analysis of the answers resulted in 100 RU (Teachers 40 RU; Students 34 RU; Professionals 26 RU) distributed by 19 categories of meaning. The category with the most RU was «Problem/Case-based learning» (23 RU), the three groups of interviewees seem to agree that solving problems or real cases is the most used strategy, especially students (12 RU):

> "I think that we have evolved, in the sense that they give us more and more practical classes and clinical cases, so that we can learn to make this discernment for our future" (STU_3).

> "(…) any question could be answered without any criticism and they [teachers] did stimulate, send details, encourage reading articles, looking for solutions, giving problems, giving that opportunity to solve a clinical case or another" (YG_6).

> "In practical terms, we work a lot with problem-based learning and from there the students asks questions (…) it's relatively easy to develop critical thinking by questioning, having them working in groups" (TCH_5).

Students also mention, in a totally different perspective from teachers (0 RU) and professionals (1 RU), that CT «It is poorly developed» (7RU), and that it is «Promoted only at the traineeship» (Teachers 0 RU; Students 7 RU; Professionals 1 RU). It is thus evident that students associate the development of critical thinking much more with the practical component than with the theoretical component of their courses:

> "It is difficult for me to see whether or not I developed a critical spirit during those years. In the initial phase, when everything is very theoretical, I don't think so" (YG_2).

> "In the internship I think that was where I developed my critical spirit. I think it also boosted that same development further. I was asked questions, cases, I was asked for my opinion. (…) Being in practice and facing situations in practice is much more, it demands a lot more from us" (YG_3).

> "in the internship (…) we are able to better develop the critical spirit, because we are already more exposed to situations. In my case, it probably developed more because they gave me the autonomy to deal with" (YG_4)

> "When I got to the internship, I realized that the fact of making appointments and realizing that it is not always those questions that I have to ask, depends on each situation. During the course, perhaps, I was not so encouraged by critical reasoning in this perspective and in the internship, in this aspect, for me, it is being the main asset" (STU_1).

The other categories with more RU were «Questioning» (11RU), «Promoting critical reflection» (9 RU), «Active search/study (additional knowledge)» (8 RU) and «Attitudinal contents» (7 RU). The remaining categories had less than 7 RU. Table 4 presents the terms that were most associated with the question « How do you know your students/trainees learnt CT? How do/did you know you acquired CT skills?».

Table 4 shows that the 63 RU that were found showed a very different frequency distribution between groups. Students and teachers refer to questioning (practical oral assessment) as the preferred way of perceiving if critical thinking was acquired (Teachers 7 RU; Students 7 RU), and in parallel, in a more formal way, through the evaluation of the resolution of clinical cases (Teachers 5 RU; Students 5 RU). Professionals indicated that the acquisition of critical thinking is verified through the existence of a «Structured thinking process» (8RU). Four of the 10 teachers admitted not to evaluate the acquisition of CT:

> "I think I'm not assessing that, I'll be honest. I don't think I'm objectively assessing it." (TCH_3).

"There is no parameter on how they are using critical thinking in problem solving" (TCH_9).

Table 4. How do you know your students/trainees learnt CT? How do/did you know you acquired CT skills?

Categories of meaning	Teachers	Students	Professionals
Questioning (practical oral assessment)	7	7	3
Solving clinical cases/scenarios (formal assessment)	5	5	2
Structured thinking process	3	0	8
Does not assess/It's not accessed	4	2	2
Self-evaluation	0	6	0
Critical reflection (in action)	0	2	2
Apprenticeship reports	0	0	3
Peer evaluation	1	1	0

Table 5 presents the terms that were most associated with the question «What are the materials that support CT learning? (Syllabi, documents produced for students or given to them)».

Table 5. What are the materials that support CT learning? (Syllabi, documents produced for students or given to them).

Categories of meaning	Teachers	Students	Professionals
Does not use (or identify) specific materials	3	8	9
Practical Cases (clinical scenarios)	7	4	0
Digital resources/technologies	8	0	1
Scientific articles	2	2	0
Debate	0	1	2
Diagrams and flowcharts	0	3	0
Photographs and images exploration	0	2	0
Feedback	1	0	0
Word clouds	1	0	0
Forums	1	0	0
Databases	1	0	0
Infusion	1	0	0

We can perceive that 20 of the 32 participants do not use, or identify, materials specifically used to promote critical thinking:

> “I don’t know if the resources I use are specific for that (CT learning) or not. I don’t use them intentionally, directed towards that, having that goal in mind.” (TCH_2)
>
> “In fact, I did not develop any tool to interact with them” (TCH_8)
>
> Specific materials, no [cannot identify]. In practical classes there was a lot of material condensed into one class. In the practices where I noticed most was to follow the cases and make us think about the cases. (STU_2)

Among the remaining participants, the teachers mostly refer to clinical scenarios (Teachers 7 RU; Students 4 RU) and digital resources (8 RU). In opposition to this idea, no student mentioned the use of technology as an element of support for the development of CT, which seems to indicate that students and teachers have a different perception of how technology is used in the classroom. Similarly, when specifying other resources, students refer to debate, diagrams and images exploration, and teachers refer to feedback, word clouds, forums, databases, and infusion:

> “I remember one teacher who really worked our critical thinking, we had, for example, every week, to read articles and make flowcharts or diagrams, in line with what we read in the article and create our own concepts. I also remember sometimes making small work groups in which they presented some case or clinical case with basic data and were asked for initial and complementary diagnoses and at the end a possible diagnosis. And all of this in a group, which had the sharing of points of view, ideas, even to improve our way of thinking. But there is a long way to go” (STU_5).

Table 6 presents the terms that were most associated with the question «Do you believe there is a gap regarding CT between what you teach (or you learnt) and what is needed on the labor market?».

The analysis identified 45 RU, distributed by 12 categories of significance, which were divided into two groups, the first group corresponding to «No» (there is no gap between what you teach/you learn and what is needed on the labor market) with 5 meaning categories and only 7 RU, and the second group to «Yes» (there is a gap between what you teach/you learned) and what is needed on the labor market), with 38 RU distributed by 7 categories of meaning.

In general, we can say that most respondents feel that there is a gap, with regard to critical thinking, between what is taught and developed in universities, and what is needed for the job market:

> “I think we are not doing enough, maybe, we are never doing enough and we should always try to improve” (TCH_10)
>
> "I think that it is impossible to expect a student who leaves the university to have the same level of thinking or critical reasoning as someone who has been working for 20 years" (VET_3)
>
> "I think that this curricular traineeship allows us to remedy a little bit any deficit that we have behind us" (VET_5)

Table 6. Do you believe there is a gap regarding CT between what you teach (or you learnt) and what is needed on the labor market?

	Categories of meaning	Teachers	Students	Professionals
NO	The practical aspects of the traineeships mitigate the gap	0	0	2
	Students are prepared	2	0	0
	CT is not decisive	1	0	0
	Importance of apprenticeships	1	0	0
	They detain a lot of [theoretical] knowledge			1
YES	Universities should prepare students better for the labor market	2	6	4
	Lack of practical training	0	6	5
	Lack of development of skills and attitudes	6	1	2
	CT is useful (Increases job opportunities)	2	0	0
	More critically analyze information	1	0	1
	Problem solving	1	0	0
	Students are not prepared for traineeships	0	0	1

"Critical spirit is not something that is acquired after five years, this is an evolutionary process, even myself, my critical spirit is very different nowadays from 20 years ago" (VET_9)

It is important to highlight that no student responded that they felt that this gap did not exist. The main aspects that justify this sense of response are «Universities should prepare students better for the labor market» (12 RU), Lack of practical training (11 RU) and Lack of development of skills and attitudes (9 RU).

“The vast majority of courses do not prepare us for the job market or for real life. However, with all the training we are doing, internships, for example, extracurricular activities, which are optional, and then with our curricular internship… I think I am not prepared to join a team (STU_4).

Professionals (4 RU) and students (6 RU) valued more the aspect that Universities should prepare students better for the labor market» (10 RU), in general, and specifically in training the practical component of the profession (11 RU), while the teachers put the problem more focused on the development of competences and attitudinal aspects (6 RU).

4 Discussion

The results indicate that there is a reason to change. The challenges raised by the job market require higher education institutions to train their students, future professionals, providing them with essential tools and knowledge to succeed in active life [9]. Training critical thinkers meets the needs of the job market and is a possible mission for universities [10, 11]. Society itself, which has made access to information easier and massive, will favor individuals who are able to think critically, in the sense that this will help them in the process of distinguishing between true and pertinent information and false or unnecessary information.

However, the problem begins with the definition of critical thinking. Respondents define critical thinking as a structured cognitive process, that requires analytical skills, and which is intended to lead to informed decision-making. A process that requires the ability to question the information available, approaching the problems (or that same information) from multiple perspectives. One of the aspects that professionals mentioned most (with a lot of experience in the labor market) was the ability to question, in an allusion that seems to indicate that the students or recent graduates they receive need to develop more skills that allow them to question the information presented to them, to question themselves about this information (quality and reliability).

Regarding the way CT is promoted, seems to be consensual that the main strategy used is the problem-based learning and case-based learning, questioning and critical reflection. Students and professionals, once again, feel that it is in the internships that the CT is most easily developed, associating this development to the practical component. From the ten students, seven stated that the CT is poorly developed. Thus, there seems, once again, to be a different opinion between teachers and students and professionals. These differences seem to result from the nature of the role of each of these stakeholders, professionals and students recognize that it is practice that brings experience and enhances the development of CT, teachers cannot neglect their importance in the transmission of the knowledge that emerges from academic curricula, and even indicate a diversity of strategies, such as active research for information, cooperative learning, analogy, self-regulation, exploiting the error, debate, concept maps, feedback, etc. In a sharper analysis, we are led to conclude that students do not seem to understand the use of these strategies as promoters of CT. An aspect that could be improved is the involvement of students in these processes, explaining the strategies and activities developed in the light of the theories advocated for the development of CT, that is, the objectives of the strategies developed must be presented to students, so that they realize that it is not only the practical component of the course that prepares them for the job market, but also that classroom activities have the potential to develop CT.

Regarding the evaluation of the CT, the main aspect to remember is that critical thinking does not seem to be formally evaluated. Only two students and two professors mentioned that the CT was formally evaluated and, even then, only as part of the classification attributed to their performance in solving clinical cases. Less formally, teachers and students report that they do practical oral assessment, while professionals value more the existence of a structured way of thinking critically (certainly related to the need to provide the client with a clinical diagnosis). Overall, it seems clear that evaluation is not a general concern, nor does it seem to be part of the CT development improvement process.

Regarding the materials used to promote the CT, it was found that professionals do not use them and that students do not seem to understand how some of the materials used by their teachers can promote CT, as is the case where teachers prefer the use of digital resources, and none of the students mentions it. Quotes analysis suggested that these digital resources, in many cases, only replace traditional resources (blackboard, worksheets…), constituting itself only as platforms more aesthetically attractive. From what has been explained, it seems that, once again, the idea that a change is necessary is reinforced: even though many of the usual resources can be used in the foundation of critical thinking, it is necessary to attribute a concrete intention to the action, rethinking the form how they are used by students and teachers. Professionals that are part of the labor market stated that there is a gap between the CT skills acquired by students and those required in professional life, and it was evident that students are aware of this fact. University can do more and better, especially regarding placing the student in more practical contexts. Internships seem to enhance the development of CT, and should occur in greater numbers and earlier, but this idea is limited by the fact that, for these internships to occur, students must already have a lot of knowledge, and that is where teachers seem to insist more, in the development of the necessary competences to think critically and be prepared to develop the necessary tools for the practical component of their courses.

5 Conclusions

Is there a reason to change? Yes. Competency-based veterinary education and the development of specific abilities needed for a wide range of professional tasks requires a change. Teachers seem to be alert to this change, although many of them exercise their actions guided more by good intentions than by concrete knowledge of functional strategies in the promotion of CT. Teachers need to involve students more in their CT learning and development process, explaining, prior to the action, the purpose of the strategies and materials used. Without being aware of the effort made by their teachers, students tend not to understand some of the approaches adopted, considering that they do not bring them a real gain between the effort applied and the results obtained. However, when faced with the reality of entering the job market, students recognize the importance of the CT and the day one competencies, becoming evident that the employer wants a professional who can make decisions based on scientific evidence, and capable to have a structured clinical reasoning (as a process), but flexible to approach multiple perspectives. Who is autonomous (but also knows how to work in a team), resilient and resistant to stress and change. Yes, change is needed, and that change is underway.

6 Disclaimer

"The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein."

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Business-University Collaboration in Designing Work-Based Activities Fostering Clinical Reasoning

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Abstract. A gap has been identified between the knowledge and skills needed in the labor market and those acquired at Higher Education Institutions. Under the Think4Jobs project, a series of focus groups (FG) were carried out with professionals (veterinarians and university professors), and Veterinary Medicine students at the end of the academic pathway, to identify putative mismatches in critical thinking skills. Based on the FG results, the University of Évora and the *Hospital Veterinário do Atlântico* partnered to design blended-learning activities to be developed in piloting courses, aiming to reinforce the development of critical thinking and clinical reasoning skills. This Business-University collaboration brought work-based scenarios to some courses' curricula, representing problems that professionals face daily in their practice. The problematization request the students in a clinical course to engage in high order thinking processes to reach a diagnosis, propose a corrective strategy, and anticipate the response to their intervention. In addition, these learning scenarios will enable the development of clinical and technical skills, and enhance autonomy as they have the potential to bridge the pilot courses to short-term intramural internships This paper describes the rationale leading to the construction of a framework proposed to be applied in clinical courses in the field of Veterinary Medicine, by business and university representatives, showcasing one activity using the proposed framework.

Keywords: Work-based learning · Critical thinking · Clinical reasoning · Activity framework · Skills development

1 Business-Academy Partnership in Reducing the Skill Gap

Nowadays, the Labor Market Organizations (LMO) demand Higher Education Institutions (HEI) to provide graduates with relevant competencies and skills. Such expectations triggered and supported the introduction of competency-based education, particularly in

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health science programs [1]. Despite all the efforts, LMO still denounce the professional skills set mismatch, while the academy tries to overcome these differences without leaving behind students' cognitive development in an era of fast-growing knowledge and technology.

Critical Thinking (CrT) is among the most praised competences in the health sciences field, for its closeness to clinical reasoning, although it is a core competency to be mastered by students in all the fields. CrT allows them to use their personal views and attitudes to address daily problems, avoiding the simple adoption of others´ judgments, attitudes, and interventions [2]. Stakeholders and society expect healthcare professionals to show more than core knowledge and technical expertise when entering in the labor market.

Think4Jobs (2020–1-EL01-KA203–078797) is an ERASMUS + project that brings together a multidisciplinary team from HEI and LMO, across five European countries (Germany, Greece, Lithuania, Portugal, and Romania). The Portuguese team focused on the Veterinary Medicine field and established a collaboration with a large private Veterinary Hospital. Overall, the project proposes the development of CrT blended curricula designed to give the Higher Education (HE) students the opportunity to systematically train CrT skills, transferring and consolidating them from an academic environment to a professional/employment context (https://think4jobs.uowm.gr/). In a first step, Think4Jobs identified existing putative mismatches in Veterinary Medicine students at the end of the academic pathway to design and implement activities later to be used in blended courses and to be developed in either the HEI or a workplace.

The explosion in knowledge and technology of the last decades and the large number of students entering the Veterinary Medicine programs, combined with the amount of information delivered to students, drove the Universities across the world to struggle to convey a balance between the cognitive competencies provided to students and the practical in-job-like training [3], which has mostly been dislocated to the last semester of the graduation program. Active learning strategies, and in particular case-based learning, have been introduced in health sciences programs, as they foster students' proficiency in case analysis, clinical reasoning, and decision-making. Moreover, due to its nature (i.e., real scenarios from professional situations/settings) they create engaging learning experiences facilitating, across the curricula, a closer contact with professional reality along with the development of higher-order thinking processes. Moreover, they allow to reinforce key critical thinking attributes crucial to their future professional performance [4], such as analysis, inference, evaluation, decision making, self-awareness and metacognition, and communications, among others. Besides, it may also foster increased transferability of acquired competencies to new situations, an facilitate the transition into the labor force.

The University of Évora (UÉvora) offers a 11 semester Master program in Veterinary Medicine. In general, the learning context involves lectures, practical sessions or mixed theoretical-practical sessions, and a few intra-mural training activities. As in similar programs in other public Universities, the curriculum is constructed according to a loose concept of competency based-learning, while the learning outcomes target the defined day-1 competencies [5]. Nonetheless, the programs present a somehow rigid organization *per* scientific domain, conveying standardized knowledge and technical intervention, but still tending to develop in a lesser extent the soft and thinking skills.

The Think4Jobs project proposes to bring together LMO and HEI in the pursuit of improving the students CrT skills identified as crucial by involved stakeholders. It defends that through this partnership it is possible to create apprenticeships (and apprenticeships-like situations) that would allow the students to be familiar with CrT concept and be able to transpose it into work settings when entering the labor market [6].

This presentation purpose is to describe how UÉvora and *Hospital Veterinário do Atlântico* (HVA) partnered to design blended-learning activities to be developed within a pilot course, aiming to reinforce the development of critical thinking skills and clinical reasoning in veterinary medicine students. This paper presents 1) the rationale leading to the construction of a framework, set to be fitted and applied in courses of a clinical domain; 2) and an example of one activity designed for the piloting course of Gynecology, Andrology and Obstetrics (GAO), which will be commented using preliminary data obtained at its implementation in the beginning of the second term of 2021–2022 year.

2 The Collaborative Design of Work-Based Learning Activities

2.1 The Construction of CrT Endorsing Activities: The Roots

Data from a series of focus groups implemented in the earlier steps of the Think4Jobs project showed that some mismatches existed in the form HEI and LMO operationalize their courses and traineeships [6]. LMO representatives expect students to show critical thinking or clinical reasoning skills and be able of decision-making, considering these as essential attributes for a competent performance. They further believe students arriving at the traineeships and at the labor market have a good level of technical knowledge; however, their reasoning and soft skills are too incipient, and that these should be promoted in the academy (data not shown). They particularly exhort the academy to develop students' ability to raise well-formulated and clear questions; to collect and analyze relevant information framed by particular contexts; to be open-minded; to recognize and assess assumptions and implications and to associate them with practical consequences; to make a sound decision about the interventions needed whilst finding solutions to complex situations; to communicate effectively with co-workers and clients, fostering a good team environment and guaranteeing the clients compliance with the medical decision. They further mentioned the need for self-awareness, autonomy, self-confidence, self-regulation, the practice of metacognition and self-correction [6].

In medical professions, a critical thinker is the person who can formulate accurate diagnosis or make sound decisions based on the history and informed clinical data collection, that consults other experts, explores pertinent causes and therapeutic approaches supported in scientific evidence, weights risk and benefits, involves the client/patient in the proposed interventions and monitors his/her decisions, changing/adapting them according to new evidence [7].

2.2 The Construction of CrT Endorsing Activities: What to Attend to

Considering that stakeholders stressed the need for students to acquire a more critical attitude during the final traineeships and at day-1, and become more empowered in their judgments and decision-making, UÉvora and HVA brainstormed over which activities could be used in both contexts (Academy/HEI and business/LMO traineeships) to develop skills and dispositions fostering critical thinking/clinical reasoning and decision making, as framed by Facione´s [8] conceptualization of CrT.

The design of a framework (understood as a structure of sequential steps) was triggered by two comments issued from the Professionals FG [6]:

> "*…we have to stimulate the students not to be simply receivers (…) of repetition of the information provided to them (...) use methodologies that allow this stimulus, case discussions, discussion of images, discussion of legislation*" (Trainer, LMO, PT_Pro_1)
>
> "*…we try, many times, to take real situations of the farms that we accompany (…) we try that the students manage through these data to try to understand what the main faults or problems of this farm are and many times the approach has to be multifactorial*" (Trainer, LMO, PT_Pro_4).

Considering that during curricular traineeships in professional context students are immerged in real problems, based on professional situations where they take an active role and are pushed to analyze a condition or problem, later to decide on the best intervention, it was agreed that the activities to be designed would encompass problems or situations that professionals face in daily practice. These work-based scenarios mimicking real life experiences, were to be faced in safer environments for students and animals, during the academic pathway. To allow for transferability of the methodology, it was decided to propose a scaffolding framework that could be adapted to other clinical courses according to their learning outcomes and field of intervention to support the activities.

For instance, in a clinical course, the problematization would drive the students in higher order thinking processes to reach a diagnosis, propose a corrective strategy, and anticipate the response to their intervention. In addition, such scenarios made it possible to combine the development of clinical and technical skills, bridging hard and soft competencies, so situations may reflect the way knowledge and skills are used at work.

Resourcing to problem-based or case-based learning (respectively PBL and CBL) as a learning strategy in courses targeting the development of clinical competencies has been shown to offer various opportunities for training multiple competencies simultaneously, while allowing the development of skills specific to a particular professional area, prompting a close contact to cases that students' will encounter during their professional performance. Both strategies represent a constructivist, active learning approach that allow each student to merge theory and practice by applying knowledge and skills to work on a solution to an ill-defined, real-world situation, and decide on the intervention to pursue [1, 9].

CBL often starts from a roughly defined situation (the problem in itself), and tend to be solved shortly, usually through an established chain of evidence, whilst PBL is rooted in an ill structured situation where the student must test different hypothesis to decide on his best approach to solve/mitigate the problem. The partnership decided on the use of case-based structure to framework the design of activities deemed suitable for clinical competencies advancement.

Considering the understanding of a critical thinker in medical sciences, activities fostering CrT would demand the students to:

- Analyze a clinical condition namely to collect a valid and coherent (clear) clinical history, adapting its detail to the severity of the situation; interpret the history collected and the clinical signs evidenced by the animal; retrieve evidence (signs and symptoms, data from the additional testing); and determine putative existing comorbidities that may affect the case outcome
- Infer the pathogeny of the disease based on the clinical signs and the results of the medical exams. Find an explanation for the condition (prioritizing differential diagnosis) and point solutions for its correction.
- Screen the available solutions into the one most suitable or reasoning with the client or the patient to ensure his compliance
- Determine the severity of the situation (evaluation), recognize the need for a swift intervention, and the existence of a life-threatening condition
- Decide on a therapeutic strategy
- Revise the reasoning steps and validate the rationale and the decisions taken (self-regulation, metacognition)

2.3 Attended Considerations When Modeling the Work-Based Activities

For the construction of the framework, the partnership took into consideration that:

- the length of a semester at UÉvora ranges from 14 to 15 weeks;
- in general, the clinical courses take up 2h + 2h or 2h + 3h (theoretical + practical classes);
- the course curricula (scientific and technical core knowledge) must be covered and simultaneously framed by the competencies at day-1 [5], as defined at European level;
- the course would be conceptualized according to active learning principles and small activities, student-centered, should also be used, together with self-learning tasks, to foster the consistent development of CrT competences.
- three "main" activities, larger and more complex than the ones previously described, would be implemented to develop clinical reasoning; these activities should be assessed and used to grade the students at the end of the course;
- make the framework reusable - using the same framework across different courses would reinforce learning, advance disciplinary reasoning, and excel a routine driving high-level of thinking, if applied transversally to the Master program in Veterinary Medicine.

It was agreed that the problematic situation – a real-life case – would be provided by HVA, extracted from the Hospital clinical records. The activity would be designed by the teacher of the UÉvora course together with a member of HVA team, according to the case-based conceptualization, to deconstruct the different steps of clinical reasoning to be experienced by the students as scaffolded with a guided questioning. For preparation, a guiding document would be published one week in advance, explaining the steps of the activity.

Each formulated case-base activity would require the students to gather further information on the clinical situation provided, organize the clinical examination (general and specific), select the complementary diagnostic exams regarding a list of differential diagnosis identified so far, construct an appropriate interpretation of facts and exams about the patient's problem to establish a tentative diagnosis and the most adequate therapy for the animal, estimate the client compliance with the therapeutics and reach a prognosis to schedule the follow up. Figure 1 presents the final framework.

The teacher(s) would prepare the material to support the implementation of the activity, in particular the documents clarifying the activity outputs, the estimated self-learning time consumption, the identification of the output (the critical report depicting the thinking process through the activity) and presenting the rubrics to be used in the assessment of the final document. Furthermore, the teacher(s) would also be responsible for grouping the students in random groups of five elements and publishing the group constitution in advance. The documents supporting the activity would be published in the *Moodle* platform.

3 From the Design to Piloting One Activity

Gynecology, Andrology and Obstetric (GAO) course was selected for pilot training the proposed framework, during the second term of the 2021–2022 academic year (from February to June). At the present, only the first activity took place. Three scenarios are planned, one for each of the main topics of the course, using three clinical situations selected from the HVA archives based on their completeness respecting complementary exams, detailed clinical record, and follow-up. This planned activity flow for GAO course is depicted in Fig. 2.

Each activity was designed for a duration of 3 h, and to be developed at the same time for all the students enrolled in the course, representing a total of 12 groups of five students each. Seven days in advance, the document regulating the activity was made available via Moodle; three days before the activity, the groups constitution was published. Throughout the course, students are asked to develop conceptual maps gathering information to support the discussion of differential diagnosis based on clinical signs; they are recommended to bring those maps to the activity.

During the activity, three moments were contemplated for students´-teacher/tutor interaction, representing the moments for requesting additional information. The additional information can vary between groups and usually relates with the different pathways used to confirm or discard diagnosis, which depends on the group interpretation of symptoms, for instance. At each time, students must provide a "request" explaining the need for a specific information. Regarding the complementary exams, raw data was provided (the files are devoid of reports or comments), and students should analyze the results and extract conclusions.

At the end of the activity, students were requested to submit on *Moodle* a draft of the group report and instructed to submit a final version up to 48h later. Figure 3 describes

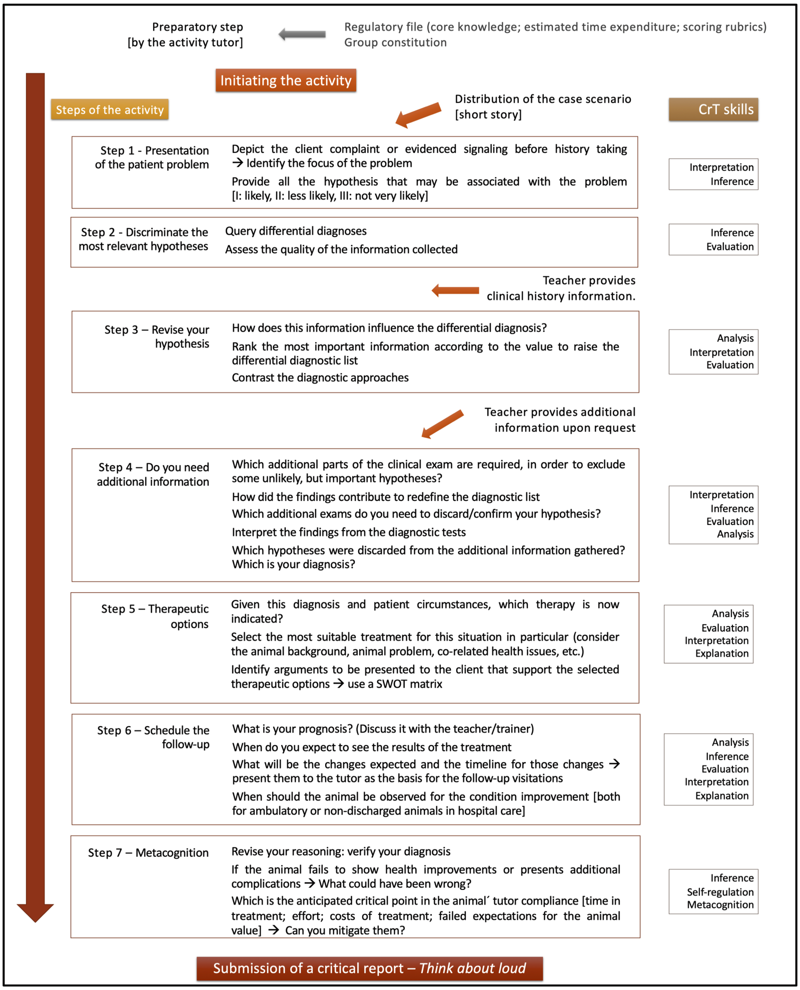


Fig. 1. The framework proposed for activities intended to foster students' clinical reasoning.

the activity provided for the Gynecology topic. At the end of the activity, students are requested to answer a questionnaire respecting the group dynamic and success, which also included an open question allowing students to comment on any aspect related to the activity.

The critical report ending the activity was assessed according to knowledge dimensions, as conceptualized by Krathwohl (p. 214–215) [10], using a 4-level qualitative scale. The different steps of the activity were deconstructed according to the dimension they represented (factual, conceptual, procedural, and metacognitive dimension) and each dimension was differently majored to the final grade (FG) [11]:

FG = (1.5* factual knowledge mean) + (2* conceptual knowledge mean) + (2.5* procedural knowledge mean) + (3*Metacognition), for a maximal total of 36 points.

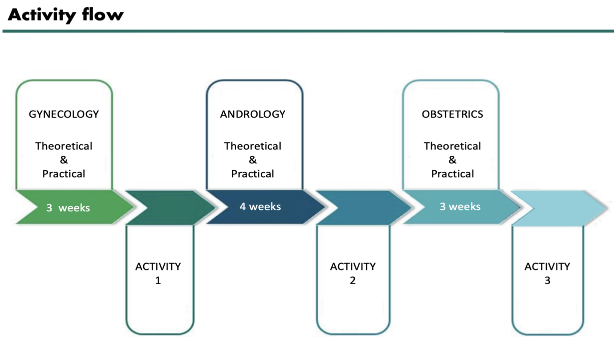


Fig. 2. Blended learning sequence to be implemented at the GAO course.

4 Global Considerations and Outlook

4.1 Regarding the Framework Design

In the proposed framework the starting point is a problem born from the professional daily work and provided to the student. The scaffolding questions across a sequence of steps were designed to mimic the mental clinical reasoning exercised by a veterinary practitioner, to be followed by the students when analyzing, debating, and proposing a solution for the case. As applied to work-based situation, these steps also help students´ engagement in the task and structure their reasoning, eliciting a deepened cognitive knowledge while also training them to search for evidence, work collaboratively and communicate between themselves and a third part – the teacher; the later favoring the development of inter-professional and peer-communication. The first three steps of the activity intend to guide the student from a poorly defined situation to a more focused one; students need to gather and analyze enough information to be able to find patterns or trends to clarify their view of the problem.

By not presenting the total amount of information at once, but instead in small sections, the activity tries to escape an overload of information that could contribute to early cognitive biases, for it is also closer to the real situation, where the doctor must explore the clinical condition to construct a mental image of the situation and reach a diagnosis. So, in the initial steps of the framework, students must ponder, rank and discard information according to its value, precision, or relevance for the diagnosis (evaluation of the problem). Students reach the diagnosis through steps 3 and 4 of the activities. Extrapolating from the additional information, students reach the focus of the case, and need to take a decision: how to solve the problem. Different situations may require different approaches, either because they have different animal-related contexts, or they represent problems of different complexity. But the pathway of the students´ reasoning might also determine different decision among the groups. In step 5, students must evaluate alternative solutions, before selecting the one they understand as the best. By asking them to use an adapted SWOT analysis matrix [12]. They will gather needed information for present arguments to the client, when exposing the recommended therapeutic approach, while simultaneously being able to identify critical issues related to treatments and to introduce the corrective measures in the therapeutic plan. On step 6 students are asked to

GAO- activity 2

Case scenario

A female Cocker aged 4 years-old, black in colour, intact and without history of previous reproductive activity, was presented to consultation with abdominal discomfort, reluctance to the exercise, increased vocalization, and reduced appetite.

When asked, the owner stated that the dog did not eat in the previous day but increased the water intake and the frequency of urination. The female was not under contraceptive treatment. She had her last season about a month ago but was not bred. The vaccination and deworming schedules are in order. The owner intends to breed the female in her next heat, taking advantage of the fact that the litter would born in late spring.

Step 1& 2

Proposed questioning:
- What was the problem that originated the consultation?
- Prioritize the putative diagnoses to include in a preliminary list? (from the most to the less probable)
- Which questions should be asked to discriminate between the most relevant hypotheses in your diagnosis list?
- What is the degree of confidence you have in the anamnesis provided by the owner. If you have a low or moderate level of confidence, which questions or strategies you can implement to strengthen the quality of the animal clinical history
- How would you approach this situation? (i.e., how would you develop the clinical consultation if the animal was on the table?)

Teacher provides the clinical history information

Physical exam:

At presentation, the female showed pyrexia (38.6 °C), tense abdomen and discomfort on abdominal palpation. Lung auscultation was normal; heart rate was 100 bpm, and the capillary refill time is within normal parameters; mucous membranes were normally coloured). No signs of dehydration were observed.

The female had a regular physical condition (BCS of 3 in 5 points). The perineal inspection evidenced no changes although vestiges of muco-haemorrhagic vaginal discharge, non-abundant and dark in colour were present.

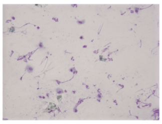
On abdominal palpation, it was detected an increase in the consistency of the caudal abdomen, compatible with an increased uterine size.

Step 3

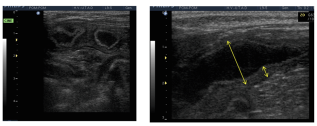
Proposed questioning:
- Did the information provided change the probability rank of your preliminary list of differential diagnoses? If it did, provide the new ranking, and explain the rationale behind the probability changes.
- Do you have all the information you need to issue a final diagnosis? Are unclear issues needing for clarification?
- Do you need to request additional test to achieve a diagnosis? If so, list the exams to be requested and explain why you need them.

Step 4 **Teacher provides upon request the results for complementary exams (independently)**

Vaginal cytology:



Ultrasound scans



Blood tests

Haematology

Parameter	results	Reference values
WBC (x 10^{-3})	19,8	6 - 12
RBC (x 10^{-6})	6,14	5 - 8
HCT (%)	35	37 – 50
HGB (g/L)	132	120-180
PLT (g/L)	280	200-500

Blood biochemistry

Parameter	results	Reference values
Glucose (mg/dL)	87	60 - 125
BUN (mg/dL)	18	7 - 27
Creatinina (mg/dL)	0,4	0,4 – 1,8
Proteínas totais	9 g/dl	6 – 7,5 g/dl
AST (UI/L)	43	25-55
ALT (UI/L)	35	5 - 60

Which hypotheses were discarded from the additional information gathered?
Which is your diagnosis?

Step 5

Proposed questioning:
- Considering your final diagnosis, which therapeutical options are available?
- Given this diagnosis and patient circumstances, which therapy is now indicated?
- Select the most suitable treatment for that particular situation (consider the animal background, animal problem, co-related health issues, etc.) Identify arguments to support the selected therapeutic options using a SWOT matrix

Step 6

Proposed questioning:
- What is your prognosis, considering the selected treatment?
- Considering a positive response to treatment, when do you expect the full recovery of the animal → schedule future appointments
- How would the owner recognise a favourable evolution of the clinical condition?
- What are the signals that may alert you to a worsen of the situation and the need to reassess the case? How can you alert the owner to presented the animal at the clinics for an unscheduled appointment?

Step 7

Proposed questioning:
- Suppose the animal fails to show health improvements or presents additional complications. What could have been wrong?
Can you foresee any critical points in the animal´ tutor compliance [time in treatment; effort; costs of treatment; failed expectations for the animal value]. Can you mitigate them?

Fig. 3. Representation of one of the activities implemented.

anticipate the evolution of the problem so a prognosis can be established, to schedule the follow-up and to gather information to inform the client about clinical clues that might be used to monitor a positive and negative evolution of the primary situation, utmost important when the animal is in ambulatory. Metacognition is the focus in step 7; it aims at stimulating students to critically evaluate the reasoning process through the activity, to reduce some gross biases in medical reasoning, and to make students understand that the case may not be closed with their intervention.

The framework proposed herein targets the development of skills identified as the most needed for learning in apprenticeships and at the entrance of the labor market. The proposed framework will also be useful in traineeships or post-graduate contexts, by the LMO, for training employees in specific interventions, which is an advantage, and reinforce the usefulness of business-university collaborations. In addition, it may also be transposed, total or partially, to an online learning environment in the future, or into an activity involving a real patient in clinical settings.

4.2 Considerations Regarding the Implemented Activity

As said previously, only the first activity was implemented, because the course only recently begun at the time this paper was written. Hence the following considerations result from the analysis of this sole activity amongst the proposed ones for this course.

During the implementation of the activity, some constraints were recognized by the tutors. No formal record of the perceptions was collected, but the students´ comments at the end of the team questionnaire allowed for the collection of some opinions.

Some limitations faced by the teacher(s) were of practical nature, like those considering the facilities available for this activity (dimensions of the room vs. the number of students, the acoustic of the room, the equipment available), and should be managed with the HEI. The existence of large groups of students enrolled in the activities will demand the preparation of larger spaces other than auditoriums that would contribute to the efficiency of group work, as it has been mentioned previously by other authors [13]. Others concerns were of personal nature. The number of groups were too large, thereby the presence of one or two tutors for all the groups was insufficient to provide timely response in all the interactions previewed in the activity. Albeit they may vary with the difficulty of the case, in some situations students had to wait for the tutors to interact with one group representative before passing to another. That standby might have disturbed the ongoing work of the groups, and increased the time spent in class. The possibility to work in a larger cohort of tutors, even if not directly involved in the course teaching, trained to respond accordingly to the situation and within the same context could contribute to a more efficient response to the planned interactions with the students. To appeal the participation of different teachers in these activities, it would be crucial the effort to be recognized by the University in a wider process of valorization and empowering of the teaching staff.

Another situation, observed during the first activity, related to the fact that students took too long to engage in the analysis and debate within the group, as they were not used to this model of activities. Consequently, the completion of the activity at home became more demanding, and an additional group meeting was necessary. Among students, the activity was described as too demanding and time-consuming compared with the learning activities developed in other courses. Moreover, they also found it strange to be assessed for their thinking abilities and decision-making, instead of the cognitive knowledge requested in traditional tests. These perceptions may convey that the students are more used to be assessed for their cognitive knowledge, not for the quality of their reasoning or the way they support their decision-making in terms of clinical reasoning. It also suggests that students need some time (and training) to adapt to new ways of learning, which may be accomplish by developing with them short activities fostering their reasoning processes and soft skills across the graduation program. The systematic use of similar activities across the curricula would facilitate the development of critical reasoning skills and strengthen informed decision making in students and new professionals. It would also promote their autonomy and self-confidence, thereby decreasing the mismatch identified by stakeholders in Veterinary Medicine pre-graduates at the entrance of their final traineeship.

However, in general, the perception of students was positive, and some mentioned that the exercises were challenging and created a good opportunity to deepen their knowledge as well as to develop their thinking process. One student stated: "*cases such as these could be very useful for our future*", suggesting they understand the activities mimic the real world and could be useful for learning. They also estranged the relatively modest grades compared to their usual, particularly for an open assessment performed in group. The perceptions informally collected from students match the available information regarding the usefulness of case-based learning in diverse health science programs.

Still, there is the need to evaluate in more detail the results of the changes introduced in the pilot course of Gynecology, Andrology and Obstetrics, which will be achieved by: 1) the assessment of their grades in the knowledge dimensions throughout the course activities; and 2) the assessment of students CrT skills at the entrance in the course and at the end (pre- and post-testing), which will be implemented in the near future.

5 Disclaimer

"The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein."

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Developing Computational Thinking Practices in Primary Education. Outcomes from a School-Year Instructional Intervention

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Abstract. Computational Thinking (CT), a problem-solving mental activity primarily dependent on abstraction, is regarded as a critical skill set for 21st-century students. Recent academic debates have led to a general agreement about the definition of Computational Thinking and the broad set of knowledge and skills that encloses, which is categorized into concepts, practices, and perspectives. The purpose of this study is to examine the effect of a Computational Thinking-based instructional intervention on the development of primary school students' computational practices. We employed a mixed methods approach and the research sample included 103 primary school students who collaborated in pairs during the regular teaching hour assigned to Information Technology throughout a full school year. Our results suggest that the proposed instructional intervention may enhance students' perceptions of their problem-solving skills. They also show that students' participation in testing and debugging as well as reusing and remixing digital games' code may improve their proficiency level regarding these Computational Thinking practices. Overall, despite its limitations, our study strengthens the hypothesis for the effectiveness of programming to develop primary school students' Computational Thinking.

Keywords: Computational Thinking (CT) · Visual programming · Problem solving · Testing and debugging · Reusing and remixing

1 Introduction

Computational Thinking (hereafter CT) gained considerable attention in 2006, when Jeanette Wing described it as a "universally applicable attitude and skill set everyone, not just computer scientists, would be eager to learn and use" [1, p. 33]. However, the origins of CT can be found in 1980, when Seymour Papert envisioned the use of computations to create new knowledge and the use of computers to enhance thinking [2]. The incorporation of CT in the PISA 2021 study may be considered as the pinnacle of Wing's statements, given that CT was included in this worldwide assessment of student performance across disciplines, but can be also seen as a normalizing move against Papert's view of CT, as he argued that computational objects could revolutionize

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students' way of thinking, but they were eventually absorbed into traditional education's practice [3].

After years of academic discussion and the proposal of several definitions following Wing's assertions, it is now widely accepted that CT constitutes a set of problem-solving methods that involve "formulating problems and their solutions in a way that can be effectively carried out by an information-processing agent" [4], a human, a machine, or a combination of both, across a variety of fields [5] and "explaining and interpreting the world as a complex of information processes" [6, p. 4]. It is also accepted that CT involves concepts, practices and perspectives [7]. Wing, according to Denning [8], inaugurated the New CT, in which knowing specific concepts leads to programming competence, while on the contrary in traditional CT, the latter derives from programming competence. However, according to Acevedo-Borrega et al.'s [9] systematic literature review "CT is all about program" (p. 12), as programming traditionally dominated the field of CT but nowadays has largely expanded its dominance. Nevertheless, the impact of programming on CT skills can be influenced by a variety of instructional design aspects [10].

The purpose of our study is to examine the effect of a CT-related instructional intervention on the development of primary school pupils' computational practices. More specifically, we investigated the effect of our CT instructional intervention on students' self-perceived problem-solving skills, their testing and debugging proficiency level, and their reusing and remixing proficiency level. The abovementioned CT practices focus on the social aspects of CT and have not been adequately investigated.

2 Theoretical Framework

2.1 CT and Problem Solving

CT is widely recognized as a set of problem-solving methods [4, 5] and is often identified with it [11, 12]. According to the recent CT framework proposed by Adams et. al [13], problem solving is regarded as a CT practice, although Brennan and Resnick [7] did not include problem solving in the CT practices of their CT framework, on which the subsequent ones were based. Furthermore, the development of students' problem-solving skills seems to be one of the most important benefits of programming activities in the context of CT [14–17].

However, prior research has mostly focused on students' problem-solving skills, while few studies have investigated the effect of CT courses on their perceptions of their problem-solving skills. Kalelioğlu and Gülbahar [18] investigated the effect of visual programming (using Scratch) on students' perceptions of their problem-solving skills. Their study involved 49 pupils that attended the 5th grade at a private Turkish school and took a one-hour weekly computer session. The students' perceptions of their problem-solving skills did not statistically significantly increase after the course, but they enjoyed programming and considered the programming environment as easy to use. Karaahmetoğlu & Korkmaz [19] investigated the effect of project-based Arduino educational robot applications on secondary school students' CT skill levels. Both the control and the experimental group worked for 11 weeks, applying project development with a programming tool and a robotic programming tool, respectively. Both tools were block-based and the researchers found that activities based on robotics programming ones may improve students' perceptions of their problem-solving skills and their CT skills in general.

2.2 Testing and Debugging

The CT practice of testing and debugging involves "developing strategies and plans for anticipating and dealing with problems during the construction of code" [20, p. 3] through a systematic, iterative process to find solutions in a computer programming environment or even not [5]. According to Zhang and Nouri [21], testing and debugging cannot be limited to a programming environment, but may be applied in hardware or in the software-hardware connection. Since CT is often identified with problem-solving, testing and debugging is considered as a fundamental CT practice [7, 13, 20]. However, testing and debugging is underrepresented in recent CT-related scientific research [22], possibly due to the design of visual programming environments –primarily used for the students' CT development– which prevents bugs.

According to Proctor [23], who evaluated middle school students' reading, writing, and debugging activities over a four-months course, incorporating interactive storytelling into a computer science course can help students improve their debugging skills. The use of an educational robotics kit may also contribute to the development of debugging skills, as recent research with primary school students in Spain showed [24]. Embodied instructions within the context of a block-based programming environment for younger student may also lead to greater testing and debugging proficiency level [25].

According to Michaeli and Romeike [26], the explicit teaching of debugging strategies had positive effect on the debugging skills and the self-perceived debugging efficacy of 28 middle school students. The researchers also emphasized the necessity of a systematic debugging approach, which includes testing the program, detecting errors, creating hypotheses, assessing them, and then iteratively revising the code until the program is flawless. Liu et al. [22] described the debugging strategies of 6–8 graders in a debugging game. They found that the students tried to solve problems using different strategies, such as making changes to the faulty part of the code, deleting parts of the code without inspecting them, making random changes, not applying the most efficient solution, or making changes to fixed bugs instead of trying to discover new ones. Finally, it seems that the development of testing and debugging skills cannot be successful in a brief period of time [21].

2.3 Reusing and Remixing

Nowadays, it is argued that we must place CT in a new context because of its creative and social nature, signifying a move from code to shared applications, from tools to communities, from creation to remixing and eventually from CT to computational participation [27]. Nevertheless, the practice of reusing and remixing "remains poorly understood" [28, p. 169], while current education heavily emphasizes individual learning and prevents students from interacting socially [29]. Reusing and remixing constitutes a fundamental CT practice [7, 13, 20], referring to students' use of a part of another project developed by themselves, modification of an existing own or others' project, or even inspiration drawn by reading other creators' code [30]. For example, students may borrow the idea of a game they like and find open-source scripts to create their own games [20].

During the last years, the scientific community has generally supported remixing activities, believing that exposing users to content produced by users with a variety of skills, knowledge, and experiences can promote learning [31, 32]. Several researchers have investigated issues related to reusing and remixing, but their research has focused on the relationships' complexity that emerges within a user community. Results from earlier studies, for example, showed that advanced learners may create fewer projects but produce higher peer interaction [29] and that programmers who are more socially engaged also tend to build more complex computer programs [33]. As a result, teachers should not only focus on developing students' CT skills, but also encourage social interactions during the programming process and differentiate the type of the programming assignments to help their students improve different CT skills [34].

The effect of reusing and remixing activities on students' development of CT skills has not been examined in detail [35]. However, Dasgupta et al. [31] found that users who remix more frequently utilize a large range of commands. They also found that greater exposure to CT concepts through reusing and remixing projects created by other users is associated to higher probability of using these concepts in their own creations. The analysis of 15,010 Scratch remixes made by Khawas et al. [28] revealed that the remixed projects usually include more blocks, as the users tend not to delete many of the original ones. Furthermore, students tend to make changes to the sprites more frequently while keeping the quality of the code at the level of the original project. Zhang and Nouri [21] made a systematic review of CT studies through Scratch, finding two types of remixing and reusing: simple ones as copies with surface changes and creative ones that differ from the original in terms of subject and structure. Kafai and Vasudevan [36] worked with middle school students (ages 11–14 years) creating touchpads, augmented board games, and wearable controllers for their Scratch games and found that most of them went beyond surface changes. Finally, Xing [35] argued that students' participation in reusing and remixing activities could contribute to the development of their CT skills, but overexposure might pose a threat to the process.

3 Aims

The main objective of the study is to investigate the effect of our CT-related instructional intervention (independent variable) on the development of 6th-grade students' computational practices (dependent variables).

The study focuses on three dimensions and the specific research questions are as follows:

1. Does our CT instructional intervention affect students' perceptions about their problem-solving skills?

2a. What is the effect of our CT instructional intervention on students' testing and debugging proficiency level?

2b. What is the effect of our instructional intervention on students' ability to employ systematic debugging strategies?

3a. What is the effect of our CT instructional intervention on students' reusing and remixing proficiency level?
3b. Which CT concepts do students modify when they engage in reusing and remixing Scratch projects?

The study is focused on CT practices that have not been sufficiently investigated by scientific research as well as on the social aspects of CT through students' pair programming and their use and remix of projects that other community members have created. Finally, it is aimed to investigate the development of primary school pupils' computational practices in real-class conditions of the Greek public education system, in contrast to research conducted with after school clubs.

4 Method

We adopted a mixed methods design to investigate the effect of our CT instructional intervention on students' CT practices. Mixed methods can be defined as research in which the investigator "collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry" [37, p. 4]. Using mixed methods may offer a more comprehensive approach to the phenomena under study since quantitative approaches often have the researcher's perspective as a starting point and qualitative approaches focus on the perspective of the research subjects, but, according to some critics of mixed methods, qualitative and quantitative approaches have strictly distinct characteristics and, therefore, should not be combined [38].

The study used the embedded design, which is the type of mixed methods design in which a qualitative or quantitative data set plays a secondary or supporting role in a study based mainly on the other data type [39]. In cases where quantitative data predominate, qualitative data can provide data for examining the process of an intervention. The present study adopted the embedded design in which quantitative data played a key role and were supported by qualitative ones. The combination of the methods is aimed at the approach of different aspects of the phenomena under study and their more complete investigation. We obtained quantitative and qualitative data simultaneously.

In the first dimension, we conducted a one-group pretest-posttest, involving the measurement of the participants' perceptions about their problem-solving skills at two time points. In the second and the third dimension, we used a repeated-measures design protocol, as we measured the mean of the same participants' CT practices levels (dependent variables) during two or four learning units (levels or related groups of the independent variable) of the instructional intervention [40].

4.1 Participants

Our study sample included 103 students enrolled in the 6th grade of three public primary schools in Athens during the 2018–2019 school year. We adapted a convenience sampling method, a type of nonprobability sampling, given that we selected the participants based on easy access to them and their willingness to participate [41]. There were 44 boys (43%

of the total) and 59 girls (57%). The students worked in pairs that were randomly formed and did not change until the completion of the instructional intervention. The number of students' pairs included in the analysis of each of the two last dimensions described in the following sections varies from 43 (second dimension) to 40 (third dimension), as we included in the analysis only those pairs who were present throughout all the dimensions' activities. We also analyzed 88 students' responses regarding the first dimension, after assessing that their attendance at classes was sufficient to include in the analysis.

We did not record any additional information regarding the demographic characteristics of the participants, as the investigation of possible differences or correlations between the variables that we measured and the participants' demographic characteristics does not fall within the scope of this study. However, it is worth noting that the students were familiar with working collaboratively, had the basic required computer skills for the activities, and gained familiarity with the interface of Scratch during the last quarter of the previous school year.

4.2 Course Implementation

The instructional intervention took place for 28 teaching hours, one per week of lessons, during the regular teaching hour assigned to Information Technology in the schools' ICT rooms, equipped with a projector, a portable computer for the teacher, and a network-connected workstation for each pair of students. Our emphasis on the collaborative learning and social dimension of CT dictated the choice of pair programming throughout the activities of the CT instructional intervention. The participants used Scratch, a block-based visual programming environment [42]. During each lesson, the researcher collaborated with the ICT teacher of the class, but the researcher entirely determined the lesson's plan. The activities of the instructional intervention comprise part of the Creative Computing Curriculum [43] and aim to encourage students to take on the role of designers or creators of computational artifacts rather than the role of consumers.

The first lesson included a brief introductory talk with the students. After that, we asked them to complete a scale with their initial perceptions of their problem-solving abilities. The two following lessons aimed at helping the participants to become familiar with the environment of Scratch and with the instructional intervention's objectives. These preparatory activities required three hours.

The first unit (*Exploring*), which required five hours to complete, focuses on sequences (CT concept), and experimentation and iteration (CT practice). During this unit, the students also faced two debugging challenges. The first one included a Scratch program with two characters (sprites). The sprites were supposed to start dancing simultaneously after the students had launched the project's scripts, but only one character, the Scratch Cat, did. In the second debugging challenge, the Scratch Cat began on one side of the screen (stage), said something, then glided to the right side and said something about being there. When the students first ran the program, it worked but then stopped working.

The following unit (*Animations*), which also required six hours, is related to media and arts and was aimed at students' experimentation with loops, events, and parallelism (CT concepts). The students not only designed and programmed animations but also practiced debugging Scratch programs. We assigned them two programs: In the first one, the Scratch Cat should have danced to the sound of a musical instrument. However, after the launch of the program, the Scratch Cat started to dance, stopped dancing after a while, but the musical instrument continued to play. The second one started with the Happy Birthday song and, while the music was playing, instructions for blowing out the candle appeared. However, they should have appeared after the music had completed playing.

For the next seven hours, the participants were engaged in digital storytelling activities. The unit (*Stories*) focused on events and parallelism (CT concepts) as well as experimenting and iterating, testing and debugging, and reusing and remixing (CT practices). We assigned the students two buggy programs, in which the Scratch Cat asked another sprite to meow and jump, but, in both cases, the sprite did not follow Scratch Cat's instructions. We also asked the students to remix a Scratch project that involved two sprites, a male and a female, and a castle. The tale was divided into three 'episodes', each with an arrow that, when pressed, continued the plot. After that, the two protagonists entered the castle and found a trunk, which they opened. The students remixed the project from this point on.

Finally, the last unit (*Games*) focused on conditionals, operators, and data (CT concepts) as well as experimenting and iterating, testing and debugging, and abstracting and modularizing (CT practices) through the creation, debugging, and remixing of games-related Scratch projects. In the first Scratch program that the students worked on debugging, the Scratch Cat moved across the stage and collected items he came across. Every time he collected an item, a list was updated, but he could only collect one item. In the second one, the Scratch Cat was moving through a maze to find a yellow rectangle, but he had the ability to walk over the maze's boundaries, which he shouldn't have. The students also engaged in remixing digital games, working further with game features, such as levels and scores. First, we gave them an existing game that included a racket and a ball and required the player to avoid allowing the ball to pass him and cross a red line. Then, we asked them to remix it. The unit's activities required seven hours.

4.3 Data Collection and Analysis

As we described in the Method section, we collected both quantitative and qualitative data simultaneously to investigate the effect of our CT instructional intervention on the computational practices of primary school pupils. We utilized the Statistical Package for the Social Sciences (SPSS®) software application package to analyze the data and we carried out the statistical tests, after ensuring that the required assumptions were met. In the first dimension, we used the Problem-Solving Inventory for Children (PSIC) [44] to measure the participants' perceptions of their problem-solving skills. The 5-point Likert scale consisted of 24 items, divided into three subscales that measure a) students' perceptions of their confidence in solving problems (Self-Confidence), b) their levels of self-control when facing problems (Self-Control), and c) their tendency to avoid problems (Avoidance). The questionnaire took students 10 to 15 min to complete and was found highly reliable for both the pre-test (24 items; $\alpha = .86$) and the post-test (24 items; $\alpha = .87$). We then ran a paired-samples t-test, to determine if there was a statistically significant difference in the students' perceptions before and after the CT instructional intervention.

In the second dimension, we used think-aloud protocols [45] to record whatever students saw, processed, performed, and felt while debugging their Scratch programs. We also used semi-structured interviews with each pair of students if there was a need to shed light on certain aspects of their descriptions. After the debugging task, we asked them to write their reflections in four prompts regarding the program's bug, how they found it and how they fixed it. Then, using content analysis [46], we described the strategies with which the students debugged their programs. For only two pairs of participants, we used content analysis of screen recordings of their actions while debugging to detect patterns of their debugging processes.

We then assessed students' testing and debugging proficiency level, using the analyzed data and a rubric. The rubric we used comprises part of the Creative Computing Curriculum and asks students to describe (a) what happens when they run their buggy projects, (b) how they read through their scripts to figure out what is wrong, (c) how they make changes and test to see what happens, and (d) how they consider other ways for solving the problem. For each question, three statements describe the actions of students who have a low (1 point), medium (2 points), and high (3 points) level of proficiency. Next, we calculated the mean score of the pairs' proficiency level in a range comprising a minimum value of 1 (low level) and a maximum level of 3 (high level).

At the end of each of the four learning units in which the students worked in debugging Scratch programs, we assessed their debugging strategy and their proficiency level regarding the CT practice of testing and debugging. In order to determine whether there were any statistically significant differences between the means of the debugging proficiency level between the units of our instructional intervention, we used a one-way repeated-measures analysis of variance (ANOVA) and then performed all pairwise comparisons (post hoc tests) [47]. We also calculated partial eta squared (partial η^2 or $\eta_p{}^2$) and partial omega squared (partial ω^2 or $\omega_p{}^2$), as a measure of the effect size on sample and population, respectively [48]. As regard students' debugging strategies, we used Cochran's *Q* test [49] to investigate possible differences in their use between the learning units and McNemar tests (with a Bonferroni correction) to make pairwise comparisons.

In the third dimension, we used semi-structured interviews and a rubric to measure students' reusing and remixing proficiency level. We conducted interviews with the students, which lasted a few minutes, while they were working remixing the original projects. The questions were based on the reusing and remixing assessment rubric that comprises part of the Creative Computing Curriculum and regarded (a) whether or not and how they got ideas from other projects and their scripts, (b) how they chose a piece from another project and adapted it for their project, (c) how they improved or enhanced an existing project, and (d) how they credited persons whose work they drew inspiration from or built on. As with the rubric of the second dimension, for each question, three statements describe the students' actions with low (1 point), medium (2 points), and high (3 points) level of proficiency. Then, we calculated the mean score regarding the computational practice, ranging from 1 (low level) to 3 (high level). We also collected the students' projects after they had remixed them and used an analytical, online tool, Dr. Scratch [50] to assess them in seven computational areas. In each area, a score ranging from 0 to 3 was attributed to the projects, resulting in a total CT score on a 0 to 21 scale.

We conducted a paired-samples *t*-test to investigate possible differences between the students' proficiency level regarding reusing and remixing after the unit of *Stories* and *Games*. As for the CT concepts of the remixed projects, we conducted a one-sample *t*-test. More specifically, we compared the scores we obtained from Dr. Scratch regarding the original project with the scores that Dr. Scratch exported for the students' remixed projects, both for the unit of *Stories* and *Games*.

4.4 Results

First Dimension: Problem-Solving Perceptions

We used the paired-samples t-test to evaluate the significance of the difference in the students' perceptions about their problem-solving skills before and after the completion of the CT instructional intervention. We found that the students have better perceptions for their skills after the course ($M = 2.92$, $SD = 0.36$) contrary to their pre-course perceptions ($M = 2.89$, $SD = 0.40$), a statistically mean increase of 0.03, 95% CI [−0.06, −0.01], t(87) = −3.24, p = .002, d = 0.34. However, although the mean value of students' perceptions of their problem-solving skills was found to be statistically significantly higher after the completion of the instructional intervention, the same did not happen with the perceptions' subscales. In particular, we found that students' perceptions of their confidence levels in solving a problem in the period from pre-test ($M = 3.08$, $SD = 0.49$) to post-test ($M = 3.06$, $SD = 0.41$) did not change statistically significantly, t(87) = −1.20, $p = .234$, $d = -.13$. This finding indicates that the CT instructional intervention may improve students' overall self-perception of problem-solving skills, but may not have a statistically significant effect on their problem-solving confidence.

The effect of our instructional intervention, on the other hand, was found to be statistically significant on students' levels of self-control regarding their emotions and behavior when facing problems. The participants stated that they have greater self-control after the instructional intervention ($M = 2.76$, $SD = 0.44$) compared to the time point before the instructional intervention ($M = 2.71$, $SD = 0.49$), as the mean value of the variable increased by 0.05, 95% CI [0.02, 0.08], $t(87) = 3.11$, $p = .003$, $d = 0.33$. In addition, the effect size of the instructional intervention was low on the previous variables but moderate on the variable regarding the students' avoidance of their problems. More specifically, our results showed that the students tend to avoid their problems less after the instructional intervention ($M = 2.81$, $SD = 0.44$) than before it ($M = 2.66$, $SD = 0.55$). The mean value of the variable increased by 0.15, 95% CI [0.09, 0.20], $t(87) = 5.24$, $p < .001$, $d = .56$.

Second Dimension: Testing and Debugging

The results of the content analysis of our data showed that the students employed three categories of strategies when they debugged Scratch programs. The first category includes the systematic strategies, when the students applied iterative processes of executing the program, finding errors in its code, making hypotheses, and finally, fixing the bugs. They often divided the code into smaller parts. The second category included partially systematic strategies, identified when the students were working in the right direction to fix the bugs, but either tried to fix correct parts of the code according to an original hypothesis or detected the part of the code where the error was but tried to correct it by replacing it with a new code. Finally, the category of the non-systematic strategies refers to the students' efforts that included only the visual inspection of the code, without making changes, or the creation of an entirely new code to replace the old one and perform the expected functions of the program.

As for students' testing and debugging proficiency level, we found that it was low or medium throughout all four learning units, as its mean barely reached value 2, which demonstrates the medium level of proficiency. We conducted a one-way repeated-measures ANOVA and found that the learning units of our instructional intervention resulted in statistically significant changes in participants' testing and debugging proficiency level, $F(3, 126) = 10.23$, $p < .001$, $\eta_p{}^2 = 0.200$. Post hoc analysis with a Bonferroni adjustment showed that the mean of the CT practice was lower during the *Exploring* unit ($M = 1.76$, $SD = 0.44$) as compared to both the *Animations* ($M = -0.17$, 95% CI [−0.31, −0.03], $p = .013$) and the *Games* units ($M = -0.26$, 95% CI [−0.41, −0.10], $p < .001$). Furthermore, the mean score of testing and debugging decreased from *Animations* to *Stories* ($M = 0.13$, 95% CI [0.01, 0.26], $p = .034$), but increased from *Stories* to *Games* ($M = -0.22$, 95% CI [−0.37, −0.07], $p = .001$).

Our results also showed that the participants debugged their Scratch programs employing more often partially-systematic strategies (78 times or 45.3%). More rarely they employed systematic strategies (38 times or 22.1%), while they employed non-systematic strategies 56 times (32.6%). We then conducted a Cochran's *Q* and found that the employment of systematic strategies was statistically significantly different between the learning units, $\chi^2(3) = 8.737$, $p = .033$. Post hoc tests revealed that the participants' employment of systematic strategies during the *Games* unit was statistically significantly higher compared to the units of *Exploring* ($p < .001$) and *Stories* ($p = .002$).

Third Dimension: Reusing and Remixing

We used a paired-samples *t*-test to investigate whether the mean difference between the students' proficiency level in the CT practice of reusing and remixing after the completion of *Stories* and *Games* is statistically significant. Our results showed that the students demonstrated a higher level of proficiency regarding the CT practice after the completion of the learning unit of *Games* ($M = 2.03$, $SD = 0.47$) compared to the completion of the *Stories* unit ($M = 1.86$, $SD = 0.43$), a statistically significant increase of 0.16, 95% CI [0.09, 0.23], $t(39) = 4.604$, $p < .001$, $d = .73$. The value of Cohen's coefficient showed that the effect of the game remixing activities on students' reusing and remixing proficiency level was large.

We then used Dr. Scratch to compute the scores of students' remixed projects regarding certain CT concepts, but also overall CT performance. We conducted a one-sample *t*-test and found that during the games-related unit, the mean overall CT score of the remixed projects ($M = 1.35$) was higher than the score of the original projects ($M = 1.29$), a statistically significant difference of −0.06, 95% CI [−0.11, −0.02], $t(39) = 2.713$, $p = .010$, $d = .43$.

The one-sample *t*-test showed that during *Stories*, the CT concept of flow control was higher for the remixed projects ($M = 1.28$) compared to the original projects ($M = 1.00$), a statistically significant difference of -0.06, 95% CI [−0.11, −0.02], $t(39) = 2.713$, $p = .010$, $d = .43$. During *Games*, the mean score of the data representation of the remixed project ($M = 1.35$) was higher than the original project's score ($M = 1.00$), a statistically significant difference of -0.35, 95% CI [-0.51, -0.20], $t(39) = 4.583$, $p < .001$, $d = .73$. A statistically significant difference was also found regarding user interactivity of the remixed projects ($M = 1.10$ for the remixed projects and $M = 1.00$ for the original project), a statistically significant difference of -0.10, 95% CI [-0.20, -0.00], $t(39) = 2.082$, $p = .044$, $d = .33$.

Finally, we ran the students' programs to detect the most common changes in their projects' code. During the learning unit of *Stories*, the students added new objects (in 87.5% of the projects), changed the flow of the story by key press or time intervals (23.5%), and added sounds (17.5%). Non-working (dead) code was found in 10% of the projects, while in 5% of the projects no change was applied. As for the students' projects in the unit of *Games*, the changes mainly concerned the addition of objects (35%), sounds (32.5%) and lists (22.5%) associated with the remaining time of the game or the remaining 'lives' at the player's disposal. Dead code was found in 15% of games, while in 12.5% of them, the students did not make any changes.

5 Discussion

This paper investigated the effect of a CT instructional intervention through the use of Scratch on the development of 6th-grade pupils' pupils' computational practices. The first dimension regarded the effect of our instructional intervention on pupils' self-perceived problem-solving skills. Our results showed that the sequence of CT activities we applied may improve students' overall perceptions, but not have any statistically significant effect on their confidence in solving problems. Our results contrast with Kalelioğlu and Gülbahar [18], who did not find any statistically significant increase regarding students' perceptions of their problem-solving skills during their survey at a private primary school. However, our results are consistent with Karaahmetoğlu and Korkmaz [19], who found that students' perceptions of their problem-solving skills may increase as a result of activities through block-based robotics programming tools.

As for the effect of our instructional intervention on students' testing and debugging proficiency level and strategy use, we found that mean score for *Stories* was statistically significantly lower than the mean of the prior (*Animations*) and subsequent learning unit (*Games*). Our results suggest that each unit's particular characteristics and CT dimensions on which focuses could impact testing and debugging proficiency level. Moreover, the students applied more frequently partially systematic or non-systematic debugging strategies, but systematic strategies more often during the *Games* unit.

The games-related debugging activities followed a number of other activities during our instructional intervention. It is possible to argue that a sequence of activities, such as the one we applied, which incorporates games-related debugging activities at its last part, could promote the development of CT-related skills. This is consistent with the claim of Zhang and Nouri [21], who argued that the development of testing and debugging skills cannot be successful in a short period of time. Although a block-based programming environment prevents errors, it may also serve as a successful tool for the development of students' testing and debugging proficiency level, as other studies have shown [25]. Finally, our students used debugging strategies that are similar to that of the

6–8 graders of Liu et al. [22]. The use of systematic strategies became more frequent as we approached the end of the instructional intervention. However, we did not explicit teach them as other researchers did [26].

The third dimension of our study regarded the effect of our instructional intervention on the reusing and remixing proficiency level of our students, as well as the CT concepts they modified when they reused and remixed Scratch projects. The results suggested that the students' level of proficiency was low during the *Stories* unit and medium during the *Games* unit. There was also a statistically significant difference between the students' mean after the completion of each unit. That may indicate that students' practice of reusing and remixing digital games in the context of our CT instructional intervention leads to higher level of proficiency.

We also suggest that each unit's special characteristics and CT dimensions on which focuses could impact reusing and remixing proficiency level. More specifically, during the games-related unit the students received expertise with conditionals, operators, and data (CT concepts), while during the stories-related unit, they gained more fluency with events and parallelism (CT concepts). Moreover, the remixed projects in the *Stories* unit were improved in terms of the CT concept of flow control, as the students added different versions of the story or added commands to control the plot. Nevertheless, most of the changes they made regarded aesthetics and not the program's functionality. The remixed projects in the *Games* unit were improved in terms of the CT concepts of data representation, as the students added variables and lists, as well as user interactivity, since they modified or added actions that trigger new situations. Although the remixed projects were significantly improved, the students focused on aesthetics, rather than functionality. Zhang and Nouri [21] divided the changes that students made while remixing in surface and creative ones. Our study's remixed projects incorporated mainly surface changes, in contrast to the findings of Kafai and Vasudevan [36], who worked with middle school students.

However, it seems that differentiating the type of programming activities can help students develop different CT dimensions, as Moreno León et al. [34] pointed out. As a result, teachers should not only focus on developing students' fundamental CT skills, but also try to engage students in communities and differentiate the type of the programming assignments to help their students develop different CT dimensions. Overall, our work further supports the viewpoint that exposing users to content created by other users can promote learning related to CT [31, 32, 35].

6 Conclusions

Our study aimed to investigate the effect of a CT instructional intervention on students' self-perception of their problem-solving skills, as well as on their proficiency level regarding testing and debugging and reusing and remixing. The main contribution of the study is the focus on CT practices that have not been sufficiently investigated by scientific research, as well as the emphasis on the social dimensions of CT, through students' programming in pairs and the use of projects that have been created by other users. Our results provide more evidence for the claim that exposing users to content produced by others can help them develop CT skills. Furthermore, our research was carried out in regular school conditions and we collected both qualitative and qualitative data to obtain the most accurate view of the students' mental processes on the progress of the CT development across the learning units. Moreover, our study strengthens the hypothesis for the positive impact of programming activities in the context of a visual programming environment on CT practices and proposes the utilization of digital game programming in a visual programming environment for the development of CT practices. However, a challenge for future research would be the investigation of the effect of the injection of game characteristics into stories to the development of CT.

Finally, there are some potential limitations regarding our results' interpretation. First, we cannot exclude the effect of exogenous variables or order effects caused by the order in which the students completed the activities. Second, this study aimed to examine the effect of a specific series of activities on students' development of CT practices and did not control order effects by counterbalancing. As a result, it would be important to reinvestigate the effects of our activities under a new sequence. Furthermore, our encouraging results should be validated by a larger sample size after adopting a different sampling process.

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Digital Transformation in Higher Education

The Challenges and Opportunities of Teaching Languages Online

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Abstract. The global pandemic situation has profoundly changed our teaching practice. In a time when schools and universities had to close down, foreign language teachers and students had to teach and learn languages online using modern technologies and collaboration. Online education has boomed rapidly, which also brings innovations to the field of foreign language teaching and learning, offering new possibilities and challenges. The aim of this study is to analyze the challenges and new opportunities that language teachers and university students face when teaching and learning languages online, as well as to work out effective methods that will enable language teachers and students to manage difficulties in language learning classrooms. Findings suggest that although there are some limitations to the online learning, there are also many aspects in which online language learning can be even more efficient than traditional classes.

Keywords: Teaching online · Language teaching and learning · University studies · Collaboration · Opportunities

1 Introduction

The world of education has been changing since ancient times. The lockdown has given teachers and students an opportunity to try teaching and learning online and using globally accessible resources and fostering global collaboration. It is not an easy task. Switching to online learning can be challenging. It can demand rethinking the parts of the course, using new methodology, learning tasks and tools that may be unfamiliar to teachers and their students. The pandemic has changed the traditional teaching and learning classroom activities, but that does not mean they must be neglected or ignored [1]. By introducing cooperation, collaborative communication and active learning into our classrooms, we can make sure students get effective and attractive language learning process, regardless

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of where it takes place. Using technology to keep in touch with students, sending feedback, sharing teaching material and videos to set assignments and tests have to be adapted for online classes. Although the integration of technology into language teaching has been evolving for decades, for the first time thousands of language teachers and learners are dependent on the internet as the only medium for teaching and learning languages [2]. Before the pandemic teachers and parents were anxious about the amount of hours our young people spent with computers, tablets and smart phones. Now parents can do nothing about the time students spend with laptops and smart phones for the sake of education. This is the main issue during the time of lockdown. In the midst of the corona virus pandemic, university teachers were forced to carry on their instruction online to ensure the continuation of teaching and learning process. Engaging language learners' learning online, motivating them to learn effectively, organizing productive online learning activities, assessing their progress, preparing language teachers for teaching online are some of the difficulties of teaching languages online. The discussions have been taking place for some time about the effectiveness of online teaching over classroom teaching. During the lockdown, we have ahd the unique opportunity to practice online teaching. A lot of situations present challenges and we as teachers are trying to overcome them. This study aims at presenting language teachers' experiences of teaching foreign languages online using globally accessible resources at Vilnius Gediminas Technical University. A qualitative study was carried out to interview 21 English and German teachers at Vilnius Gediminas Technical University to find out what difficulties of teaching students online they face. The object of the research is teaching languages online in university studies. The aim of the research is to investigate the challenges and opportunities that university teachers face when teaching foreign languages online. The objectives of the research are as follows: 1) to present a theoretical background of the challenges of teaching and learning languages online in university studies; 2) to discover the challenges teachers face when teaching languages online; 3) to reveal the opportunities of teaching and learning languages online for teachers and students.

2 Theoretical Background

The literature on teaching online claims that online learners succeed as well as their face-to-face counterparts. However, online learning causes challenges to language teachers as well as students [3]. When learning online, most communication leads to an isolated learning environment. A number of researchers have noticed the limited opportunities of listening and speaking in language courses, which may affect students' speaking skills [4]. The isolation can make language learning "extremely difficult. Moreover, this isolation also provides less chances for face-to-face communication, which may influence students' understanding about online language courses, and it is face-to-face communication which remains learners' most favourite learning style [5].

We should didtinguish between online instruction and emergency remote teaching. The former is deliberate and elaborate, whereas remote teaching, on the other hand, is a temporary transition due to crises such as weather or war. Remote teaching differs from planned online teaching. In spring 2020 the main objective in this situation was to provide temporary access to instruction in a quick to set up manner and is available during the pandemic. Moreover, remote teaching might be different in divergent situations. Most of the instructions in spring 2020 were delivered in an online format.

Furthermore, large amounts of self-learning, a lack of feedback, a lack of teacher-student, and isolation from a language learning group during the course have increased such affective factors as learning anxiety [6] and a lack of students' motivation to continue the course [7, 8]. Although online learning provides teachers with a lot of flexibility, it may also create an additional workload for them, especially at the beginning. Finally, providing feedback as quickly as possible and assisting students' learning process remain to be the biggest challenges to language teachers [9]. The challenges of online language courses are as follows: designing online course materials, a lack of teachers' skills when using the technology, inadequate practice opportunities to develop students' speaking skills, different expectations between teachers and students, and a lack of soft skills on the part of the students. [10, 11].

3 Research Methodology

Our study focuses on how twenty-one university teachers understand and formulate the challenges of teaching and learning languages online in the university studies. The study participants voluntared to participate in the study. The respondents are all experienced teachers with 11- 34 years of teaching experience. Pseudonyms T1-T21 were used in order to guarantee anonymity. The respondents were given open-ended questions, which created a possibility for a deep study into the issue. The questions focused on what the most memorable satisfying personal experiences were when teaching students online and what the most memorable challenging situations of teaching online were. It should be observed that the data was collected was in one institution, but in the future it could be carried out in a number of institutions for further results.

4 Findings and Discussion

All the answers of the respondents fall under the following categories of challenges of online language teaching: 1) challenges using technology; 2) participation and feedback challenges; 3) need for self-management skills, and 4) a category of the opportunities of online teaching. We are going to analyse the three categories of challenges as well as overview the opportunities the respondents faced and identified.

4.1 Challenges Using Technology for Online Teaching

The research participants observed that there were some challenges while using technology in online teaching and learning sessions (see Table 1).

Reliable internet connection is perhaps the biggest fear for any teacher who teaches online, as without a reliable Wi-Fi connection, you cannot teach students decently and and the way they expect. [12]. It can be rather irritating for online English language learners when their teacher's image is constantly freezing or jumping around during the class. Student needs to be focused on the topic in and it is the English language teacher's

Table 1. Challenges using technology for online teaching

Theme I	Subtheme 1	Subtheme 2	Meaning Unit
Challenges using technology	Internet connection issues	Audio and video connection issues	*T4 ″ <… > Even if you are a fantastic English teacher, if students cannot hear you, then the class will fail″* *T19 ″The majority of students do not use their cameras during the online lessons <… > ″*
	Challenges handling technology	Lack of technology handling skills	*T9 ″You can watch many instructions but the best way is to learn is by doing it yourself <… > ″* *T16 ″Elderly teachers are not very comfortable coping with the technology as well as the young generation <… > ″*
	Challenges of presence	Distraction and invisibility	*T5 ″ <… > the noise and other activities in the students' homes <… > ″* *T21 ″ <… > In classrooms, students enjoy and remember teachers' gestures and they add to classroom teaching″* *T3 ″Students log in but teachers cannot check if they are actually present <… > ″*

task to ensure that the internet connection is proper and reliable. For some teachers, technology can be challenging: so many buttons to press, that is why they face a fear of failure. Technology is a tricky aspect of online teaching, but it can be adapted. The advice is to be patient and to eb willing to learn.

Another difficulty encountered by every teacher is the presence. Teachers keep calling out names or asking questions for opinions sometimes without any response. In addition, students cannot see teacher gestures and body language which enhance communication during face-to-face sessions.

When studying online, students are not distracted by other groupmates in a classroom, but there are other family members or pets in the background. There could be other distractions so the students need to deal with their English class and other activities simultaneously. The key here is knowing that students must participate in learning activities. Online classes usually are smaller in size, so teachers should constantly check in with the students that are starting to disstract their attention from the topic. Teachers can ask questions to make sure they are staying focused on the lesson and not on some other tasks so that they don't lose interest.

Speaking about challenges handling technology and need for technology handling skills there is so called "neophobia", i. e. fear of new things, which is similar to the term of "technophobia" [13]. Teachers are certainly people of habit, but they also enjoy challenges. Neophobia and technophobia could definitely be overcome within a short period of time as teachers get used to the peculiarities of delivering lessons online. It is difficult to adapt the right time for adapting to using new technologies, but it is more difficult to adapt it according to the needs of the students. Keeping in mind the lack of visible body language of the students, teachers also have to rely on frequent feedbacks. The major difficulty to the teachers is to handle the lack of these things. Thus they need clear instructions and everything has to be clearly explained. Students are of great help in this challenging situation. They are very active on social networks, they find online teaching very attractive. During the classes students can help when teachers get struck and help their teachers handle any technological problem that they face. We should be indeed happy when students teach us and we learn from them. Teacher must always be learners.

4.2 Participation and Feedback Challenges of Online Teaching

Teaching, practicing and assessing the four language skills- reading, listening, writing and speaking- during online classes are a major concern to any teacher of English (see Table 2). It is expected that working online will make students more focused, and develop their listening skills much faster than in a traditional face-to-face lesson where listening is maintained by other types of communication. Reading, listening and speaking are hoped to be fluently done by students. However, teaching students writing and speaking online is more difficult.

Table 2. Participation and feedback challenges of online teaching.

Theme II	Subtheme 1	Subtheme 2	Meaning Unit
Participation and feedback challenges	Passivity	No active participation	*T18″ <… > online teaching can turn students into passive listeners rather than active participants″* *T20″ <… > I observed certain student passivity due to the online instruction″*

(*continued*)

Table 2. (*continued*)

Theme II	Subtheme 1	Subtheme 2	Meaning Unit
	Feedback issues	Need for feedback	*T11 ″Feedback is the key to building connections with learners when teaching them online <... > ″* *T13 ″It took a lot of effort and time to provide feedback but it always seemed that the provided feedback was not as effective as I expected <... > ″*
	Collaboration challenges	Limited collaboration	*T17 ″Interaction among students is the most important aspect of successful online education <... > ″* *T2 ″ <... > cooperation is the most difficult element to achieve when students are not physically present.″*

The research participants recognize student passivity as a challenge. Thus, when students are learning online, teachers must realize that students will only be active if they see the teaching material as important. With open questions, it is easy to check comprehension of course material. These questions can be used to introduce new terms, increase students' understanding of topics and assess them.

Speaking about the identified feedback issues and the need for feedback it could be advisable for teachers to give feedback and make adjustments accordingly right after students complete a task. To provide effective feedback, teachers must explain why a student is receiving it, and suggest the ways to improve their performance in the future. This process also motivates students to think on that feedback, thus creating an interaction focused on individual progress over the course material. Since this is an endless process, regular online assessment can become ongoing feedback loop. Moreover, student support of higher quality is the opportunity that is given by online learning. Teachers will surely have to develop some rules so that they do not write and respond to emails all the time. Nonetheless, better support brings better outcomes.

Another problem identified by the research participants stands out to be limited collaboration while teaching online. Collaboration motivates learning and stimulates an attitude to the course material that is based on deeper and more critical awareness.

To promote collaboration, teachers can give students a specific task, not only commenting on each other's ideas, for example, teachers can ask for feedback about their group mates' presentations. This method helps students enhance their creativity skills and critical thinking. Students are encouraged to analyze, synthesize the information presented to them. By relying on one another's expertise and through online resources, students who use problem-based approach can achieve their course's learning objectives collaboratively.

4.3 Need for Self-management Skills of Online Teaching

The research participants identified certain problematic areas concerning the need for self-management skills while teaching and learning online (see Table 3).

Table 3. Need for self-management skills of online teaching.

Theme III	Subtheme 1	Sub-theme 2	Meaning Unit
Need for self-management skills	Need for independent study habits	Need for students self-discipline	*T14″ <… > online courses require self-discipline, motivation, good time management, and self-study skills″* *T1″ <… > some students do all their self-study tasks the last minute″*
	Coping with character differences	Coping with personal character traits	*T10″Coping with quiet students can also cause problems <… >″* *T13″ <… > online classes are not for every student.″* *T18″Passive students are one more challenge in your online teaching <… >″*
	Time management	Managing work and life balance	*T12″Combining household chores with getting ready for online classes add up to tiredness <… >″* *T11″ <… > Work- life balance should be managed as well.″*

Not all students have time management, independent study and self- discipline qualities, and they might not know if they have these features until they start studying online. To tackle the problem, it is advisable to organize the course in such a way that students cover the given material before participating in the online class. If they are not ready, online class will not go properly and that kind of situation will be unpleasant to the unprepared students as well as the students who were prepared. Doing assignments the last minute is not useful to them if they want to achieve fluency in English. One of the ways of avoid this might be to split the independent tasks into a few clusters with a deadline for each set. Unmotivated students may understand the lecture material, but they will not able to apply it in real life. They might pass tests and complete activities, but they are unable to make connections with previous material. To achieve effective learning, students should take care of the quality of their learning. Language teachers should provide them with opportunities to practice course concepts and that will ensure proficiency even after completing their final exam.

Another issue identified by the respondents is connected with the individual character features. It is often the case that quiet students are more of a challenge than loud students. Loud students are very visible and command your attention, while quiet students can quite easily fade into the background and before the lesson is over the student has not said more than two words. This is a problem because even though the student is still getting input, they are not being allowed the opportunity to practise their speaking. While this is problematic in a group class situation, it is even worse in a 1-to-1situation. In a group class, teachers should make use of break out rooms or whatever similar tool your teaching platform has. In a 1-to-1 situation, the key is to embrace the silence. Teachers should not feel the need to fill the silence. They should give their students time to think and formulate what they need to say before they speak as well as provide them with enough scaffolding so that they are capable of producing the language you want. However, some people just do not enjoy studying online, preferring face-to-face lessons.

4.4 Opportunities of Online Teaching

Despite all the challenges of teaching languages online, there are also new opportunities of it.

Let us look at some benefits of learning languages online. Teaching online is not as impersonal as some might believe. With online classes, teachers can teach whereas students can study in the comfort of their home. This creates a friendly atmosphere, and you can establish strong ties and with your students (see Table 4).

The time saving and comfort factor is among the most frequently mentioned advantages of studying online. Teachers and students do not have to commute in case of online teaching, and it’s so much more comfortable for everybody. That makes people happy, which means that online studies are even more attractive to all the participants. The hours of commuting can be spent on preparation for online classes. Educators can even give their lessons if they’re travelling, and so can the students, thus the attendance rates are higher.

The research participants identify that students seem to be more focused online while working on tasks, talking or writing, whereas, in on-campus classes there are lots of distractions that might scatter their attention and then it takes time to focus on the topic

Table 4. Opportunities of online teaching.

Theme IV	Subtheme 1	Sub-theme 2	Meaning unit
Opportunities of online teaching	Better comfortability	Wider range of availability and accessibility	*T17 ″ <… > students are more relaxed than in a classroom.″* *T14 ″ The teachers are more available online than in the classroom <… >.″* *T6 ″ <… > Wider range of easily accessible materials can be offered during online classes.″*
	Enhanced learning	Focus on learning	*T8 ″Greater focus on learning <… >.″* *T21 ″Greater focus on listening comprehension skills <… >.″* *T4 ″ <… > students studying online are more concentrated than in on-campus classes.″*
	Convenience	Time saving	*T7 ″ <… > there is no travel time involved.″* *T11, ″Students can and study wherever they like, as long as there is a good internet connection <… >.″*
	Global Context	Opportunities for global context and collaboration	*T10, □□ <… > there are global resources available for teaching online□□* *T2 □□You can teach and study collaborating with other colleagues and students from other universities or even industries <… >.□□*

[14]. Furthermore, there are a lot of various resources on the internet, and that makes your classes more diverse. Teacher research participants also mention the possibilities to use globally accessible teaching-learning materials which could be successfully used for online teaching and setting homework. They also add the insight that there are instances of collaboration with other colleagues and students from other universities who also seek

for more engagement and versatility in the teaching and learning process. In addition, industries have interest in collaborating with universities and providing instances of teaching and learning sessions online.

5 Conclusions

Since the global lockdown motivates language teachers and students to study foreign languages online, which means that teachers and students must rely on technology to continue their language studies, using global tools and also the engaging collaboration with other universities and industries. Teaching online is a new tendency in ELT, but it is obvious that there is a great demand of it. Teachers do not have to turn away from their personal teaching style, and they can easily adapt it, everything depends on their willingness to use the modern technology and the opportunities that are available. The challenges like need for technological literacy, lack of time or of confidence to use digital equipment, lack of student interaction and self-management skills act as barriers to cause the full potential of online teaching to remain untapped. Teaching students online offers numerous opportunities and challenges. Students have online language classes at home, so they can learn in very comfortable environment. That kind of convenience is really appealing for most people, however, it causes difficulties that can diminish student's potential to study languages. It is crucial that when teachers teach online classes, they should know these issues and the ways to solve them to make sure that the students have the best opportunities of learning English and understanding the information they are learning. All aspects considered, although there are some drawbacks of the online learning environment, there are numerous aspects in which online language learning can be more effective than a classroom lesson.

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Facilitation Within the Scope of Co-creative Educational Projects: Case Study

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Abstract. The following paper describes a recently implemented initiative developed within the scope of the Link Me Up – 1000 ideas project, which aims to promote co-creation, cooperation, innovation and multidisciplinarity in Portuguese Polytechnic Institutions. Focussing on a specific challenge – the need to create inclusive and immersive experiences for 21st century museum goers – and working with an external partner – the Municipality of Vila do Conde – and a team of 5 students stemming from different Institutions and fields, the paper will outline the key design and implementation stages of the project, reflecting on the affordances of the Demola methodology and facilitation within this scope. Drawing on the facilitator's perspective, as well as observation and documentary research, it is divided into 4 main sections: Background, Methods, Project Stages (Discovery, Ideation and Design, Feedback and Validation, and Refinement), followed by a brief conclusion summarizing key project insights and upholding the adoption of collaborative co-creative methodologies in Higher Education.

Keywords: Co-creation · Collaboration · Competencies · Facilitation · Teamwork

1 Introduction

As university-industry collaboration (UIC) and open innovation (OI) are increasingly being perceived as key drivers of innovation [1], there has been a growing interest from stakeholders and policymakers in developing platforms and models that facilitate the development of joint-projects and overall interaction and engagement. Aware of these circumstances and in order to meet this need, in 2021, 13 Portuguese Polytechnic Institutions launched the Link Me Up project, whose key goals were to promote pedagogical innovation and entrepreneurship, through co-creative processes involving multidisciplinary teams and real-world challenges.

Working with Demola, "an open innovation platform and university–business collaboration model for the creation of new products and services" [2], participants

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(faculty members stemming from different polytechnic institutes or affiliated professional/vocational schools) were given specific training on facilitation and innovative collaborative methodologies, aligned with design-thinking approaches, which they would have to apply to specific projects.

Based on these premises, this paper will describe the development of the project "Building immersive and inclusive museum experiences", focussing on the facilitator's perspective as to document its implementation. In addition to offering insights on the collaborative work carried out within a multidisciplinary team, over a period of 8 weeks, it will also discuss the role of the project's partner and reflect on the final outputs, thus reflecting on the potential of co-creation as a driver for innovation, as well as the challenges for facilitators within this scope.

2 Background

Co-creation is often associated with engagement, creativity and the creation of value, involving "interactions through the experiences of individuals" [3], i.e., a shared "process where different stakeholders are involved in the creation of 'the products'" [4]. In educational settings, co-creation strategies are believed to encourage student participation, taking advantage of their intellectual abilities and opinions [5], and their creativity and experience, to produce an innovative product (a prototype, demo or concept) that are aligned with stakeholders' current and future needs. Playing on a relational factor – "almost half of a student's personal development can be explained by the educator-student social relationship, measured by factors such as academic integration, informal faculty relations, and student commitment." [6] – co-creation hinges on the role of facilitators (or process promotors) that continuously support change and "bring people together, participate conversations and share information" [7].

In order to assist co-creation and scaffold the role of facilitators within a "deliberate pedagogical strategy" [8] that can "build sustainable basis and continuity for development" [7], Higher Education Institutions are increasingly resorting to UIC and OI platforms (both private or managed by Public-Private Partnerships) that can provide a "standardized methodology" [9] that supports partnerships, collaboration and overall project management (including contracts, intellectual property rights and output control).

One of these platforms, run by Demola Global, a Finnish company, is currently under service contract by 13 Portuguese Polytechnics as to provide facilitation training to faculty members and support co-creative projects within the Link Me Up network. Based on the OIP concept, the Demola platform and system can be described as a "university-business collaboration model for the creation of new products and services" [2], acting as an operator sustaining project work and communication within the scope of the project. Following a double-diamond methodology "based on divergent and convergent thinking both for the definition and solution of a problem" [10], students are engaged in finding solutions for the challenge set by the partner, working together as to design a solution.

As seen in Fig. 1 [11], in the Demola system, the element at the core of the project is the team (which, in this case, can include up to 6 students from different fields, institutions and levels), which will receive input from academia (not only through facilitators, who supervise the project, but also from experts and researchers who can validate and further support the team's work) and project partners (private or public industry stakeholders).

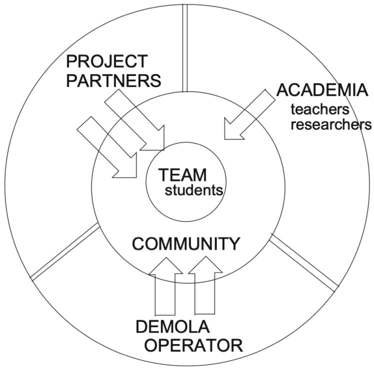

Fig. 1. Flows of communication according to the Demola methodology (in Kilamo T, Hammouda I, Kairamo V, Räsänen P, Saarinen JP (2011, p.308).

Leveraged by the Demola platform and supervised by facilitators, teams are created based on students' interest and motivation, with members signing up voluntarily for the challenges set by companies. Teams will then have 8–10 weeks to work on the challenge, following 3 different stages: Discovery, Ideation and Prototyping and Refine and Packaging, whose outputs will be monitored by the facilitator and discussed with the partner in frequent sessions. In addition to monitoring the process, as "the person who runs the most important events and helps and guides teams" [12], the facilitator, albeit not a member of the team, will provide team members with tools and content, as to support co-creation, as well as be responsible for group dynamics.

Despite their importance within the scope of the project, these key facilitating competencies extend far beyond this particular system, being aligned with what the International Association of Facilitation (IAF) defines as core competencies in its framework, most specifically to: 1) create collaborative client relationships; 2) plan appropriate group processes; 3) create and sustain a participatory environment; 4) guide group to appropriate and useful outcomes; 5) build and maintain professional knowledge; and 6) model positive professional attitude as a process facilitator [13].

Drawing from these competencies and the project stages outlined above, the following sections will focus on describing the facilitator's perspective within a specific project – **"**Building immersive and inclusive museum experiences", reflecting on potential of co-creation in Higher Education, as well as the current challenges to its implementation.

3 Methods

Bearing in mind the outlined objectives, this paper aims to discuss the role of facilitators within the scope of a co-creation project. Empirical and practice-based, this exploratory research employs qualitative methods, based on unstructured participant observation and documentary research, being aligned with the single-case study design approach [14].

Hence, it will address the project **"**Building immersive and inclusive museum experiences" (the case), focussing on a specific unit, most specifically, the role of the facilitator.

In addition to being crosscut with the project's stages (which have been tailored to meet the project's specificities), the description will also take into consideration facilitators' core competencies, as defined by IAF [13].

4 Project Stages

The Demola methodology (based on design thinking and double-diamond methodologies) advocates 3 different stages: Discovery, Ideation and Prototyping and Refine and Packaging, to be framed by different events: a kick-off session, jam I, jam II (progress meetings) and a final meeting [9]. Given the nature of the project described in this paper, most particularly the fact that the partner was a public organization, whose challenge was mostly aspiring (aimed at a future museum) and focused on a set of recommendations (rather than a demo or prototype), the stages described in this section have been slightly adapted, not only as to reflect the project's specificity, but also to better include different spheres of facilitation.

Regarding the role of the facilitator, as mentioned previously, the description will focus on the core competencies defined by the IAF framework, ranging from A1 to F3.

4.1 Discovery, Ideation and Design

The first stage of the project began with a kick-off meeting, in which the partner and team members had the opportunity to meet and discuss the key aspects of the challenge, as well as their mutual expectations. Prior to this meeting, a brief description of the challenge (as designed by the partner) had been made available by the facilitator on the Demola platform as attract potential candidates. In this case, the challenge was to put forward a set of recommendations on how to make a museum (Nautical Arts Centre) more inclusive and immersive, thus appealing to a wider range of audiences.

In addition to this discovery, aiming to make the context and participants known, this stage also focused on developing general ideas and identifying current and future trends. As a result, over a period of four weeks, team members were challenged to identify stakeholders and best practices and to collect data that would allow them to develop general insights on potential target audiences and their needs. In order to collect these insights, the team focused on industry reports, benchmarking, interviews and focus groups as to develop empathy maps and get a better understanding of their needs and expectations.

Considering the role of the facilitator, this stage was instrumental in developing working partnerships (competency A1), both with the students and the partner, as well as establishing each of the participants' roles and level of involvement. Given the fact that team members stemmed from 3 different schools and fields (Hospitality and Tourism, Computer Science and Communication), it was also important to establish common ground and negotiate meeting times. Even though weekly meetings with the partner were to be expected, it was decided to meet on a bi-weekly basis, given the different scheduling constraints. Team meetings, on the other hand, were held every week.

In these meetings, participants would discuss their findings and decide on future tasks. Given the different profiles and varying degrees of interest, it was key that the facilitator engaged participants who had different approaches and ways of processing information (competency B1). This was achieved mostly by resorting to examples (that could illustrate the complementarity of the different fields and approaches) and by scheduling bilateral meetings that would give each participant the opportunity to better explain their point of view.

Notwithstanding, following the initial weeks, when asked to provide feedback on the project in a midterm report (present report), some of the participants voiced their frustration over the need to compromise with the team, expressing their wish to concentrate on their own field of expertise, rather than exploring different alternatives, making it necessary for the facilitator to openly discuss their opinions and manage group conflicts (competency C3). As a result, to foster mutual understanding, participants were asked to work concurrently in two different groups (combining different fields) as it would make it easier to interact and discuss ideas. The team was also encouraged to meet without the presence of the facilitator, as to avoid possible constraints, and to include their findings in shared platforms, to be discussed as a team, rather than submitting standalone proposals (competencies D2 – Guide the group with clear methods and processes; and D3 – Guide the group to consensus and desired outcomes, using a variety of approaches and assessing and communicating group progress).

Still on this phase, following the discovery and preliminary ideation phase, participants narrowed down their scope by refining their targets and started working on design proposals. Focusing on finding future solutions, they were challenged to ask themselves future questions, using a speculative design approach based on two key questions – "What if…? and "How might we…? – to create future personas and make educated guesses as to how to address their needs and meet their expectations.

For the facilitator, this task was particularly challenging, having required practice reflection and learning (E3), as well as the support of the community, i.e., other facilitators and Demola trainers, whose insights were instrumental in overcoming these barriers.

Finally, based on these insights and potential solutions, team members drew up a comprehensive set of recommendations to be discussed with the partner and external experts.

4.2 Feedback and Validation

Based on the ideas and solutions designed in the previous stage, the team was able to schedule two different meetings with experts (an expert in people within the autism spectrum, one of the targets of the project, and with a panel of master students specializing in digitalization and ethics, who could provide feedback on the feasibility of the proposals) as to discuss and validate their solutions. Having taken place online, these sessions made it possible to validate and further refine the initial proposals to be presented both to the partner and to other teams in a joint session (final project pitch).

When it comes to facilitation, this particular stage, though initially not as challenging as the previous (given the fact that the facilitator had a less intervening role, having mostly helped set up the sessions and manage the sessions effectively - competencies A1 and A3), it did prove to be taxing on a personal level, as it required a "trust group potential and model neutrality" (competency F3), which was not easy to achieve. Though not part of the team, given the relational level achieved, it was necessary to maintain a high level of self-awareness and a very objective stance, as to not undermine or question the role of experts nor influence the team's future responses.

4.3 Refinement

In this final stage, the team presented their final recommendations (deliverables) both to the partner (final project meeting) and to their peers (final pitch session with all the teams participating in the network). Regarding facilitation, given the team's autonomy, the facilitator played a mostly supportive role, having been responsible for setting up the final session and commenting on the pitch.

Following this stage, both the facilitator and the team assessed each members' participation in the project based on their curiosity, empathy, optimism and teamwork (peer and self-assessment), with the latter ranking higher than in the initial self-assessment surveys.

5 Final Insights

A joint alliance of different partners (including Higher Education Institutions), Demola is a privately-owned organisation that supports co-creation projects involving students and companies, both at local and international levels. Using its own registered framework and platform (based on design-thinking approaches and acting as an educational crowdsourcing platform) it focuses on solving real-world challenges, enabling forward-thinking strategies that challenge participants to think ahead and challenge their own beliefs.

Hinging on the role of facilitators, to whom it provides specialized training, its core principles lie on UIC and OI, and on enhancing student's role as active partners and agents in co-creative, collaborative processes.

Based on the project described in this paper, even though the method relies on the students' insights and potential, facilitation is perceived as structural to the whole process, in that facilitators help navigate and monitor its different stages, also acting as mediators between the team and the partner. As the project unfolds, however, the role of the facilitator becomes less visible, as the team is expected to become more autonomous and self-reliant. This discretion, does not, however, take away from its importance, rather signaling a shift towards a consultancy role, someone the team trusts and can come to clarify and discuss options, as well as to manage the project.

In terms of core facilitation competencies, as framed by the IAF, developing working partnerships, selecting clear methods and processes that foster open participation and engage participants who have different approaches to learning and ways of processing information and guiding the group to consensus and desired outcomes were highlighted as key throughout the project, as it was necessary to keep participants motivated and make them aware of the importance of multidisciplinarity, complementarity and teamwork.

Neverthless, maintaining a professional standing (particularly when it came to practicing reflection and ongoing learning) and trusting group potential, model neutrality and the experience of others, while keeping an objective, non-judgmental stance, proved to be challenging, making it necessary to rely on training and peer support to avoid potential pitfalls.

All in all, based on the overall experience and final outcomes, the adoption of co-creative strategies and models resorting to specialized facilitation rendered positive results, with participating students and external partners acknowledging its potential and being open to participate in future initiatives.

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TED Talks for Public Speaking Skills and Global Citizenship in ESP Classroom

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Abstract. TED Talks represent an inspiring platform for teaching and learning both public speaking and global citizenship which both represent highly important factors of functioning in our globalized modern society. With the aim to find out whether watching and analysing TED Talks during ESP classes facilitate public speaking skills and global citizenship a questionnaire survey was conducted involving first and second year bachelor students at VilniusTech. This survey showed that a vast majority of students enjoy watching TED Talks and given so many benefits of the TED Talks in terms of facilitating public speaking skills and promoting global citizenship that were strongly supported and illustrated by the survey results, we tend to conclude that TED Talks facilitate public speaking skills and help to foster global citizenship in ESP classroom and we could highly recommend integrating them as a language learning method.

Keywords: Teaching and learning · Public speaking · TED talks · Global citizenship · ESP

1 Introduction

TED Talks with the variety of globally important domains and topics and inspiring examples of public speeches could be used as an effective tool and material for both raising awareness of global citizenship and fostering public speaking skills. Growing world globalization has increased the importance global citizenship discourses in education. The development of the globalized world has affected the global society socially, culturally, economically, politically, environmentally, and technologically. This increased the demand for education to empower learners to be educated as engaged global citizens so that they could understand such factors as globalization, the global economic crisis, the refugee crisis, the climate change challenge and etc. Educating global citizenship has

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become an important part of teaching and learning to increase learners' awareness of the interconnectedness of the world, diverse cultures, and the possible ways of responding to global challenges with the aim of educating create active and responsible global citizens.

Furthermore, public speaking is an oral communication act that incorporates a number of important aspects such as linguistic, psychological, physiological, and cultural. Competence of public-speaking is one of the key factors of professional growth, a strategic skill for obtaining a competitive advantage, trustworthiness, and a solid reputation [1]. Therefore, communication serves a more significant purpose than simply transmitting information. When it comes to influencing listeners, such aspects as the tone, tempo, and speech expressiveness come into foreground. Unfortunately, glossophobia (fear of public speaking), as a kind of anxiety that affects people all over the globe, is one of the hindrances to effective communication [2]. This kind of fear causes communication problems, which have influence on a person's individual, social, and emotional dimensions of life. Lack of speaking experience, a lack of knowledge of the topic, and/or a low self-image are some of the factors that contribute this problem. In today's world, public speaking is a critical component of communication, and academic speaking is a highly relevant skill of students to be discussed and developed. The number of instances in which almost all members of society have to give speeches is growing, and public speech has become one of the criteria by which they are judged as specialists. The educational setting of a higher learning institution not an exception. High schools have fewer oral tests, and their students are not often instructed about eloquence and public speaking, thus public speaking can be a real struggle for a number of university students. Many undergraduates expressed concern about giving a speech in front of an audience. Fear of public speaking is strongly linked to factors such as female gender, unfavourable perception of one's own voice, lack of control of the voice, and lack of participation in public-speaking events. The relevance of being able to talk in public effectively differs depending on the students' study field. For instance, the relevance of this skill for VilniusTech students at such faculties as Architecture, Business Management, Creative Industries, Environmental Engineering, and Mechanics is obvious. The scope of their studies and the nature of their future careers necessitate their ability to talk effectively and eloquently in public, express themselves compellingly, and be very detailed and clear. Nonetheless, numerous students find public speaking to be a difficult task. Some view public speaking as extremely challenging as they have to cope with the fear of standing in front of the audience and maintain eye-contact while interacting with it. They have to master the skill of not only presenting the text, but also analysing it and providing comments. The focus of this study is on students' attitudes toward watching and discussing TED talks within the ESP course in order to improve their public speaking skills and encourage global citizenship. The aim of this research is to examine first and second year bachelor degree VilniusTech's students' attitudes toward the benefits of watching TED talks in English classes for improvement of their public speaking abilities and encouraging global citizenship. The following objectives were defined in order to achieve this aim: 1. To analyse the academic discourse on the concepts of public speaking and global citizenship; 2. To discuss the findings of the survey that shows students' attitude towards the advantages of using TED talks in English classes to develop public speaking skills and foster global citizenship; 3. To discuss the research results and provide insights into the use of TED talks to promote public speaking and global citizenship.

2 Literature Review

The European Union allows the free movement of people to live, work, pay taxes, and even vote in other member states. However, in the philosophical insights it is observed that such a utilitarian model could be applied to exercise greater implications not only for Europeans but also it should be possible to expand the mentioned model in other regions of the world, or even to the entire world for the benefits of people [3]. Still the EU envisioned global citizenship affects the individuals who live and work within transnational norms defying national boundaries and sovereignty among the EU nations. A more wholistic version of the global citizen allowing an individual to choose where you work and live without being tied down to one's land of birth has recently been suggested [4]. Modern life offers a greater number of choices which in its own turn shapes the lifestyle politics, making newly emerging global citizens to be naturally engaged in active global efforts embracing modern business ventures, environmentalism, concern for wars and weapons, health, or immigration problems. Individuals use the communication and organization tools of the Internet to pursue their goals and activities as global citizens. The Internet allows citizens to express themselves in globalized fashion not only tackling the societal concerns but also choosing the clothes to wear, music to listen to and places to visit. Global citizenship is described as getting beyond national boundaries and related to a sense of belonging to a broader community [5, 6]. Similarly, global citizenship is based on the universal values of human rights also including democracy and diversity [7].

The topic of global citizenship has become more important than ever in today's world of globalisation where globally competent citizens actively participate in the processes of global community. Globalisation has brought the topic of global citizenship in education systems worldwide and education readily assumes its role to foster more just, peaceful and tolerant societies [8]. The United Nations Global Education First Initiative identifies the need to promote global citizenship and help learners become part of the larger world context. This encourages education institutions to come up with the ways to teach and learn global citizenship. The need for quality education developing the skills, values and attitudes that enable citizens to respond to local and global challenges is highly stessed [7]. Additionally, the need to develop learners' global competence, involving cognitive, socio-emotional, and civic dispositions as teaching and learning global citizenship can empower learners to engage and assume active roles in global civil society is observed [9].

With regards to public speaking, academic speeches are a subtype of public speeches that are based on specific topics and activity areas of the speaker [10, 11]. Such speeches are usually delivered with the help of some visual aids (such as power point presentations, video extracts, and audio materials). Designing proper visual materials likewise entails application of certain language skills to establish the logical link between the presented visual aid and the delivered speech [12]. Visual aids should not distract from or overwhelm the speech itself, should be clear and readable or audible, should not be too abstract or overloaded with information and should allow the audience to follow the visual aids and the speech in a coherent way. Public speaking is a distinct mode of communication, a specialized spoken form of language, and an organized type of communication. Nonetheless, it differs from communication in that the latter is primarily used for expressing and exchanging information, while public speech is a monologue delivered by a presenter to a pre-arranged audience on a specified topic.

The intricacy of public speaking lies not so much in its planning and development as it does in its direct interaction with the audience [13]. Frequently, the presenter needs not only to prepare for the delivery of the speech and choose the relevant material, but also to be ready to deal with different reactions of the audience. Thus, a thorough planning and development of the speech is only one of the vital aspects of speaking in public, as the direct contact with the audience is not less crucial. Therefore, two phases of the presenter's actions can be differentiated: pre-communicative and communicative [10]. The key component of the pre-communicative phase is one's knowledge of the subject matter and the ability to effectively develop ideas into a logical and coherent speech, meanwhile the communicative phase entails delivery of the speech as such and interaction with the audience and dealing with the feedback. Presenters are most anxious about feedback as they can control the process of looking for information and drafting the text, whereas they cannot control the feedback in the same way. The ability to communicate effectively with any type of audience and excellent skills of dealing with the trickiest questions cannot be mastered easily by simply reading textbooks [14]. One should have a gift of eloquence.

All presenters hope for a positive response and spend a lot of time preparing their speeches, but they are also anxious about failing [15]. Despite the more informative and educational nature of academic speeches, in the sense that they are intended to keep others informed, clarify, prove, or advise, it is important to keep in mind that these speeches, nonetheless, have to arouse interest of the audience and draw its attention. By all means, the style of informative speeches has to be maintained and they have to be clear, consistent, and accurate.

Public speaking skills as a form of communication have to be developed via practice as theoretical knowledge itself will not make one become a competent speaker [1]. Practice has been highlighted as one of the methods for overcoming audience phobia. Yet, the analysis of students' responses reflecting on their feelings when speaking in front of an audience reveals that this element does not boost their self-esteem. Public speaking is related to negative emotions that are the result of anxiety caused by presence of the audience [2]. Apparently, the audience element is relevant indeed as it is the audience that observes and notices all symptoms of anxiety of the speaker. The audience, as the most intimidating component, is present when the speaker starts delivering a speech in public. The condition of individuals who said that it was difficult to breathe is of particular relevance because it reveals the real fear of the audience. Yet, worry and anxiety are higher only when the speaker is getting ready for a public speech and while speaking, however, at the end of the speech most speakers feel relief and this worry disappears [16]. Tension, worry, and anxiety, as well as the desire to avoid the unpleasant situation are what makes people feel tense, and when people feel stress, they usually are unable to think clearly, therefore some information is omitted or not conveyed properly [17, 18]. In these circumstances, a draft of the speech or at the very least an outline could be extremely useful. Even those who said they were anxious before or during the speech, finished it with a sense of fulfilment [19]. As a result, anxiety is generated by the fear of failure, poor performance, or saying something inappropriate, rather than the actual fear of the audience.

The foundation for delivering public speeches is partially based on the verbal activity, however the non-verbal aspect is still crucial, even though it is less evident [20]. These findings indicate that students are worried about giving a speech in front of an audience, and they tend to consider not only the text they have to present but also how they act and appear in front of the audience, thus they tend to use non-verbal communication to enhance the message. In essence, public speaking is a difficult task that requires significant effort. Thus, public speeches are usually delivered only when absolutely essential, such as when presenting research reports. Nonetheless, there are some individuals who would gladly volunteer to speak in front of an audience.

Fear of public speaking is reported by a large number of students. The fear of public speaking is more dominant among females, students who have less practice in speaking to groups, and those who perceive their own voice as either too high-pitched or too soft [21]. Fear of public speaking is a predominant type of anxiety among students of higher education institutions. The majority of students are willing to have public speaking sessions as part of their university education. A great number of students reported fear of public speaking [22].

Oral communication is a crucial component of professional success in the corporate environment. Large enterprises appreciate it and encourage potential employees who, among other things, can speak confidently in front of a group. Public speaking is thought to be an anxiety-inducing factor that causes fear and has an adverse effect on individual success and academic performance. Females are more afraid of speaking in front of an audience than males, as evidenced by earlier studies [23]. Some research show that fear of public speaking is unrelated to gender, ethnicity, or age; yet, it has been linked to females in some cases. The factors of age and being an undergraduate student had no significant correlation with fear of public speaking. We believe that fear of public speaking affects people of all ages and occupations. As literature analysis reveals, extensive experience and mastered ability to manage situations which require public speaking can help reduce negative effects on communication.

3 Methodology

The questionnaire was carried out in spring 2022 among VilniusTech university first and second year bachelor students of the Faculties of Creative Industries, Mechanics, Environmental Engineering, Business Management, and Architecture. 107 respondents participated in the survey. They were presented with a questionnaire and filled it in anonymously online. 15 questions were provided in the survey, associated with the attitude towards the necessity of public speaking skills and the advantages of TED talks to facilitate them. The methods of mathematical calculation and questionnaire survey were used enabling to gather information about the benefits of TED talks to facilitate public speaking skills. The analytical method was used for the purpose of analysis and interpretation of survey findings.

4 Research Results

According to the questionnaire poll, the vast majority of the respondents (92.2%) love watching TED Talks. Only 7.8% of the students indicated that they do not find watching TED Talks enjoyable (see Fig. 1). This question was asked to determine whether students have a favourable or unfavourable attitude to TED Talks. Based on the data that the most respondents expressed their love watching TED Talks we might conclude that they are great for developing public speaking skills and providing good grounds for discussions fostering global citizenship awareness in ESP classes. Students' motivation is more likely to be higher if they find activities and methods used in the learning process enjoyable. This is due to the fact that motivation plays a significant role in teaching-learning process. The success of learning is determined by the motivation of the students [23]. Achievement of educational objectives depends on student motivation, which should be viewed as a core part of effective teaching. This suggests that student motivation is probably the most important element of learning. Learning is fundamentally challenging since it pushes the brain to its limits, which can only occur with strong motivation [24]. Motivation to study is of great importance as mere physical presence of learners in the classroom does not ensure that they have a desire to learn and is only an indicator that learners live in an environment where they must go to school. High student motivation can make any class enjoyable both for students and teachers, whereas low motivation can result in poor student performance and make the study process a source of frustration and anxiety.

Even though the overwhelming majority of the surveyed students enjoy watching TED Talks, most of them watch them only a few times per year (56.4%), and only a small percentage of the respondents (5.1%) watch them out of the academic environment once a week or more frequently. 21.8 percent of the respondents watch them one or two times a month, while 16.7% do so once every two months. When the respondents were asked about the frequency of watching TED Talks outside of the academic environment, it was established that, while they like this activity, they rarely engage in it on their own (see Fig. 1).

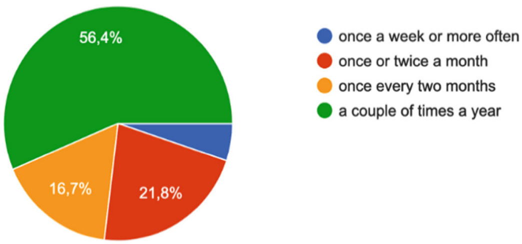

Fig. 1. The frequency of watching TED Talks outside of the academic environment

In terms of the scope of TED Talk themes, the respondents were given a list of topics and inquired about their preferences in watching TED Talks outside of the academic environment. The respondents' most favourite topics are those that are related to entertainment, which made up 51.3% of the responses. The next most popular topics are technology (46.2%), business (38.5%), global issues (34.6%), science (28.2%), and design (19.2%) (see Fig. 2).

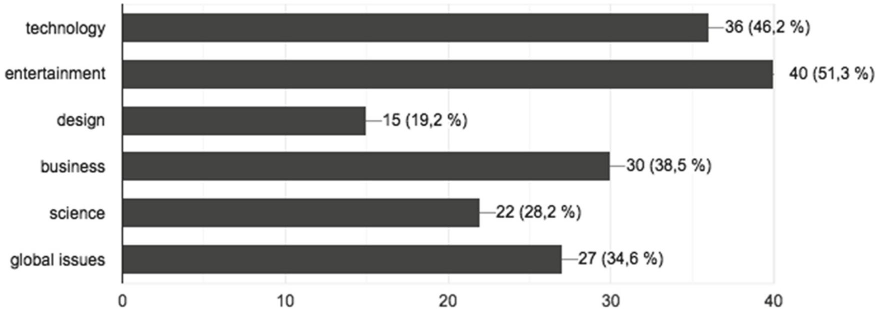

Fig. 2. TED Talk topics chosen to watch outside the academic environment

The diagram on the popularity of topics watched by the students in their free time provides a valuable insight that high percentages of students are interested in technology, business, global issues and science which gives good grounds for involving these topics into the classroom teaching and learning for fostering global citizenship.

The question was asked if students felt that TED Talks and the follow-up class discussions build global citizenship. A vast majority of students (86.8%) agreed with the statement that TED Talks, and the follow-up class discussions build global citizenship, some students were not sure about that (12%), and only a few (1.2%) disagreed.

Following that, the respondents were given a variety of options to evaluate the effectiveness of different types of TED Talk openings in terms of their engagement in the presentation. The most effective opening, according to the respondents, is an inspiring quote, which made up 39.7% of the responses. The other most engaging openings as viewed by the students are a thought-provoking question (26.9%), a personal anecdote (23.1), and a striking visual aid (10.3%) (see Fig. 3).

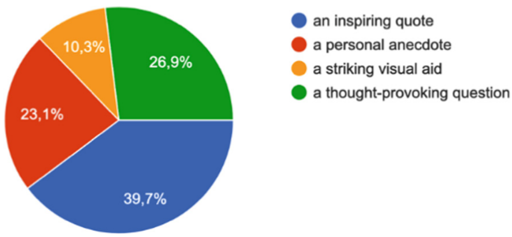

Fig. 3. TED Talk openings considered to be the most effective and engaging in the talk

Another question about the effect of TED Talk openings on the engagement of the audience was added to see if the respondents found TED Talks helpful for improving their public speaking skills in terms of engaging the audience in their talk. In this regard, most of them (80.8%) expressed their agreement with the idea that TED Talks help improve their public speaking skills in terms of engaging the audience. Nevertheless, some respondents (16.7%) were unsure about the statement, and only a few disagreed with it (2.5%) (see Fig. 4).

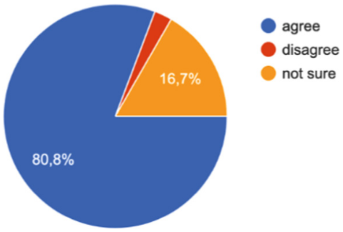

Fig. 4. TED Talks build public speaking skills in terms of how to engage an audience in your talk.

Likewise, a large number of students (78.2%) acknowledged that TED Talks improve their public speaking skills in structuring their talk; nevertheless, some students (17.9%) were unsure about it, and only a handful disagreed with the statement (3.9%).

Yet more respondents (85.9%) agreed that TED Talks help them improve their public speaking skills in terms of presenting visual aids. However, some respondents (11.9%) were unsure about this statement, and only a handful disagreed (2.2%).

The respondents were also asked how often they switched on subtitles while watching TED Talks to learn more about their viewing habits. Responses to this question varied greatly. According to the survey, 36.4% of the respondents always use subtitles when watching TED Talks. A bit smaller number of the respondents (27.3%) often switch on the subtitles, while 16.9% do this sometimes and 19.5% never do that.

While only a relatively small part of the respondents, i.e. less than half, showed strong enthusiasm for constantly switching subtitles on while watching TED Talks, an immence majority (88.5%) acknowledged that watching TED Talks with subtitles on can help them develop their lexicon, with only a small percentage disagreeing.

Similarly, the same number of students (88.5%) agreed with the assertion that watching TED Talks with subtitles on can help them better understand the message of the presentation; again, only a small percentage of students disagreed.

Conversely, there is a wider division of opinions when it comes to the assertion that watching TED Talks with subtitles on will distract one from the core message of the presentation. Almost half of the respondents (46.2%) expressed disagreement with this idea, about one third (34.6%) agreed with it, while and almost a fifth of the students (19.2%) were not sure about it.

Next, the respondents were given one more question related to having subtitles switched on while watching TED Talks and distraction from the visual aids used by the speaker during the presentation. The division of opinions in this case is nearly equal, i.e. 36.4% of the students expressed agreement with the idea that having subtitles on while watching TED Talks can divert their attention away from the visual aids used by the speaker, 35.1% expressed disagreement with the statement, while 28.6% were not sure about it.

In addition, the respondents were given a list of suggestions on how to facilitate public speaking and asked which ones the found most appealing to them. The responses differed greatly in this case. The highest number of the students indicated watching TED Talks (30.8%) as the best tip to facilitate public speaking skills. Studying outstanding public speakers (24.4%) as well as learning a technique how to relax their body language (24.4%) were the second popular choices, while some respondents preferred learning a technique how to practise voice and breath control (12.8%) and recording their own speeches (7.7%) (see Fig. 5).

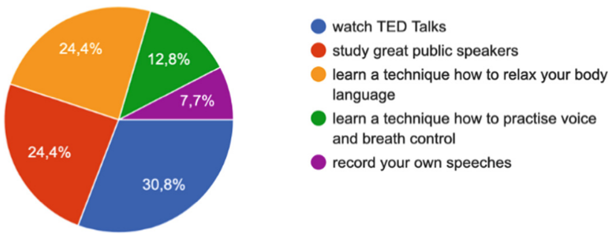

Fig. 5. Public speaking facilitation tips appealing the most

Furthermore, the respondents were asked if TED Talks are effective at improving their public speaking skills in terms of learning how to be more conscious of their body language while giving a presentation. The majority of the respondents expressed agreement with the statement and showed a positive mindset towards using TED Talks in the study process (69.2%), while only a few of them disagreed with the statement (2.6%), and others were unsure about it (28.2%).

The participants were also asked if they believe that we can use TED talks to learn what an effective presentation is like. The responses to this question revealed a significant positive attitude of the students about using TED talks to improve their public speaking skills. An immense majority of the respondents (80.8%) agreed with the idea, 15.4% were not sure about it and only a small number of the respondents disagreed with it (3.8%).

5 Conclusions

To sum up, language teaching and learning could not only show students the complexity of a language but also by exposing them to close-to-real-life situations in a safe, flexible and dynamic environment could be beneficial when improving students' public speaking skills and fostering global citizenship. Public speech is a distinct form of communication and is unique due to its nature which is characterised by speaking in front of the audience, its informative and educational goals, etc. It can raise awareness on various topics important in our modern globalized society and if used as a tool in teaching and learning could help foster global citizenship and raise awareness. One more feature of public speaking is its monologic form mainly aimed at larger audiences. Audience is commonly mentioned as the source of the most anxiety and concern for presenters who are worried about the audience's emotions and attitudes toward the presenter, even when he or she is well acquainted with the listeners. According to a survey of VilniusTech first and second year bachelor degree students, they have a highly positive attitude toward developing public speaking skills and enhancing global citizenship through the use of TED Talks in the study process. Majority of students identified that they are interested and watch TED Talks on such topics as technology, business, global issues, and science in their free time. They also acknowledged that focused topics and the follow-up class discussions build global citizenship. An immense majority of the respondents expressed agreement with the idea that they can learn from TED Talks what an effective presentation is like. TED Talks are extremely handy for developing their public speaking skills in terms of awareness of their body language while delivering a presentation, which adds to their positive attitude towards using TED Talks in classroom. Most of the respondents also agreed that watching TED Talks with subtitles on can help develop their lexicon. In essence, they agreed that TED Talks can help develop their public speaking skills in terms of designing and presenting visual aids to the audience, structuring their presentation, and engaging the audience. As the findings of the study show that an overwhelming majority of the surveyed students enjoy watching TED Talks and there are numerous advantages of using TED Talks in terms of developing students' public speaking skills and fostering global citizenship, as strongly supported by the survey data, we assume that TED Talks do help to improve students' public speaking skills in language classroom, thus we strongly recommend using them as a teaching tool which also builds global citizenship.

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Facilitating Online Collaboration – A Training Proposal for Teachers

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Abstract. Focusing on the need to upskill educators' professional and pedagogical competences and on the ongoing challenges raised by digitalization and digitally-enhanced collaborative communication and learning, the following paper outlines the key outputs of EDUdig, an Erasmus + project currently underway. Operating on the European Framework for the Digital Competence of Educators (DigComEdu) this project aims to contribute with practical content, including didactical concepts for online lectures, e-learning tools and recommendations, as to foster the development of the educators' professional and pedagogical competences, with particular emphasis on the structure defined for the online course – i.e., "Facilitating online collaboration". In addition to putting forward the project's background and overall goals and describing the rationale behind the course, the authors establish the key role of collaborative learning within this scope, emphasizing the importance of peer learning and communities of practice based on training, sharing and joint-reflection processes to anchor pedagogical transformation.

Keywords: EDUdig · DigCompEdu · Collaboration · Online course

1 Introduction

In recent years, the sudden and inevitable shift from face-to-face to online teaching and learning, in all education levels, required many changes on the part of teachers and learners. In fact, the circumstances that emerged from COVID19 lock-down have raised a series of constraints and concerns to all those involved, in particular to those with very basic digital competences. On the one hand, these had to quickly cope with the use of digital tools to be able to interact; in many cases, skipping several steps/levels in the development of this competence. On the other hand, others that were able to handle digital tools, lacked the needed pedagogical training to structure and provide meaningful digital learning experiences. In the scope of Higher Education (HE), this is faced as an opportunity to develop digital and pedagogical updating and upskilling for teachers, learners and staff.

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In this scenario, the ERASMUS + project EDUdig – Enhancing the development of the educators' digital competencies (ref. 2020–1-AT01-KA226-HE-092677)[1] is being developed, based on DigCompEdu framework [1]. Given that the latter is a holistic framework, it is not always easy for educators to use to find out where they stand regarding their digital competences or to find relevant resources to improve them. Thus, the goal of this project is to complement the DigCompEdu framework with concrete examples and content, to develop an online course on selected levels and to establish an e-teaching manual for self-paced learning. Hence, the main goal of this work is to outline EDUdig's main contribution to foster the development of the educators' professional and pedagogic competences, with particular emphasis on the structure defined for the online course – i.e. "Facilitating online collaboration".

2 EDUdig – Enhancing the Development of the Educators' Digital Competences

EDUdig is an Erasmus + project that involves 4 partners with different backgrounds, i.e., the University of Applied Sciences Upper Austria (FH OÖ, Austria, coordinator), the University of Aveiro (UA, Portugal), Laurea University of Applied Sciences (LAUREA, Finland) and Stiftung Evaluationsagentur Baden-Württemberg (EVALAG, Germany) (see footnote 1). As above mentioned, the DigCompEdu framework [1] was the starting point to this project. This document, which addresses the educators' professional and pedagogical competences, as well as the learners' competences, establishes 22 digital competences organized in six areas, i.e., professional engagement, digital resources, teaching and learning, assessment, empowering learners and facilitating learners' digital competence, as presented below (see Fig. 1).

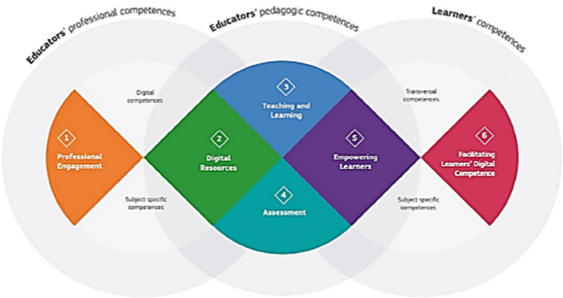

Fig. 1. DigCompEdu areas and scope [1:15].

These competences include a list of activities that are formulated as examples for what each competence covers, "However, this list is not exhaustive: it illustrates the focus and scope of the competence, without delimiting it" [1:27]. Although relevant, these activities do not provide educators with practical resources to support them in

[1] See EDUdig homepage, https://edudig.eu/?page_id=62.

developing their digital competences. Thus, in EDUdig, three different outputs were defined to enhance and augment the DigCompEdu framework, so it can function as a practical, useful resource for educators willing to increase their digital competences, namely: i) a collection of content (curricular plan), an online course, and a e-teaching handbook for self-paced learning.

As to the first, it encompasses the collection of content for all the 6 areas of the framework, which will be available online in the projects' web page, so that any educator, independent their digital competencies, can access, explore, and use according to their personal needs. Based on this first output, the consortium is now developing an online course, focused on the educators' pedagogical competences and which will set grounds for the development of an e-teaching handbook for self-paced learning. These e-manuals will be available on EDUdig's web page to enable educators from other institutions to independently improve their digital competences.

Being the full online course one of the central pieces in EDUdig, the first step was to define a topic, flexible enough to crosscut the educators' pedagogical competences defined in the DigCompEdu framework [1] – i.e., digital resources, teaching and learning, assessment and empowering learners –, but also to promote professional engagement (area 1) and facilitate the learners' digital competence (area 6) (see Fig. 1). Having this in mind, partners jointly agreed that it was increasingly relevant to comprehensively address the promotion of active learning approaches and, in the scope of this project, it would crosscut 'digital communication' and 'online collaborative learning', as explained below.

3 Collaborative Learning

In collaborative learning, learners are urged to work with their peers, contributing to the discussion of solutions with their ideas and listening to and reflecting upon other viewpoints and articulating their points, to get a more comprehensive understanding than they could individually [2]. Thus, learners assume a more active and constructive role and build new shared knowledge based on sharing experiences and responsibility [3].

Collaborative learning has been growing in several HE as an active learning method not only because it mirrors the working contexts, but also because it may enhance learner-centered learning. In this scenario, there is a shift in the role of educators, i.e., rather than being the center of learning they must guide the groups helping learners achieve their learning outcomes through collaboration. Educators become facilitators and learners contribute actively to the construction of collective and their individual knowledge [4]. Nevertheless, online facilitation of collaborative learning can be challenging, not only from the pedagogical but also from the technological point of view [5]. In other words, it may be challenging to design a learning strategy that is to be developed and facilitated using digital tools, in particular because digital technology is evolving at a fast pace.

Having in mind the concepts of 'digital communication' and 'online collaborative learning', and the issues they may raise for teachers, the topic defined for the online course was "Facilitating Collaborative Learning", with the following learning outcomes: i) to identify and describe pedagogical approaches that promote collaborative learning; ii) to analyse and select facilitation methods to promote and support collaborative learning;

iii) to design digitally-enhanced activities to facilitate collaborative learning. This was the basis to design the course structure, presented in the next section.

3.1 Facilitating Online Collaboration – Online Course

This course is designed for a total workload of about 27h (1 ECTS) and encompasses an estimated amount of 15h of synchronous work and 12h of asynchronous work. As presented in Fig. 2, the course will start with a presentation of several topics that will anchor the pedagogical transformation, followed by the exploration of digitally-enhanced activities, including digital tools and resources. In the end, the goal is for trainees to have a plan to implement pedagogical transformation in the scope of a subject that they are responsible for.

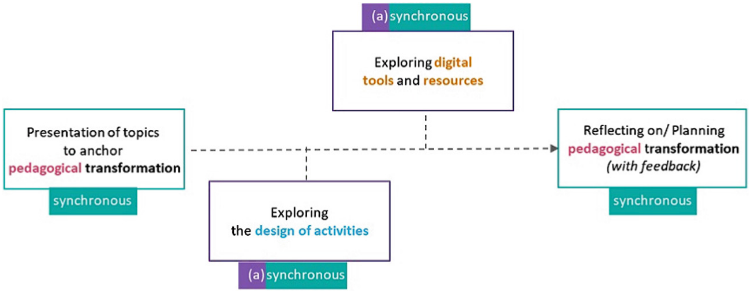

Fig. 2. Facilitating online collaboration – course structure.

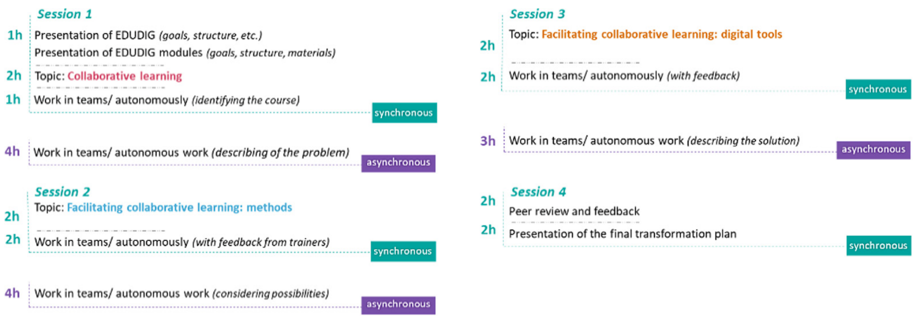

Fig. 3. Facilitating online collaboration – course plan.

As to its operationalization, this course will have synchronous and asynchronous moments, offering flexibility to work in groups. In the first synchronous session (Session 1, see Fig. 3) will focus on the clarification of important aspects/concepts to anchor the design digitally-enhanced collaborative learning strategies, including case studies/ examples. Afterwards, trainees will be given the opportunity to organise in groups/teams to explore and discuss resources actively and to identify a course/subject on which they will work in terms of pedagogical transformation. Afterwards, trainees will be invited to describe (in detail) how they are going to include collaborative learning in the selected course/subject (individual, asynchronous work).

The second synchronous moment (Session 2, see Fig. 3) is focused on facilitation methods and trainees will be challenged to find solutions/methods for the facilitation of collaborative learning in their courses and will receive feedback from the trainers, including potential constraints and potentialities of the selected solution.

The third synchronous moment (Session 3, see Fig. 3) the main goal is to present different digital tools and discuss advantages and potential disadvantages of their use in the scope of the solutions found in the previous sessions. Thus, in the following asynchronous moment trainees will be asked to specify and justify their selection of digital tools. Finally, in the last synchronous session (Session 4, see Fig. 3), trainees will be asked to share and present their pedagogical transformation plan; thus, benefiting from peer review and feedback to refine their work.

4 Final Considerations

The main goal of the EDUdig project is to enhance and augment the DigCompEdu framework with open educational resources that will be in open access. The outputs of EDUdig project – i.e., content collection, the online course and e-teaching handbook for self-paced learning – are meant to provide DigCompEdu framework with more concrete resources to allow educators to further develop their professional and pedagogical digital competences, always considering the development of the learner's digital competences.

Summing up, the proposed structure aims at promoting digitally-enhanced collaboration between educators themselves to share and discuss pedagogical solutions and the topic selected for the online course also serves the purpose of leading educators to promote digitally-enhanced collaborative learning. This may lead educators to delve deeper into pedagogical issues, and, given that collaborative learning is socially and intellectually tangled, it may also help them to prepare learners better for real working contexts.

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Drifts of Collaborative Online International Learning (COIL) Towards Pedagogical Innovation: A Foretelling Bibliometric Analysis

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Abstract. In the current global world, and also due to the CoVID-19 pandemic and the evolving digital technologies, education is changing faster and more dramatically now than at any time in history. In this context, education is drifting away from the traditional approaches and into the integration of international, intercultural and global dimensions in higher education, vocational education and training, as well as in secondary education. Thus, the purpose of this exploratory study is to unveil current trends and future needs of research and practice focused on Collaborative Online International Learning (COIL), to set conceptual foundations for further pedagogical innovation. Following the PRISMA 2020 statement, the *corpus* of the study integrates a final set of research studies (n = 135), published between 2019–2022. Considering the main key-terms of recent literature in the area, the collected data were analyzed by means of a bibliometric analysis, using VOSviewer's network and overlay visualization of most frequent terms.

Keywords: Internationalization of the curriculum · COIL · Pedagogical innovation

1 Introduction

In the current global world, and also due to the CoVID-19 pandemic and the evolving digital technologies, education is changing faster and more dramatically now than at any time in history. In this scenario, internationalization is being widely discussed, in particular as regards to studying abroad, internationally minded social opportunities, international student recruitment, inclusion of foreign language study, etc. [1]. Moreover, several EU cooperation initiatives in the scope of education and training (e.g., ET 2020[1]) underline the need for improving inclusion and mobility, as well as supporting the green and digital transitions in and through higher education, vocational education and training, as well as in secondary education [2].

In fact, internationalization relatively broad, and varied phenomenon in the educational setting in which light is being shed. As de Wit and Altbach [3:28] mention:

[1] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:ef0016.

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> The European Commission, international organizations such as OECD, UNESCO, and the World Bank, national governments, as well as higher education organizations such as the International Association of Universities (IAU) and the European Universities Association (EUA), gradually placed internationalization at the top of the reform agenda.

Having this in mind, the purpose of this study is to unpack current tendencies and prospect future needs of COIL-based research and practice, considering the main key-terms of recent literature in the area, by means of a bibliometric analysis.

2 Background

Internationalization in education has been materializing in various ways, including mobility of students, teachers, scholars, programs, courses, curriculum and projects. Traditionally, internationalization abroad (IA) was the most common option in Europe and it implies "a geographic relocation of students from one country to another country for the purpose of education" [1:267]. However, it was not open to all because of a myriad of personal, logistical, and/or financial reasons. Some authors argue that internationalizations at a distance (IaD) is also a relevant possibility to reach a broader target audience, given it refers to "all forms of education across borders where students, their respective staff, and institutional provisions are separated by geographical distance and supported by [digital] technology." [1:269].

Even though, in the past, IA was often the only possibility considered for educational purposes, internationalization at home (IaH) began to gain ground, given that it allows for physical interaction between nationalities 'at home', to develop international and intercultural competences in all participants without having to go 'abroad'. As Beelen and Leask [4:64] underline, "If a broad concept of 'culture' is accepted (…), then every classroom has a diverse range of students. This can be the basis for exploration of the international and intercultural dimensions of the curriculum, whether or not international students are present". Hence, IaH should not be understood as a didactic approach in itself, but rather as a "the purposeful integration of international and intercultural dimensions into the formal and informal curriculum for all students, within domestic learning environments" [[4]:69].

More recently, a different approach to internationalization is gaining momentum – i.e., internationalization of the curriculum (IoC), which Leask [5:9] defines as "the incorporation of international, intercultural and/or global dimensions into the content of the curriculum as well as the learning outcomes, assessment tasks, teaching methods and support services of a program of study". In this matter, it is important to underline "the active engagement of students in the learning process and, through this, the systematic and purposeful development of international and intercultural learning out-comes in all students" [6:50].

By concentrating on the formal educational environment and on the incorporation of international and intercultural dimensions into the *curriculum*, pedagogy and learning outcomes within technology-enhanced contexts [4], internationalization of the curriculum sets grounds to promote more equity for students, teachers and staff without mobility.

Bearing this in mind, this approach to internationalization (IoC) may also stand as an important means to meet the United Nation's Sustainable Development Goal (SDG4) on Quality Education, and in particular SDG4.7. – which aims to "ensure that all learners acquire the knowledge and skills needed to promote (…) a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development"[2].

Besides, in terms of added-value of internationalization of the curriculum, in the words of Leask and Gree [7], Jones and de Wit [8:91] emphasise that:

> [Internationalisation of the curriculum] represents a rich opportunity for global learning at home, as online learning can open up the possibility of 'border crossing' for all students. Programmes such as Collaborative Online International Learning and virtual internships, combined with meaningful intercultural learning encounters on campus and in local communities, offer exciting potential to engage all students in meaningful intercultural learning on a global scale. The post-mobility world will allow for international partnerships to change from exporting education to collaborative models that use multinational expertise and situate education locally, while still building meaningful connections across borders and cultures.

In this work, the focus is on collaborative online international learning (COIL) as a possible approach to operationalize internationalization at home. COIL was first developed by the State University of New York (SUNY) COIL Center[3] and based on the use of information and communication technology to develop international learning experiences; thus, opening up the opportunity for a wider participation in academic mobility programs, which usually demanded geographical displacement. With COIL the learning environment crosscuts different nationalities (cultures!), in which students are given the opportunity to develop online collaborative learning, including intercultural and digital competences with international peers and combines virtual learning facets, namely: the collaboration of teachers and students, the use of digital technology for interaction and communication, and the integration of the internationalization layer into the curriculum [9]. Alvarez and Seiner [10:20] also underline that "COIL is a complex academic organization that has to be clearly thought through before starting its implementation. Using a COIL format changes the method of teaching, and requires technological input too".

In general terms, the development of a COIL project is rooted in the following: i) two or more nationalities collaborate in the design of the curriculum and are jointly liable for the teaching and learning strategies to be used, ii) students from the institutions involved must work online in teams to complete assignments, iii) the students learning process and product(s), based on their online international collaboration, must be formally considered in the students assessment [11], and iv) special attention should be paid to the integrated development of intercultural, communication and digital competences.

From the operational viewpoint, it is relevant to stress that the duration of these projects results from the negotiation between the parties involved and this joint venture

[2] Retrived from https://www.sdg4education2030.org/the-goal.

[3] See https://coil.suny.edu/.

can be of mono- or multidisciplinary nature and focused on any discipline(s)/area(s) – which are perceived as great advantages of this approach to the internationalization of the curriculum.

3 Methodology

This is an exploratory and descriptive study of scientific publications, in the scope of a bibliometric analysis, which is based on quantitative analysis to measure the interrelationships and impacts of publications within a given area of research. Drawing on descriptive publication data (author, work title, keywords, abstracts, etc.), as well as text mining techniques, the bibliometric similitude maps that can be generated allow for identifying research topics and future research directions [12, 13]. Several authors recognize that, in recent years, "bibliometric analysis has gained traction as an approach to reviewing educational research" [14:624].

Grounded in a keyword search method, this study the bibliometric analysis methodology is used to provide direction for research and practice. Thus, keyword search allows for scanning the co-occurrence of keywords in specific areas of research works – e.g., title, abstract, keywords, etc.

In this study, the key-term used was 'collaborative online international learning' and the databases selected to conduct the search were: Web of Science, Elsevier, Scopus and Sage. In what concerns selection criteria, the works had to be published between 2019 – 2022, be peer-reviewed articles published in a journal or conference proceedings and include abstract and keywords in English.

The initial search was undertaken on 14 January 2022 and yielded 162 documents. The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Liberati et al., 2009) was used to search for and screen documents, as presented below in Fig. 1.

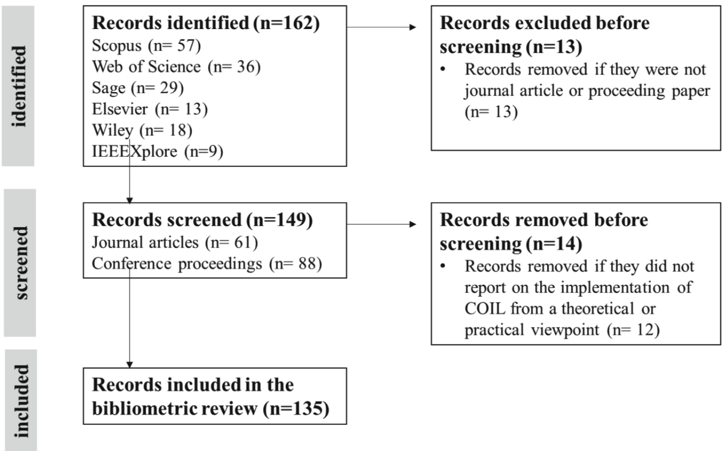

Fig. 1. PRISMA flowchart: document search and screening.

The 135 documents included in this study were analyzed resorting to the co-occurrence of keywords, which is considered a content analysis technique that allows for visualizing relations between the terms that appear most frequently in a *corpus*; thus, enabling the construction of conceptual inferences in a given domain [16]. The bibliometric similitude maps were based on text mining, afforded by VOSviewer, to analyze research patterns. Moreover, in a first analysis of the results, besides the references to geographical location of the studies, the terms "COVID", "pandemic" and "coronavirus disease" were also excluded, given that most works were published in this scenario.

4 Analysis of the Visualization Maps

A first analysis of the results, obtained using VOSviewer clusterization technique, allows for the identification of four closely interconnected clusters – the more prominent being "Education" with higher number of occurrences (n = 44) and number of links with other items (n = 36). VOSviewer analysis yielded 3 other clusters, namely: "Activity" (no. of occurrences = 21; no. of links = 24), "Internationalization" (no. of occurrences = 16; no. of links = 27) and "Groupwork" (no. of occurrences = 14; no. of links = 24), as presented in Fig. 2.

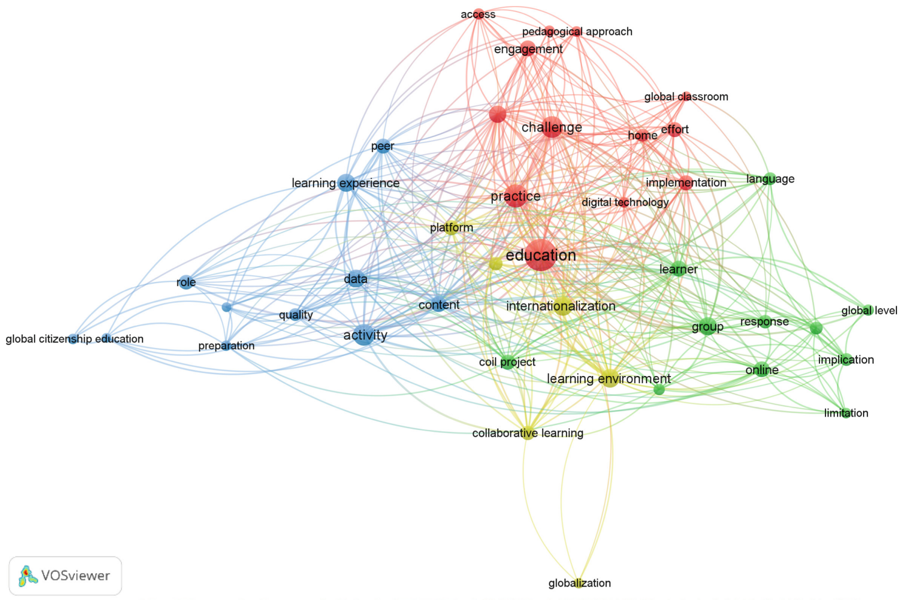

Fig. 2. Network visualization of most frequent terms (Constructed via VOSViewer v.1.6.10 for the sample N = 135, f (frequency) > 5).

By being a comprehensive cluster, "Education" is more strongly linked with 13 other items. As presented in Fig. 3, "practice" and "challenge" stand out in this set with a similar weight, which may be evidencing the concerns that researchers have been having with the hurdles posed by the operational aspect of the COIL projects. This is probably because proficiency in the use of "digital technology" required for the design and "implementation" of innovative "pedagogical approaches", trying to ensure the "engagement" of participants. In this matter, and as evidenced in the visualization map presented in Fig. 3, the "effort" also seems to be greater when it comes to bringing the "global classroom" to domestic context ("home"). Moreover, COIL is also presented as an opportunity to ensure "access" to international "learning experience" based on "peer"-to-peer interaction/collaboration, which allows for the inclusion of a wider diversity of participants, especially those that are usually deprived of international mobility and, at the same time, incorporating a greener design for collaborative international learning.

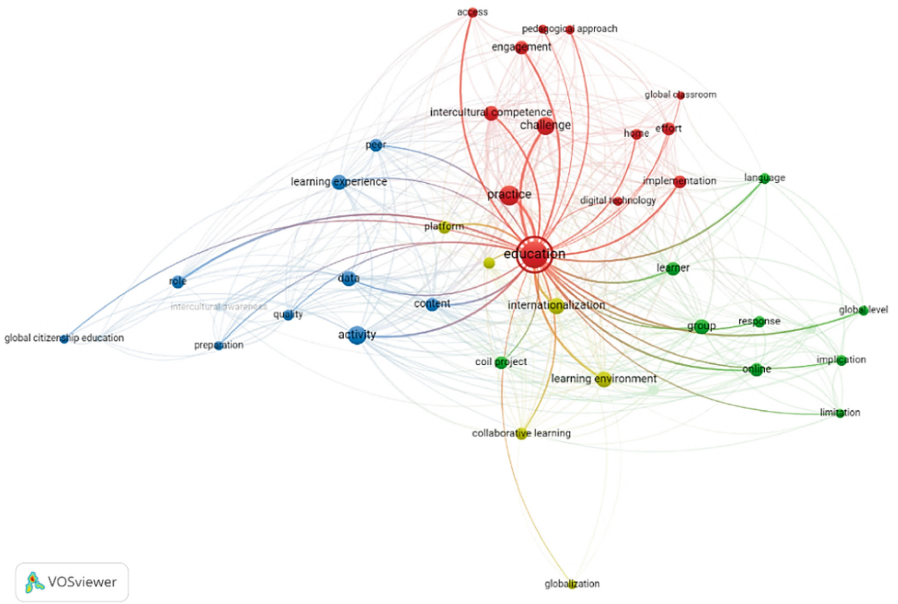

Fig. 3. Network visualization of most frequent terms – zoom in on "Education" link strength.

At the European level, it is increasingly stressed the importance to promote innovation through the integration of ubiquitous (anytime and anywhere) teaching/learning strategies and resources to endorse on collaborative international teamwork. Thus, given that COIL is fully built on the relevance of developing collaborative learning within international teams, in this case through digital means, it is logical that the results of the bibliometric analysis also yield Cluster 2 – "Groupwork", grounded on the relevance on the items "learner" and "group". In fact, the item "group" has 14 occurrences and 24 links and the item "learner" has 11 occurrences and 25 links. If VOSviewer would allow for a merge of these nodes, it would result in about 25 occurrences and 49 links, clearly showing the relevance of the topic.

In this cluster, "virtual collaboration", on the one hand, is organically linked to "online" environment, stressing out the possibilities that it opens take the students education to a "global level". On the other hand, "virtual collaboration", as well as "language" are also directly linked to the items "implication" and "limitation", probably highlighting the constraints that educational stakeholders may encounter in this modality (i.e., from technical issues to low language proficiency or to conflict management). In line with this, another link of the item "group" also crosscuts the node "challenge" and interlinks it with "intercultural competence", which may be underlining the complexity of defining activities/tasks that clearly address the development (and assessment) of transversal competences (see Fig. 4).

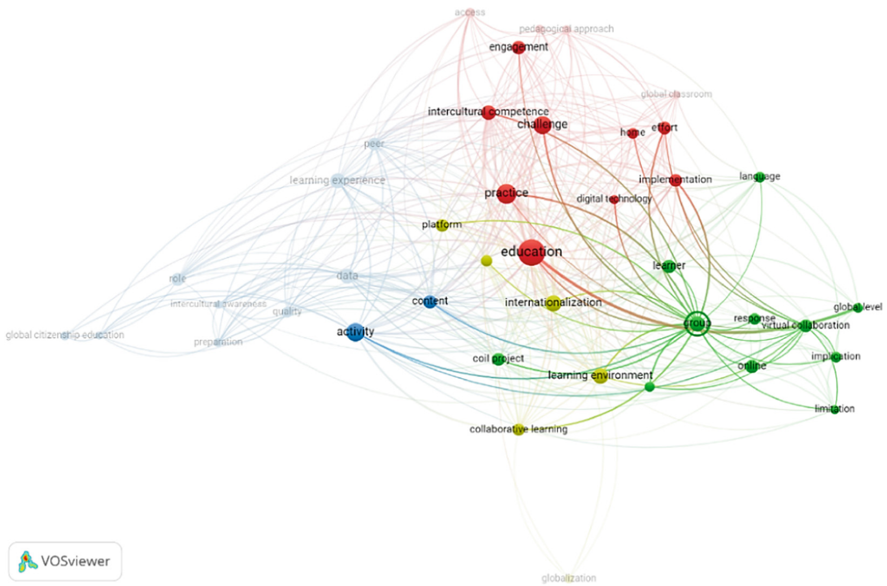

Fig. 4. Network visualization of most frequent terms – zoom in on "Group" link strength.

Concerning Custer 3 – "Activity", as presented in Fig. 5, the items with more visibility are "learning experience" and "data", with 14 occurrences and about 24 links each. Nevertheless, only the former is directly linked with the core item of this cluster ("activity"). The item "preparation" has a similar behavior, given that it links to the "activity" mainly through the items "content" and "learning experience". In fact, the stronger link of "preparation" is "data", which may the need anticipate data collection procedures to ensure the "quality" of the "learning experience". Furthermore, it also assumes considerable relevance in direct connection with "intercultural awareness" and "global citizenship education", which are two increasingly relevant concepts – for instance, considering the United Nation's SDG4.

Finally, regarding Cluster 4 – "Internationalization", even though its items are strongly interconnected with the other 3 clusters, the most noticeable one is "learning environment", with 15 occurrences and 30 links (see Fig. 6). Furthermore, it bridges "globalization" and "education" through "collaborative learning", supported by digital

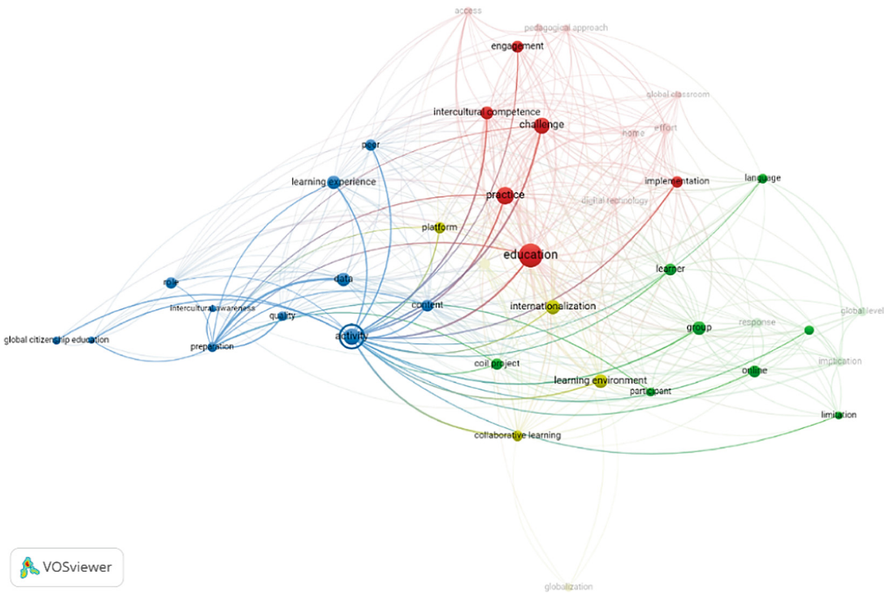

Fig. 5. Network visualization of most frequent terms – zoom in on "Activity" link strength.

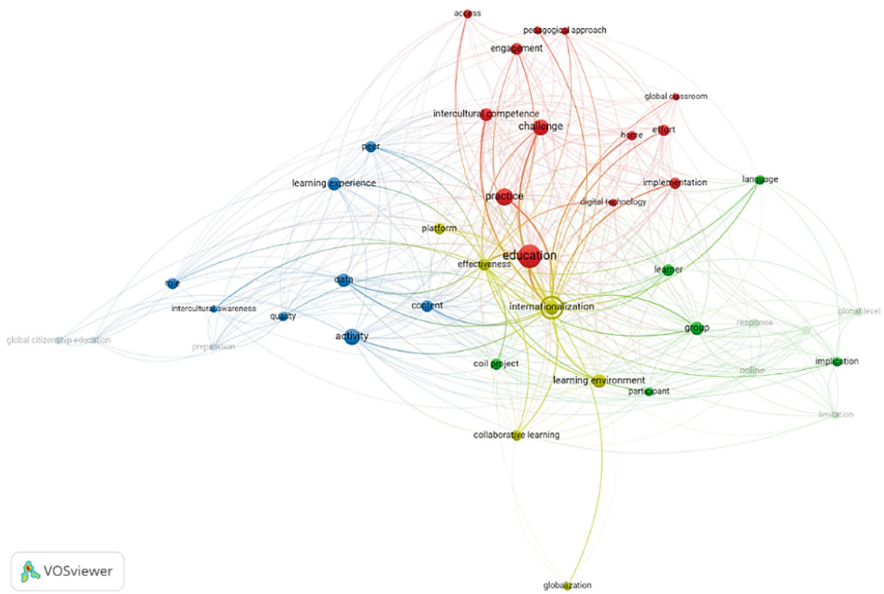

Fig. 6. Network visualization of most frequent terms – zoom in on "Internationalization" link strength.

"platforms", which seems to be an "effective" means to collect "data" and interact with "content" in "COIL projects" (see Fig. 6).

It may also be important to shed light on the results from a different point of view, i.e. through the lens of an overlay visualization to look at the item drifts over time (in this case, 2019 – 2022), as presented in Fig. 7.

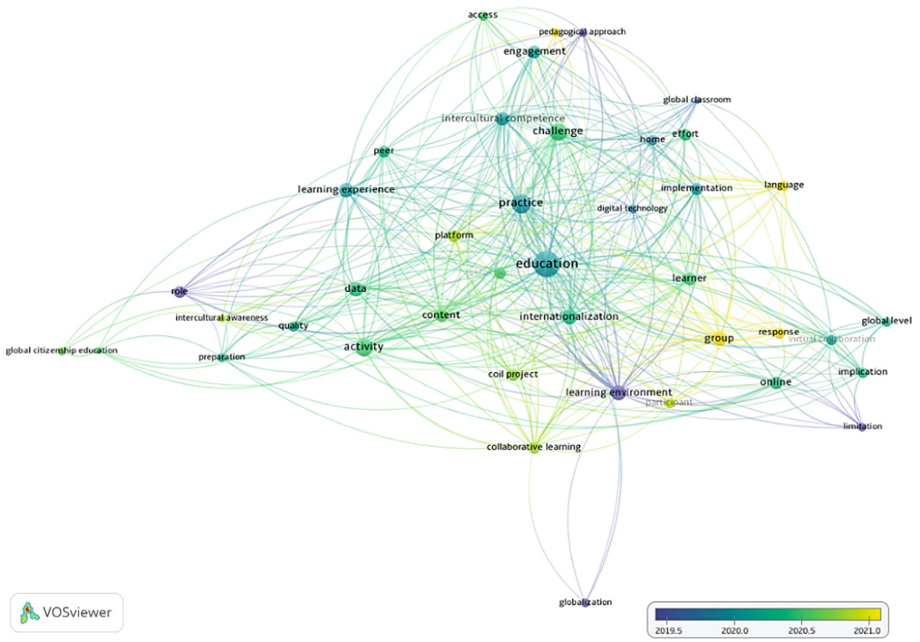

Fig. 7. Overlay visualization of most frequent terms (Constructed via VOSViewer v.1.6.10 for the sample N = 135, f (frequency) > 5), where the score of the item is time since publication.

Bearing in mind that the core term in this work is COIL, it is revealing that:

- in the first half of 2019, the most prominent items in the *corpus* were "learning environment" (no. of occurrences = 15) and "role" (no. of occurrences = 10), followed by "pedagogical approach", "limitation" and "globalization" (no. of occurrences = 5); and in the second half were: "education" (no. of occurrences = 44), "practice" (no. of occurrences = 24), "learning experience" (no. of occurrences = 14), "engagement" (no. of occurrences = 11);
- in the first half of 2020, there was a shift towards "activity" (no. of occurrences = 21) and "challenge" (no. of occurrences = 20), followed by "data" (no. of occurrences = 14), "intercultural competence" (no. of occurrences = 13) and, and "internationalization" (no. of occurrences = 10); and, in the second half, towards "COIL project" and "platform" (no. of occurrences = 10 each), followed by "collaborative learning" (no. of occurrences = 9) and "effectiveness" (no. of occurrences = 8);
- in 2021, the focus was "group" (no. of occurrences = 14), "response" (no. of occurrences = 8), and "language" (no. of occurrences = 7).

5 Final Considerations

In this study, 135 works, published between 2019 and 2022, were identified and analyzed. Based on a keyword co-occurrence analysis, it was possible to classify the findings on COIL-related research into four key hotspots – i.e. education, groupwork, activity and internationalization.

This exploratory study indicates that, in terms of commonalities, the 4 cluster intersect and the converging items are foreseen as key research topics that may provide guidance play significant roles in future research. In other words, four strings were identified based on the commonalities (i.e., common items) to the clusters considered, namely the focus on: the challenges of COIL practice with a special focus on learner engagement (Cluster 1), the significance of language competence in the development of COIL projects (Cluster 2), the role of content in activity design (Cluster 3), and the development of collaborative learning in online international learning environments (Cluster 4).

In terms of further work, the aim is to broaden the scope of this work including more comprehensive databases, such as Google Scholar or Semantic Scholar to confirm these results.

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Strategic Alignment of Knowledge Management Systems

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Abstract. Managing company knowledge and using it effectively is more than ever a strong competitive advantage in the business world. The scientific area of knowledge management and knowledge management systems have been intensively studied in the last years; however, we still see the unstructured implementation of knowledge management systems in organizations, the misalignment of knowledge management systems from the business model and the frustration non-use, lack of systems integration and/ or non-return on investment made either in technology or spent on heavy implementation processes. The state-of-the-art conducted during this study, showed that most knowledge management systems alignment models in the business context have a strong focus on the organizational dimension, e.g., culture, organizational processes, organizational structure, and leadership, having been identified only three models that also cover, simultaneous, the technological and strategic dimension. Our final objective in this study is, following the research survey methodology, to develop a proposed framework for the strategic alignment of knowledge management systems that can support company managers in their decision-making, and to contribute to the development of scientific knowledge in this area.

Keywords: Knowledge management · Knowledge management systems · Learning content management systems · Corporate strategy · Business context

1 Introduction

Organizational knowledge management remains on the strategic agenda and is critical for organizations [1]. In the contemporary business environment, managers increasingly recognize that the ability to create (or acquire), retain, store, protect, disseminate, and reuse knowledge is crucial to gain a competitive advantage for the organization [2, 3]. Knowledge management (KM) emerged as a discipline that aims to enable organization members to acquire, share and collectively leverage knowledge to achieve business objectives [2, 4]. Alavi and Leidner [5] highlighted that it is not often the lack of knowledge that hinders organizational performance, but the lack of ability to transform knowledge into effective action. Several factors, related to individual characteristics, process design, systems, and organizational culture, can contribute to individuals not applying

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the knowledge they obtain in their activities in the workplace [6, 7]. The authors then suggest that an important but lacking area of knowledge management research would encompass "the identification of these factors and the development of organizational practices and systems to fill the knowledge application gap".

Knowledge management systems are a system, or set of information systems, applied to manage organizational knowledge, supporting, and improving the organizational process of creation, storage/ retrieval, transfer, and application of knowledge [5]. This type of information systems has as main objective to facilitate the sharing and integration of knowledge.

For the implementation of knowledge management systems, the organization requires a significant number of arrangements. If the process is not adequate, it will not only make the knowledge management system inefficient and unprofitable, but it will also incur harmful effects for the organization [8]. According to Frost [9], failure factors in the implementation of knowledge management systems include the lack of performance indicators and measurable benefits, inadequate management support, inadequate planning, design, coordination and evaluation, inadequate skill of managers and users and organizational culture.

The development of e-Learning has made it possible to sustain knowledge management systems in organizations. e-Learning and e-Knowledge are just two sides of the same coin, whose objective is to manage something that has a high value for the organization – the skills of employees. "Knowledge is information that gains value in interaction with intellectual capital. The same is to say that it gains value after being processed by the collaborators. Therefore, we cannot dissociate online training from knowledge management" [10].

In this context, this study aims to (1) understand how organizations position knowledge management in their corporate strategy; knowing the importance of the strategic alignment of knowledge management systems for the performance of organizations, (2) identify and understand what support models are available, (3) based on this study and after the identification of the gaps, to propose a conceptual framework for the strategic alignment of knowledge management system in the companies, which can be used by managers of the relevant areas in the organization.

To this end, and as a starting point, we carried out a Systematic Literature Review based on two research questions, the first, to understand how companies position training and knowledge management in defining their corporate strategy, and the second, to identify the current models that support the strategic alignment of knowledge management systems or learning content management systems in the business context and understand the current gaps.

2 Theoretical Background Foundations

2.1 Knowledge Management

Knowledge management (KM) terminology has become more relevant with Wiig [11], defining knowledge management as a systematic, explicit, and deliberate construction, renewal, and application of knowledge to maximize an organization's knowledge-related effectiveness and return on investment. According to Wilson [12], knowledge management is used synonymously with information management for the "management of work practices" that aim to improve knowledge sharing in an organization. Knowledge management is predominantly a construction of organizational science. However, knowledge management also has a strong link with business strategy. The referred benefits of knowledge management are to quote where considerable thought has been given to how good knowledge management practices can improve the competitiveness and financial performance of companies and how this can be measured [13]. Knowledge management practices aim to extract the tacit knowledge that people have, what they carry with them, what they observe and learn from experience, rather than what is usually stated explicitly. The distinction between tacit and explicit knowledge is critical to assessing the scope of knowledge management and how it differs from managing information and data. Broadbent [13] adds that an individual's tacit knowledge becomes explicit as part of the company's management processes. In the field of knowledge management, we must mention Nonaka et al. [14], referring to the knowledge spiral, where new knowledge always starts with tacit knowledge, not always visible or difficult to express. Knowledge is created through the interaction between tacit knowledge and explicit knowledge through 4 modes of knowledge conversion, namely Socialization, Externalization, Combination, and Internalization, also defined as the SECI method or spiral.

Nonaka and Takeuchi's spiral of knowledge is represented as shown in Fig. 1.

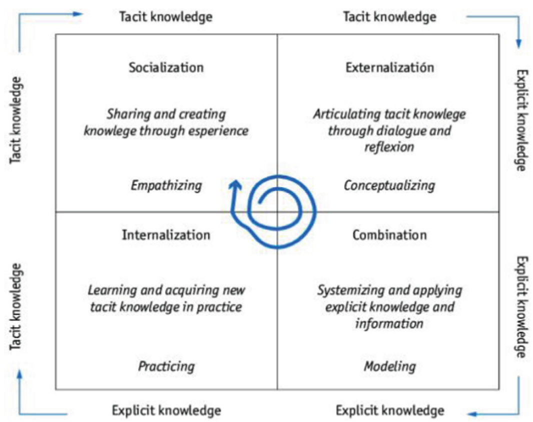

Fig. 1. SECI adapted from Takeuchi & Nonaka [15]

The great challenge for organizations is to focus on providing an appropriate context for the creation and sharing of organizational knowledge [15].

2.2 Knowledge Management Systems

Knowledge management systems (KMS) are a group of information technologies that support the extraction, storage, transfer, and distribution of knowledge among workers. Typically, a knowledge management system is open and distributed, customizable, measurable, secure, accessible, available, and appropriate [16].

Alavi & Leidner [5], mentioned that "IT can support KM in sundry ways. Examples include finding an expert or a recorded source of knowledge using online directories and searching databases; sharing knowledge and working together in virtual teams; access to information on past projects; and learning about customer needs and behaviour by analysing transaction data, among others. Indeed, there is no single role of IT in knowledge management just as there is no single technology comprising KMS. There are three common applications of IT to organizational knowledge management initiatives: (1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks", (p. 27).

Laudon e Laudon [17] adds that "KMS enable organizations to better manage processes for capturing and applying knowledge and expertise. These systems collect all relevant knowledge and experience in the firm and make it available wherever and whenever it is needed to improve business processes and management decisions. They also link the firm to external sources of knowledge" (p. 54).

The authors have identified three main types of knowledge management systems: enterprise-wide knowledge management systems (KMS), knowledge work systems (KWS), and intelligent techniques. Corporate KMS are related to the collection, storage, distribution and application of digital content and knowledge. These systems include features for searching information, storing structured and unstructured data. Systems also include supporting technologies, such as portals, search engines, learning management systems, or collaboration and social business tools. Knowledge work systems (KWS) are more specialized systems built for engineers, scientists or to create new knowledge for a company. Finally, the third type of knowledge management system, related to intelligent techniques, such as data mining, machine learning, computer vision systems, robotics, or other "smart" agents.

2.3 Knowledge Engineering: CommonKADS Methodology

CommonKADS is a methodology to support structured knowledge engineering. This method has been gradually developed and has been validated by many companies and universities in the context of the European ESPRIT Program. Since the 1990s, this methodology has been a *de facto* European standard for the analysis and development of knowledge-based systems, having been adopted in whole or in part into existing methods by many large companies in Europe as well as in the USA and Japan [18, 19]. The method has its origin in the need to build the knowledge system in a structured, controllable, and repeatable way [20]. Initially, the development of a method for acquiring knowledge in the process of building a knowledge-based system was proposed, and it was called KADS (Knowledge Acquisition Design System). Subsequently, the project was extended to the construction of a complete methodology for the development of KBS (Knowledge-Based Systems), which begins with the analysis of the organization where the KBS is oriented and for the management of projects through Programs. It is at this moment that the name CommonKADS results [21]. The methodology consists in three phases [22]:

(1) **Contextual Analysis** (Context): in this phase, the focus is on the organization that will eventually use the system, describing the business processes, resources, and knowledge assets and the impacts that the knowledge-based systems will have.

(2) **Conceptual Analysis**: this phase intent to clarify the knowledge that will be represented in the knowledge-based systems, the reasoning that will need to be conducted on this knowledge and the interactions that will be required with users and other external agents.
(3) **Artifact**: at this stage, the project is created for the knowledge-based systems that can be translated into code in some appropriate programming language.

In addition to the three phases mentioned above, the CommonKADS methodology comprises six independent models, which capture various sources of information, allowing the feasibility and implementation of the project to be analysed. The six models, despite being independent, are related to the others and can be developed at various times and by different teams.

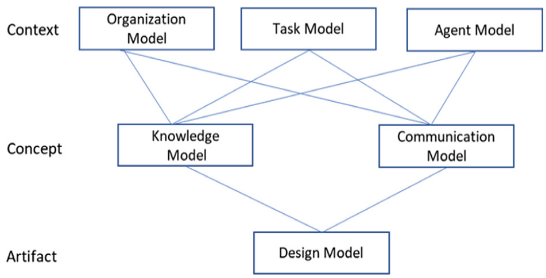

Fig. 2. CommonKADS methodology adapted from Schreiber et al. [20]

For Dias and Pacheco [22], the CommonKADS methodology, Fig. 2, can be considered the most complete as it involves all stages, ranging from planning to implementation, en- compassing not only the technology aspects, but also the characteristics and aspects of the organization, being able to make the most of your own knowledge.

3 Methodology

This research paper applied a systematic literature review (SLR) method and followed Kitchenham's [23] approach, considering three steps:

1. Planning: identifying the needs for review, summarizing all existing information about some phenomenon in a complete and unbiased way. For this, we specified the research questions and developed the review protocol.
2. Conducting: selection of primary studies and data extraction, using the review protocol developed in the first stage.
3. Reporting: summarize the extracted data and report the results. The purpose of our review is to bring definite evidence as a synthesis of the best quality scientific studies on our specific topic or research questions and to identify gaps to suggest areas for further investigation.

3.1 Planning

The most important pre-review activities are defining the research questions that the systematic review will address and presenting a review protocol, i.e., the plan defining the basic review procedures [24]. The research questions are the follow:

– RQ 1: How do companies position training and knowledge management in defining their corporate strategy?
– RQ 2: What models or artifacts exist to support the strategic alignment of knowledge management systems in a business context?

The first step in developing a Review Protocol is to define the search string that will be used to search the chosen data sources and find the maximum number of articles or works on the subject. For its definition, the adaptation of the PICOC criteria (Population, Intervention, Comparison, Outcome, Context) was used [24]:

– Population: CIO, CEO, Chief Learning Officer, corporate directors
– Intervention: strategy, learning systems
– Comparison: knowledge management systems, learning content management system, learning management systems
– Outcome: framework, model, artefact
– Context: business organization, business corporation, business

The data source used for the research was the b-on platform (https/www.b-on.pt/) provided by Universidade Aberta and Scopus (https://www.scopus.com/), to which the following search string was applied:

((CIO OR CEO OR “Chief Learning Officer” OR “Corporate Directors”) AND (strategy OR “learning systems”) AND (KMS OR LCMS OR LMS) AND (framework OR model OR artefact) AND (“business organization” OR “business corporation” OR business)).

The second step was to define the inclusion and exclusion criteria and apply them to the set of articles that we obtained in the first step. It is often useful to evaluate selection criteria on a subset of primary studies [23]. The defined criteria are shown in Table 1:

Table 1. Inclusion and exclusion criteria

Inclusion	Exclusion
Research papers or academic articles	Papers prior to 2006
English or Portuguese papers	Incomplete papers
Papers available in the search platform	Subject not correlated
Papers reviewed by peers	Without citations
	Duplications

Although the research area has studies prior to 2006, the technological development of information systems and the concern to align company strategies and knowledge management have gained greater expression in the last 15 years. Other criteria were based on quality assessment, therefore, we also excluded incomplete articles or articles without citations. After applying the defined criteria and obtaining the first set of articles, the abstract and conclusions of all articles were analysed to assess their relevance to the research. The resulting set consisted of selected articles, which were read in full in the next step, to obtain the final set of selected works. The review protocol is shown in Fig. 3.

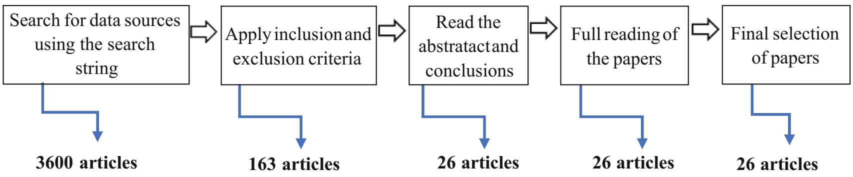

Fig. 3. Review protocol

3.2 Conducting

After choosing the data source and applying the defined search string, we obtained more than 3,600 articles, which we later reduced to the first set of 163 articles, applying the inclusion and exclusion criteria presented in Table 1, and finally after reading the full articles we obtain 26 articles that were used to answer to our research questions and that are mentioned in the next tables on the Sect. 3.3.

As per Fig. 4, there was a greater interest in this specific topic in the years 2012, 2013 and between 2015 and 2017, with an increase in the number of studies in 2020.

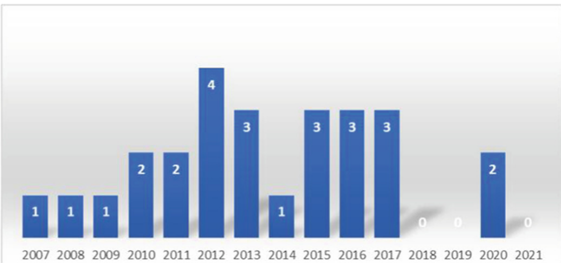

Fig. 4. Quantity of selected papers per year

Our search string brought some articles in the year 2018 and 2019, however, after reading the abstract and conclusions, they were rejected as they were not directly correlated to our scope of study.

3.3 Reporting

Based on the twenty-six selected works, an investigation was conducted to answer **RQ1: How do companies position learning and knowledge management in defining their corporate strategy?** Of the twenty-six final works selected, five are related to information systems strategy and indirectly to knowledge management, and how this reflects in business or corporate strategy. Corporate strategy takes a portfolio approach to strategic decision making, analysing all a company's businesses to determine how to create the most value. To develop a corporate strategy, companies must observe how the various businesses they own fit together, how they impact each other and how the holding company are structured to optimize human capital, processes, and governance. Corporate strategy is based on business strategy, which is concerned with making strategic decisions for an individual business. Based on this concept, the selected works were grouped in Table 2, using three elements and correlated to the information systems strategy, namely: Organizational Structure, Processes and Governance.

Table 2. Corporate Strategy and IS

Corporate strategy and information systems				
Paper Id	References	Organizational Strictire	Processes	Governance
P004	[28]	√	√	
P005	[29]	√		
P013	[37]	√		
P020	[44]			√
P025	[49]		√	

The selected studies focus on organizational structure, showing the influence of the CIO or the structure of top information technology executives [29] and the understanding of the CEO and CIO in facilitating the alignment of organizations' information systems with business strategy and the contribution of information systems to business performance [28, 37].

Khaiata et al. [49], propose an instrument that measures the maturity of the alignment between business and information technologies, with the objective of identifying the main gaps. The proposed instrument was based on the Strategy Alignment Maturity Model (SAMM); it directly encodes all attributes of the SAMM alignment areas using a one-dimensional structure. The instrument was successful in identifying six major gaps for the company in the various areas of alignment. These gaps were benchmarking, business metrics, strategic business planning, inter and intra organizational learning, architecture integration and the impact of information technologies on business processes.

A study conducted by Chau et al. [44], addresses the effects of the strategic alignment of information technologies, the business, and their governance, on company performance and investigates the curvilinear relationship between alignment, misalignment, and company performance. They conclude that the results emphasize that managers of initiative-taking organizations must pay attention to alignment and governance to leverage information technologies more effectively and ensure powerful performance results.

Related to the answer to **RQ2: What models or artifacts exist to support the strategic alignment of knowledge management systems in a business context?** The data collected from Table 3, was organize, and analysed to correlate the KMS models or frameworks proposed by each article, with the three main dimensions of knowledge management implementation [51]: Organizational, Technological and Strategy.

From the analysis, we identified three articles whose proposed models consider the three dimensions of implementation of a knowledge management system and which we will discuss in greater detail (Paper Id P002, P006 and P025).

Table 3. KM dimensions/KMS models

KM dimensions/KMS models				
Paper Id	References	Organizacional	Technological	Strategy
P001	[25]	√		
P002	[26]	√	√	√
P003	[27]	√		
P006	[30]	√	√	√
P007	[31]	√	√	
P008	[32]	√	√	
P009	[33]	√	√	
P010	[34]	√	√	
P011	[35]			√
P012	[36]			√
P014	[38]	√	√	
P015	[39]	√	√	
P016	[40]	√		
P017	[41]	√		
P018	[42]	√		
P019	[43]	√		
P021	[45]	√		
P022	[46]	√	√	
P023	[47]	√		
P024	[48]	√		
P025	[49]	√	√	√
P026	[50]	√	√	

Baloh et al. [30], referred as Paper Id P006, unlike conventional research, arguing that the development of a knowledge management solution for the entire company is of limited value. Not only do different knowledge challenges exist in organizations, but people also have different tasks in the course of their daily work. The authors propose a model to guide the design of knowledge management systems based on knowledge needs. The model shows in Fig. 5.

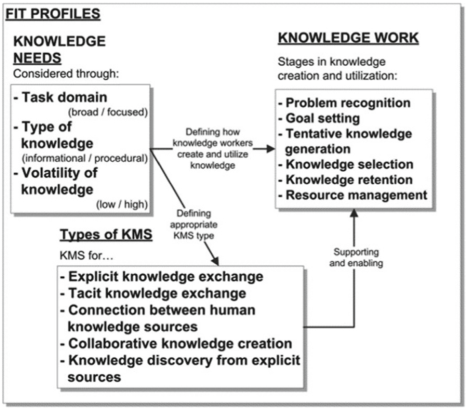

Fig. 5. KMS design model [30]

The model consists of "ideal" combinations of knowledge needs and characteristics of knowledge management systems, which should result in improvements in the use and creation of knowledge. The design model developed allows the knowledge management community to critically evaluate ongoing efforts to leverage organizational knowledge with support systems. The proposed model can also apply to retroactively analyse successful and unsuccessful KMS implementations. Finally, they present guidelines for professionals on how to use the model to build a knowledge management system as part of knowledge-related organizational change projects, as shown in Fig. 6:

The authors mention that the results of their research show that the model of technology choices and the guidelines for its use form a highly relevant KMS design model, and that the findings represent the first step towards a robust approach to the design science that supports a new construction of the appropriate knowledge management systems.

Mehregan et al. [26], Paper Id P002, takes a different approach, using Critical Success Factors (CSF) as a method to define knowledge management systems evaluation criteria and uses the Gray Relational Analysis (GRA) matrix to score and prioritize knowledge initiatives. Critical Success Factors (CSF) refers to something that must be implemented if companies want to succeed in a specific field. These factors must be controllable and measurable. The study defined eight categories of CSFs, Fig. 7, which, after applying a survey to five target companies, presented the following results by category and company:

The main contribution of this article is to propose a novel approach to evaluate knowledge management systems. The study enumerate three advantages in the proposed model, (1) it proposes a tool to compare the performance of knowledge management solution providers, (2) it provides a comprehensive evolution to reveal the weaknesses

Fig. 6. Process of designing and implementing solutions for KM [30]

Table 2: value of each company in each criterion and the relational coefficient of each company

value of each company in each criterion								
Company	Critical Succes Factors (CSF)							
	Top management support	Communication	Document management	KM user satisfaction	Knowledge quality	KMS quality	KM-Business alignment	Culture
1	1.8	2.4	4.2	0.8	2.4	4.4	3.2	4.6
2	4.8	2.2	1.2	2.4	3.4	3.8	2.2	1
3	3	2	4.6	3.6	1.2	3.2	2.2	2.4
4	1.8	1	4.6	3.2	1	1.4	3.6	3.6
5	3.2	2.2	1.4	1.8	4.6	2.8	2.8	4
	the relational coefficient of each company in each criterion							
1	0.286	1	0.769	0.286	0.396	1	0.58	1
2	1	0.741	0.286	0.482	0.548	0.667	0.286	0.286
3	0.4	0.58	1	1	0.298	0.5	0.286	0.396
4	0.286	0.286	1	0.741	0.286	0.286	1	0.588
5	0.43	0.741	0.298	0.396	1	0.43	0.412	0.702

Fig. 7. Critical success factors by company [26]

and failure points of KM initiatives in a particular organization and helps managers to improve the performance of those systems and (3) is generic in nature and is applicable to any organization such as industry, healthcare, consulting firms, etc. and can overcome the disadvantages of statistical methods.

Khaiata et al. [49], Paper Id P025, state that the alignment of information technologies (IT) strategy with the business clearly has an impact on organizational performance, in the same way that they mention that the big problem of this alignment is knowing how to "measure" it. The study approach proposes an instrument that measures the maturity of the alignment between business and information technologies, with the objective of identifying the main gaps. The proposed instrument was based on the "Strategy

Alignment Maturity Model" (SAMM) [49]. The instrument explicitly addresses four distinct groups. Group Management is best suited to address business strategy issues. The IT Management group, on the other hand, can better handle IT strategy issues. The Staff group is more familiar with business operations. Finally, the IT team group is the most competent to manage operational IT issues.

SAMM [49] proposes that IT-Business alignment can be captured according to six areas of maturity, namely:

Communication maturity: to ensure continuous knowledge sharing across the organization and IT understanding of the business and vice versa.

Value Measurement Competency/Maturity: to demonstrate the value that IT is contributing to the business.

Governance maturity: to ensure that appropriate business and IT stakeholders are reviewing IT priorities and resource allocation.

Partnership maturity: to reflect the level of trust developed between IT stakeholders and the business, in sharing risks and rewards.

Scope and Architecture Maturity: the level of flexibility and transparency that IT is providing to the business.

Skills Maturity: to reflect the level of innovation, change, hiring and retention, and how they are contributing to the overall effectiveness of the organization.

For each of these areas, this maturity model classifies the alignment between business and information technology at five levels:

1. Initial/ad hoc process, where business and IT are not harmonized or aligned.
2. Committed process, where the organization is committed to aligning with IT.
3. Established/focused process, where the alignment between IT and business is established and focused on the business objectives.
4. Improved/managed process, where the concept of IT as a "Value Centre" is reinforced.
5. Optimized process, where strategic business planning and IT is integrated and have reached a co-adaptive stage.

All other items listed in Table 4 reflect a strong focus on the organizational dimension, being 100% of articles pointing "culture" as a key factor in knowledge management and in the process of implementing a support system, followed by factors related to processes. Structure and leadership are less mentioned as a relevant factor. In the technological dimension, despite the technical aspects of information systems and infrastructure, the quality factors of the information systems and the return on investment stand out.

4 Conclusions and Future Work

In conclusion, while knowledge management (KM) is about people and human interaction, the support systems have evolved far beyond an optional part to being a critical component today. The establishment of an effective knowledge management system (KMS), inseparable from the business context, also requires a clear strategy, reflecting the different dimensions mentioned to be successfully implemented and aligned with the corporate strategy.

The answer to the first research question, "how do companies position learning and knowledge management in the definition of their corporate strategy?", we conclude that there is a clear influence of the organizational positioning of the functions that lead the knowledge area or information systems strategy with the corporate strategy and its contribution to the business performance.

The answer to the second research question, "what models or artefacts exist to support the strategic alignment of knowledge management systems in a business context?", from the articles analysed, we conclude that only three present models that somehow support the strategic alignment of knowledge management systems or IT in the business or enterprise context, covering the three dimensions (organisational, strategic, and technological). The first article [30], it's a model proposal for the design of knowledge management systems, considering the specific needs of knowledge, starting from the assessment of the AS-IS situation to TO-BE. The second article [26], brings us a model for evaluating the critical success factors of knowledge management systems, which may differ from company to company. The third article [49], proposes a model for assessing the maturity of IT and business alignment as a fundamental step to improve an organization's performance, addressing alignment gaps, and allowing the organization to set the focus.

This study shows that there is a lack of a model or framework that represents the alignment between: company strategy, knowledge management strategy and the strategy of the systems that support it.

In our future work, based on the information obtained from the literature, and with the combination of the knowledge engineering methodology, CommonKADS [20], we will carry on our investigation to propose a conceptual framework for the strategic alignment of knowledge management systems in the business context. For that purpose, and to obtain information, the research survey methodology [52] will be used.

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Artificial Intelligence in Education

Practical Ethical Issues for Artificial Intelligence in Education

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Abstract. Due to the increasing use of Artificial Intelligence (AI) in Education, as well as in other areas, different ethical questions have been raised in recent years. Despite this, only a few practical proposals related to ethics in AI for Education can be found in scientific databases. For this reason, aiming to help fulfill this gap, this work proposes a solution in ethics by design for teaching and learning processes using a top-down approach for Artificial Moral Agents (AMA), following the assumptions defended by the Values Alignment (VA) in the AI area. Therefore, using the classic Beliefs, Desires, and Intentions (BDI) model, we propose an architecture that implements a hybrid solution applying both the utilitarian and the deontological ethical frameworks. Thus, while the deontological dimension of the agent will guide its behavior by means of ethical principles, its utilitarian dimension will help the AMA to solve ethical dilemmas. Whit this, it is expected to contribute to the development of a safer and more reliable AI for the Education area.

Keywords: Education · Ethics · Artificial intelligence · Value alignment

1 Introduction

Artificial Intelligence (AI) technologies are increasingly present in contemporary life and proving themselves capable of promoting significant changes in how people interact, solve problems, and make decisions [16]. This makes evident the need to encourage discussions and seek solutions to the impacts that this can pose on the different dimensions of social life. In the educational context, especially concerning solutions for teaching and learning, these issues need to be given equal importance, as, likewise in other areas, the trend is for an increase in the use of AI solutions to support teaching and learning processes [21].

Thus, to address the ethics in AI problem, there are three widely disseminated research dimensions, namely: ethics by design, ethics in design, and ethics for design. This work is focused on ethics by design, dedicated to developing algorithmic solutions to provide AI systems with ethical reasoning capacities [13]. From this viewpoint, the set of research efforts to produce intelligent systems aligned with human values is organized in a field called Values Alignment (VA) in AI [15].

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The objective of this work is to propose a solution based on Artificial Moral Agents (AMA) aligned with the ethical principles for AI proposed by the United Nations Educational, Scientific and Cultural Organization (UNESCO), capable of supporting collaborative learning teams. For this, using a top-down approach, it is proposed to use the Belief, Desire, and Intention (BDI) model to implement a hybrid architecture capable of applying deontological and utilitarian frameworks to make decisions and deal with ethical dilemmas [11]. Thus, firstly, we intend to discuss the deontological and utilitarian bases that will compose the ethical ground of the proposed AMA. Next, it will be shown how these bases should be applied in practice to enable the proposed solution.

2 Deontological Grounds

Deontological ethical frameworks hold that a given action should be judged based on its compatibility with a set of duties recognized as legitimate by rational decision-makers [20]. Such frameworks are duty-oriented and establish general rules to be followed by decision-makers.

The establishment of principles, therefore, is the basis of the deontological framework. This means that AMAs developed in a top-down approach, based on deontological frameworks implement moral principles that will be used as criteria for the selection of ethically appropriate actions [1]. An example of AMA that applies this approach is described in [2], in which principles established in [5] for biomedicine are used.

Currently, several initiatives aimed at establishing ethical limits for AI are being organized around the world. For instance, one can highlight the Asilomar AI Principles; the Global Initiative on Ethics of Autonomous System maintained by the Institute of Electrical and Electronics Engineers (IEEE); actions by UNESCO [19], among others.

This paper is focused on UNESCO's proposal, as this one focuses on the ethical implications of AI technologies on the areas under its domains, that includes Education. Thus, as shown in Fig. 1, the responsibility for complying with some of the principles proposed by UNESCO [18] can be attributed to AI technologies. Other principles, however, depend more on direct human action.

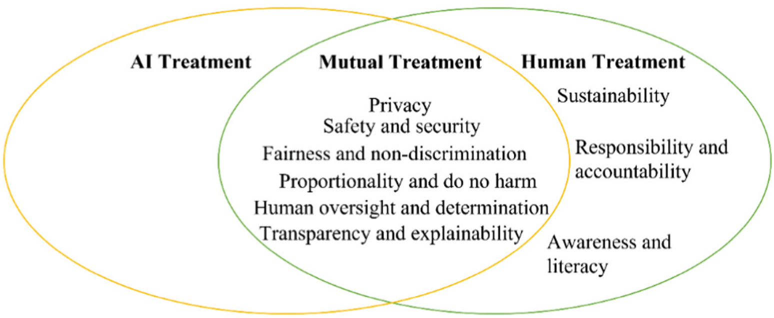

Fig. 1. Principles whose treatment can be delegated to AI

The principles and values contained in the UNESCO's document make it clear that responsibility for ethical issues in AI should always be human and Fig. 1 follows this premise. The central idea, however, is to define a set of principles that can be codified through ethics by design and delegated to AI. Thus, this paper adopts as the deontological basis, the set of principles contained in Fig. 1 classified as mutual treatment.

The use of principles to guide AI systems behaviors in ethics by design can contribute to the construction of more reliable, secure solutions, as in addition to guiding the decisions of such systems, it also makes it possible to restrict unwanted behaviors. However, it is also needed to enable the resolution or mitigation of conflicts between such principles or between its derived rules. The next chapter will address this issue.

3 Utilitarian Grounds

It is not always possible or desirable to avoid conflicts between principles and internal rules of an AMA, e.g., deciding whether to accept an overdue activity or not may require context analysis. In these cases, prioritizing between meeting deadlines or pursuing student success may be inappropriate. To deal with this type of situation, it is important to endow AI technologies with the ability to resolve ethical dilemmas.

To this end, some solutions have been studied and applied over the last years. The more appropriate for this work is the Double Effect Doctrine (DDE) and the implementation of Jeremy Bentham's Hedonistic Utilitarianism. As this is a work focused on education, pure utility functions will be disregarded as they are too quantitative.

The algorithm based on Hedonistic Utilitarianism, which will be used in this work, is better known among researchers in the field as Hedonistic Act Utilitarianism (HAU). The HAU operates by selecting from a set of available actions and considering equally all those affected, the one that results in the greatest net pleasure or happiness [3]. With this, the algorithm calculates, for each person, the product of the intensity, duration, and probability of obtaining such liquid pleasure. Finally, add the individual net pleasures to get the Total Net Pleasure.

$$\text{Total Net Pleasure} = \sum\nolimits_{i=1}^{n} (\text{Intensity}_i \cdot \text{Duration}_i \cdot \text{Probatility}_i)$$

where n is the total number of people affected by the action. The action to be considered most right will be the one with the greatest total net pleasure and when two or more actions result in the greatest net pleasure, such actions can be considered equally right. An example of using this algorithm is a counseling system using utilitarian ethics developed and described in [3].

In short, the implementation of utilitarian reasoning to deal with ethical dilemmas is crucial for AMAs in the educational context, as the interaction with human beings represents great chances of conflicts of interest, visions, principles, or rules [10]. Dealing with these conflicts using only a prima facie approach or rule prioritizations is not enough, as it is not possible to foresee all possible situations.

4 An Artificial Moral Agent to Support Teaching and Learning

The proposal contained in this article is a refinement of the central idea published in the paper entitled "A Conceptual Model for Artificial Moral Agents in the Educational

Context" [11] It is therefore an AMA that adopts a top-down approach, implementing a hybrid solution uniting deontological and utilitarian structures using the BDI model. Figure 2 presents an outline of the proposed model.

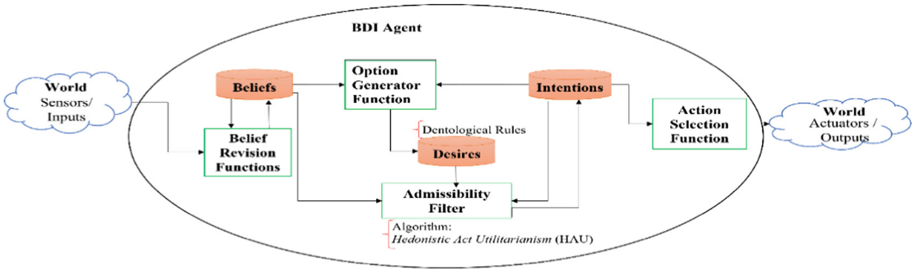

Fig. 2. Architecture of the proposed AMA

The AMA proposed in this work includes a set of moral principles and rules to be implemented in the agent's set of desires so that they are pursued among its objectives. In the admissibility filter, we propose the implementation of the HAU algorithm, presented in Chapter 3, to deal with ethical dilemmas. This feature will enable commitment to intentions, whose ethical dilemmas, when applicable, have already been resolved.

The abstract model described above was proposed to meet teaching and learning processes that use AI technologies. However, more specifically, this work proposes as a proof-of-concept, a more detailed presentation of this model for collaborative learning environments. Further details of this proposal follow.

4.1 Assumptions of Computer Supported Collaborative Learning

Collaborative learning aims to promote joint work among students. One of the central ideas of this approach is that it gives students more control over their learning [17]. Thus, the idea is assumed that learning occurs when students and teachers work together to create knowledge. In addition, one can say that collaborative learning occurs when two or more people try to learn something together. Thus, an important thing in this approach is that members of the same group work together on the same project, but not necessarily on the same task [12]. That is, there may be division and organization of tasks among group members.

In this context, Computer-Supported Collaborative Learning (CSCL) can be defined as a branch of learning science concerned with studying how people can learn together with the help of computers [18]. To meet this demand, many technologies have been used. Some examples that can be cited are educational social networks [7], discussion forums, video or audio-conferencing meetings, systems for the construction of syntheses, like glossaries and concept maps, and content organization systems [9].

Finally, with a more specific purpose, one can mention groupware, which differs from other types of software by making its users aware that they are part of a group. This happens by introducing mechanisms capable of keeping group members updated about the state and changes of the shared virtual space, about the actions that other members are performing, and, more recently, about the emotional states and movement of the colleagues' eyes on the screen of the computer, using artificial intelligence [14]. These are, in brief, some possibilities for using computers to support collaborative learning. In the next chapter, it will be presented which characteristics are intended to be attributed to the proposed AMA.

4.2 Proposal of AMA to Support Collaborative Learning Groups

The proposed in this work solution will be integrated into a virtual forum to assist in guiding collaborative learning groups. Its architecture based on the BDI model will have a hybrid implementation of deontological and utilitarian ethical frameworks.

Regarding its deontological dimension, some principles and rules based on the characteristics of collaborative learning, on the principles established in Chapter 2, and those proposed in [5] are used as the basis in this proposal. Accordingly, Table 1 presents some of the rules to be implemented and their references, and the relationship between such rules and the ethical principles for AI.

Table 1. Examples of ethical rules and principles to be implemented into the AMA.

ID	Rules	Related ethical principles for AI
1	Some student in the group must interact	Proportionality and do no harm
2 3 4	All students must interact All students must interact equitably Some student must continue to interact throughout the activity	Justice and non-discrimination Privacy
5	All students must be informed of their peer interactions	Transparency and explainability Privacy
6	All groups must complete activities in time	Proportionality and do no harm Justice and non-discrimination Privacy
7	Do not interfere in students' decisions	Proportionality and do no harm Justice and non-discrimination Privacy
8 9 10	Avoid disproportionate levels of demand Avoid sending discouraging messages Avoid exposing the student to peers in the group	Proportionality and do no harm Justice and non-discrimination Privacy

In addition to being inspired by some expected characteristics of collaborative learning groups, the rules presented in Table 1 are also based on some features of CSCL systems. These rules are part of the objectives to be pursued by the system. The imposing characteristic of some of them is directed to the AMA, which should seek to satisfy them, even if given the environmental variables, it is not always possible.

For example, considering the rule *some student must interact*, if no student does so, the objective will not have been achieved. The agent may fail under certain conditions. In these cases, the plan will be considered failed, there will not be replanning. Likewise, it is possible to notice some contradictions between some rules defined in Table 1. With this, whenever the AMA faces a conflict between its own rules or between them and an external condition, its utilitarian dimension will come into play to solve it.

However, to mitigate possible unnecessary conflicts, a prima facie approach will be adopted by prioritizing some rules. For example, at first glance – prima facie –, the agent must make all the students of a given group interact equitably in the forum, if this is not possible, the agent will seek that all the students of this group interact, even if not equitably, otherwise at least one student should do so.

Regarding the established ethical principles, some of them must be met as functional requirements, namely: respect for autonomy; transparency and explainability; and justice and non-discrimination. Other principles are highly desirable and consist of non-functional requirements, e.g., safety and security, and responsibility and accountability are notoriously relevant and need to be met throughout the development lifecycle.

The principle of human oversight and determination, on the other hand, even though it does not appear in Table 1, represents the need for attention so that critical decisions – student approval or disapproval, for example – are not delegated to the agent. This nature of the decision is outside the scope of the proposed AMA, which, as a result, will not need human oversight in the scope of its decisions.

As for its utilitarian dimension, the adequacy of the HAU to this proposal will take place at the level of calibration of its input parameters in relation to the time of the students' assignments. For example, the intensity of pleasure that the agent's intervention will bring to students is greater, the closer to the end of the assignment's deadline, while the duration of this pleasure and the probability that it will occur are smaller. As general pleasure is the main objective, the agent may consider that his intervention, despite bringing less pleasure to the student who underwent the intervention, can bring greater general pleasure by contributing to the success of the team.

Another important point concerns the learning of ethical behavior, because although this is not a desired characteristic in AMAs in the context of teaching and learning, other contexts for the use of learning resources may be important. The agent proposed here will not have mechanisms for this purpose but will be able to adapt to different environmental conditions by reviewing and updating its beliefs. That is, the AMA will not learn from cases of ethical conflicts that it has already resolved but will have enough flexibility to meet the dynamics of learning processes.

In this sense, when integrated into the discussion forum, the agent must monitor the environment and interactions in a discrete way, simulating a teacher who, every 2 h, for example, checks the state of student interactions. Thus, to better elucidate how the rules defined in Table 1 will guide the agent in fulfilling its objectives, the description of some hypothetical scenarios follows: Let a collaborative learning group formed by three students, *a*, *b*, and *c*, interact through a forum to solve a given problem situation defined by the teacher. This activity lasts three days – 72 h.

- In the first case, after 24 h the agent verifies that no interaction has been performed. This state activates its desire corresponding to rule 1 of Table 1. However, such a desire conflicts with rule 7, forcing an ethical dilemma resolution before the agent commits to any intention.

- In the second case, after 36 h, students *a* and *b* registered 15 interactions, and student *c*, none. This scenario activates the desire related to rule 2, which again conflicts with the desire related to rule 7, leading the agent to a conflict that requires the resolution of the dilemma.
- In the third case, after 50 h the agent checks 3 interactions from student *c*, 23 from student *b*, and 17 from student *a*. Once the desire corresponding to rule 2 is satisfied, the agent verifies disproportionality in the amount of interaction, arousing his desire related to rules 3 and 6 of Table 1, as the student presents few interactions and the activity time exceeds 60%. However, once again, rule 7 conflicts with the above-mentioned desires, which leads to the need to resolve the dilemma.

In the three cases, although there are different types of interaction in the forums – such as posting a topic, replying to a topic, or sending a file –, as the present proposal does not provide for content analysis, each interaction will count as only one interaction. It is a quantitative analysis of interactions. However, the objective mechanism of this proposal is to test the agent's reasoning based on ethical criteria. The model is flexible so that both the rules and parameters of the HAU algorithm and the agent evaluation criteria can be adjusted for other scenarios later on.

Finally, the agent will use messages to try to make changes in the state of its environment, encouraging students' interactions. Such messages should also be subjected to rules 7, 8, and 9 of Table 1. In this way, it is intended to meet ethical criteria since the specification of the requirements for the agent, covering all its life cycle.

5 Final Considerations

The importance and need to investigate solutions for ethics in AI are notable. This is even more important in the educational context, where training processes are at stake and is needed greater care about the use of this type of technology capable of directing, with greater or lesser autonomy, the directions of teaching and learning processes.

In this context, the use of ethical frameworks already validated by a community of practices, such as codes of ethics, as well as the use of reasoning capable of solving ethical dilemmas, can make the decisions made by intelligent systems more predictable and explainable. Likewise, the BDI model, being guided by intentions, makes it more intuitive for the end-user to understand why an agent made a certain decision [6]. These features mad AI systems more explainable.

Furthermore, in environments in which AMAs, more than relating to people, conduct learning processes, which can have an important impact on human education and, consequently, on society, these characteristics are necessary. For these reasons, the model proposed in this work can contribute toward a more ethical AI in Education.

However, despite serving the purposes of testing the inclusion of ethical criteria in the architecture of mental states, which is the case of the BDI, the quantitative analysis of interactions may not accurately express the performance of a collaborative learning team. The proposed model, however, is flexible so that new rules can be included, as well as new decision weights for utilitarian reasoning can be defined. In addition, the incorporation of other AI techniques, such as NLP for interpreting the content of messages, or mechanisms that explore emotions, can contribute to enriching the list of criteria used by the agent for decision-making. Thus, qualitative analyzes of interactions could bring more assertiveness to the agent's decisions.

Besides, the proposed model can also be applied to other teaching and learning techniques, both individual and collaborative approaches. The choices made in this paper regarding the teaching approach and ethical criteria are not the limits of the proposed agent but will serve as the proof of concept necessary for the validation of the model.

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A Toolkit for Re-Mar to Enhance Classroom Ocean Literacy

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Abstract. Developing environmental concerns about the ocean at all ages underlies ensuring a better and healthier planet. To cope with that, there are several international initiatives to promote ocean literacy. However, there is an instigation lack in the introduction process of the sea theme in school education. A domain repository with marine learning objects could mitigate this gap by providing educational material that can be used in classroom activities or even for self-learning. So, to be successful, the repository has to be attractive to users and motivate them to become ocean literate. Artificial Intelligence technologies can play a relevant role, providing assisted services, such as learning object publication and search. The Re-Mar repository employs some technologies (defined as a toolkit), such as ontology and thesaurus, natural language processing, and a multi-agent system. The integration of these technologies provides a rich environment to promote ocean literacy.

Keywords: Ocean literacy · Repository · Learning objects · Artificial intelligence

1 Introduction

Worldwide, governments and companies are investing in Artificial Intelligence (AI). Its vast potential can be exploited in different sectors in search of innovation to build intelligent entities.

The field of Education widely addresses AI. We can cite its usage since robotics to improve students' learning experience in childhood education, to intelligent and adaptive web-based systems that self-adjust according to the behavior of the instructor and learner.

Nowadays, AI affects education directly. According to Chen et al. review [5], in a qualitative research study, administration and management tasks, teaching, and learning are educational areas with AI's head impact. The authors also depict that machine learning, learning analytics, and data mining are closely related technologies for education.

Regarding the human perspective in education, Coelho and Primo [7] highlight that the human ability to maintain focus is limited. It is necessary to engage students with

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materials and contents. They also cite that incorporating Educational Computer Programs (ECPs) in classroom environments relies on infrastructure characteristics, pedagogical practices, and curricular adherence. In this way, they propose a digital ecosystem based on Learning Objects (LOs) and data-oriented analysis for student learning performance. The LOs must be concerned with technological and pedagogical aspects for an effective teaching-learning process [23].

The present study focuses on a combination of open-source software for learning objects supported by artificial intelligence technologies to increase Ocean Literacy. The research problem is to advance some clues about how AI can help improve the use of a learning object repository for the ultimate objective of filling school gaps concerning ocean themes.

2 Ocean Literacy Context in the Azores

In the last decade, digital technologies have occupied the classroom, as learning incorporates the internet [4]. The use of digital technologies is of great relevance to teachers, as it provides teaching materials for children's development and apprenticeship. In the archipelago of the Azores, access to other teaching solutions is not as easy as in mainland urban centers. Therefore, digital resources can be a good solution for teachers to promote meaningful learning that reduces the geographical barrier [17, 22]. However, there is a perception that these methodologies are not yet fully explored by teachers in schools, and it is required to counteract this trend.

Within the Sea-Things project [12], a recent study [17] intended to explore the perception of Azorean schoolteachers concerning the use of learning objects to promote ocean literacy. In this, our research group developed a questionnaire survey with open and closed questions to understand to what extent digital resources, particularly learning objects, are present in schools and how they are used to promote ocean literacy. This work reinforced the idea that even with the technology advances, the use of non-digital resources continues to be more common among teachers. To plan their classes, teachers in the Azores prefer to follow current curricular and programmatic guidelines used in textbooks [17]. From a learning object perspective to promote ocean literacy, the initial results showed that if the content is unavailable in the official curricula (published in [8]), teachers find it overwhelming to develop, use, or create new resources regarding the thematic. However, many teachers state that digital platforms and web pages provide specific content for their practice, and this seems to be a starting point for encouraging the use of this kind of material in their pedagogical practices supported by artificial intelligence applications.

3 Repository of Marine Learning Objects

The Repository of Marine Learning Objects (Re-Mar[1]) arises intending to engage both teachers and students about the marine thematic [1]. It is an open access repository

1 http://re-mar.uac.pt.

containing a variety of learning objects about ocean literacy, from infographics to lesson plans, implementing concepts like the ones developed by Santos-Hermos et al. in [18].

Within this collaborative environment, it is possible to share and search learning objects. Those can link with one or more LOs already in the repository. They can be new versions or fused to produce new learning objects. For example, an experience report on using some LO for documenting activity results is a new linked LO.

The submitted learning objects are the subject to two revision steps, a scientific and a pedagogical one. To guarantee the correct functioning and quality of biological or oceanographic content, respectively. Once available, it is possible for users to group favorite LOs and establish a star rating (scale from one to five). Repository stores search, access, and download statistics for future analysis.

The repository organizes the LOs by using the OBAA [21] metadata standard. With a broad scope, it allows a description of several resources in different ways. It is an extension of the well-known IEEE-LOM [15] metadata standard. With support interoperability among platforms, relations establishment, several learning content types description, interactions, didactic strategies, accessibility for users, and segmentation for objects. In the scope of Re-Mar, a subset of OBAA was employed, as depicted in Fig. 1.

This context allows us to explore some ideas that can provide a more efficient use of the repository. Our objective is turning it into an useful resource for teachers and students. We call a toolkit because we want to explore several dimensions of ideas to be adapted. Make the repository structure adjustable, *e.g.* add new metadata related to the number of practical experiments done in class using a specific learning object. The first tool that uses artificial intelligence technologies to support research, creation, and management of LOs is under development. The second tool is reagarding to invite teachers and students to use learning objects and later reproduce them in context of learning activities in class. The following two sections will debate our expectatives how to provide these tools in the repository.

4 Re-Mar as a Toolkit for Learning

The toolkit concept helps us identify several tools that could enhance the use of a repository. It can have different kinds users and includes a large set of learning objects, from didactic videos to written documents about concepts. What tools kind do we need to support the research and their use? How can we understand if a set of learning objects are adequate or useful for learning a concept? How can we facilitate active learning of subjects related to ocean literacy?

Artificial Intelligence is a broad field with several subareas. In the scope of this work, we can cite Knowledge Representation and Reasoning, Natural Language Processing, and Multi-Agent Systems that the Re-Mar repository is integrating. The repository is also a way to operationalize collective intelligence as described in [14].

4.1 Using an Ontology as a Search Tool

Using an ontology as a knowledge description for metadata allows both machines and humans to interpret the data. It is possible to reason about data, classify, verify metadata

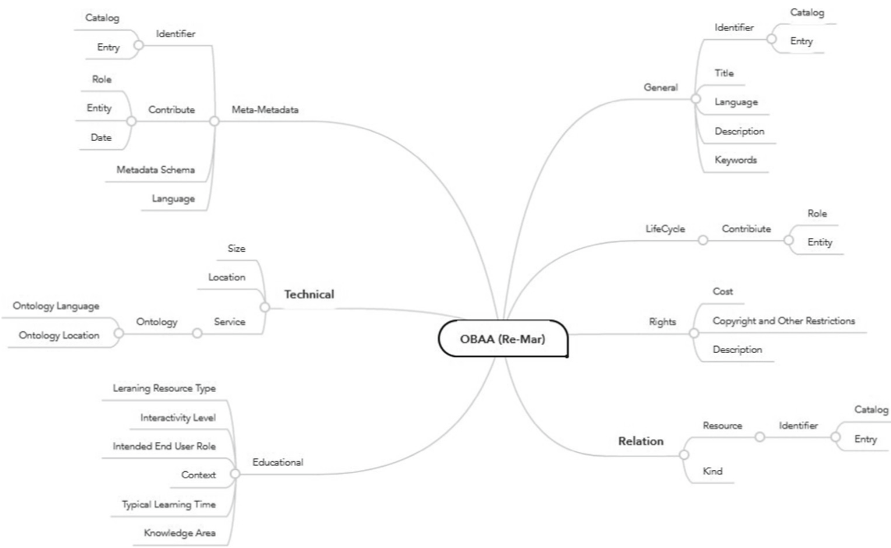

Fig. 1. Subset of OBAA metadata used in Re-Mar.

inconsistencies, or provide semantic search [9, 10]. Through Linked Data, it can build a Knowledge Graph for the repository. Every part of learning object metadata can be linked, reused, and held in a triple-store database. Besides that, it is possible to connect resources outside the repository and expand the knowledge graph. For example, we can link LO's keywords with several Uniform Resource Identifiers (URIs) from DBpedia. It is possible to obtain several other pieces of information related to the keyword by accessing these URIs. Figure 2 depicts a relationship between a lesson plan that requires a book. These two learning objects have keyword relations with DBpedia resources for further navigation.

One way to extract named entities for keywords is using DBpedia Spotlight from raw text, for example, from a title or a description. Re-Mar repository calls its API to obtain URIs and stores the values in keywords data properties [3]. To unburden the metadata form filling, Natural Language Processing is important.

We expect to add in Re-Mar some language model to help users filling the submission form.

4.2 A Multi-agent System as Ecosystem Management Tool

The concept of the ecosystem has been widely used in different research areas, from the original biological concept to those related to management and innovation [6]. From an original ecological concept, E. P. Odum defined it as a unit that includes all the organisms interacting with the physical environment, defined as trophic structure and biotic diversity, and where there is an exchange of material, between living and nonliving parts [13]. In [20], it discusses the concept of ecosystem related to management technology and innovation. Five points characterizes it:

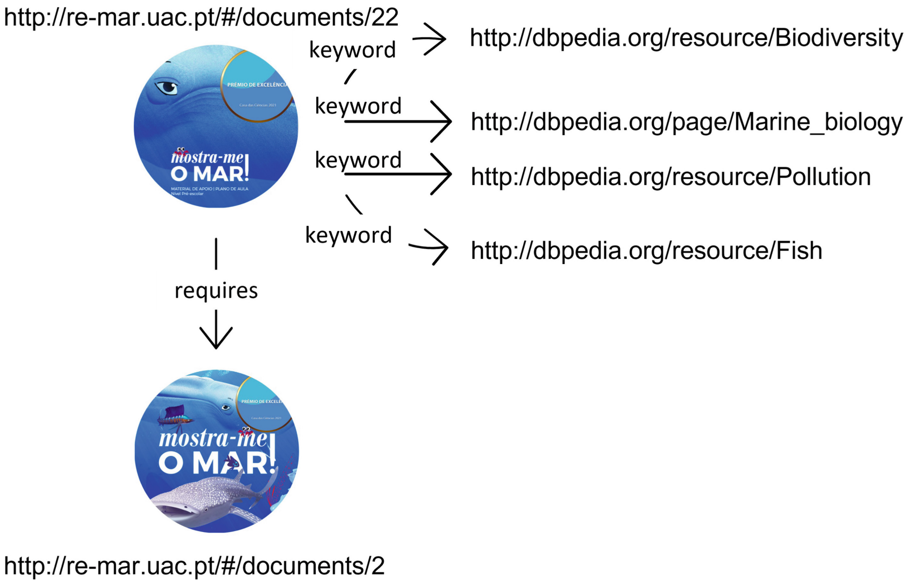

Fig. 2. Partial knowledge graph for learning objects in Re-Mar.

- The concept is related to organic networks based on their own positive and less positive aspects, such as predation, parasitism, and destruction of the system.
- It has different actors with different attributes and principles, *i.e.* they are composed of agents.
- It is extended not only to their actors and to outside, in the case of non-business actors.
- The analysis of an ecosystem requires longitudinal observations of its evolution.
- Finally, ecosystem research is all about finding patterns that affect their growing or decline under specific boundary conditions.

We find some similarities in this definition with key concepts identified in multi-agent systems in a repository. The fact that the interaction is not only identified inside the ecosystem and it extends to outside, in the physical environment of interaction (*i.e.* the users of the system) is one identified contact point. The care taken about its sustainability is another, although not mentioned in the E. P. Odum definition. In fact, the definition helps us to understand how organisms related to each other and in the environment and, most of the time, how can we take benefit from it (*i.e.* ecosystem services).

We intend to use this concept and adapt it as one of the tools to improve repository usability. If you want to take benefit of it, you have to create their own rules. That is what we have been doing to make the repository more dynamic.

For constructing the ecosystem, we developed a series of agents related in various ways, as completely described in a recent publication [2]. For instance, the Manager Agent acts as the central agent of the social organization (like a deamon). The Analytics Agent is responsible for evaluating and managing the learning object repository. The Repository Agent conducts tasks related to the local repository that stores LO's metadata and statistics. And a Recommender Agent can assist users while they fill in metadata for authoring, using data from the Analytics Agent. Security Agent has the mission to identify some failures and promote the re-equilibrium of the system.

The main goal of this ecosystem is to gather statistics and adjust the behavior of the learning objects in the system. It is achieved by, for instance, evaluating the LOs usage over time. According to statistics from the number of downloads, access, rates, metadata updates, and the number of times it appears on the front page of Re-Mar, this leads suggestions to LO owners, providing some actions to improve the use of their LO. Actions currently implemented include presenting the OA on the front page, editing the OA's metadata, or sharing it on social media.

4.3 Repository Technology Inside a Classroom

As cited in [16], Stegmman [19] considers digital technologies as "computer-based technologies that present domain-general and domain-specific content and/or allow for interaction with or about the content and support teachers and/or students during that interaction".

The impact of having technology in class is not linear with the amount of sophistication of these technology. As mentioned in [16], "teachers basic digital skills seem much more important for both the frequency of digital technology use during teaching and for fostering a variety of student learning activities involving digital technology". On the other hand, the type of activities that technology can provide depends not only on the technology but also on how it is used. For example, ICAP Theory [6] refers to behaviours depending on the type of action that students have. In this theory, there are two main types of behaviours, being passive or active. Among the active, there is the constructive actions and the generative actions. The last one corresponds to behaviours where learners produce externalized ideas containing information "that goes beyond what was provided in the learning materials or instruction". We believe that using Re-Mar repository can provide opportunity to foster learning active behaviours in a classroom, *i.e.* promoting the active learning [11].

In Re-Mar, different sources provide learning objects. And as usual, in repositories, there is supervision on object quality. Experts in the field, or fields, addressed in the content of that object.

5 Conclusion

A repository is an opportunity to share validated knowledge and present it as a document, a video, a text, or an activity lab that can improve learning in a specific area. But the repositories must be more than just a way to keep organized documents that can be searched and selected by interested students or teachers. It can encourage active learning, promote the use of LOs, and identify as related to a certain researched subject. Or by other users in similar search or selection contexts.

This text argues that active learning involves transforming, adapting, reorganizing, and readapting some new resources based on previous sources. The achievement of these goals cannot be only by technology with interfaces that limit the interaction with the user.

Re-Mar supports the use of Artificial Intelligence to provide a better search and to keep an ecosystem of LOs, that is, LOs that remain active and assume that each one has its unique role in the repository as a whole.

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The Impact of Artificial Intelligence on a Learning Management System in a Higher Education Context: A Position Paper

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Abstract. This position paper provides an overview of the most important practices in the field of Artificial Intelligence (AI) used in educational contexts, with a focus on the main platforms used for teaching (LMS) to support the development of a research work at Eduardo Mondlane University (UEM) in Mozambique. To that end, definitions and descriptions of relevant terms, a brief historical overview of Artificial Intelligence (AI) in education and an overview of the common goals and practices of using computational methods in educational contexts are provided. The state of the art regarding the adaptation and use of Artificial Intelligence is presented and we discuss the potential benefits and the open challenges. The paper also presents the methodology and key steps which will be developed at UEM to achieve the research goals.

Keywords: Artificial Intelligence (AI) · Higher education · Learning Management System (LMS) · Position paper

1 Introduction

The advance and adoption of technology, along with the data science revolution brought to education, has provided countless opportunities for educators, students, curriculum developers and pedagogical directors, content creators and researchers [1]. Technology is having and will continue to have a major impact on the education system all over the world, and advances in artificial intelligence (AI) brought new possibilities and challenges to teaching and learning, with the potential to change management structures and architecture of higher education institutions.

According to Kavitha & Lohani [2] AI arouses enthusiasm for the future of how the education system works, and AI is part of some e-learning platforms, by providing support to the teaching and learning processes. According to Vicari [3], artificial intelligence promises to introduce improvements in education for all levels, with promises of unprecedented qualitative improvement, focusing on providing students and other actors in education systems with a precise customization of their needs according to their requirements, and being able to integrate the different forms of human-machine interaction. In educational platforms such as Learning Management Systems (LMS),

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according to Morrison [4], Artificial Intelligence offers numerous possibilities related to inclusive education where solutions focus on products and services to support people with disabilities in their interaction with the environment.

In this way, this position paper discusses the impact that Artificial Intelligence can have on the higher education system using the Eduardo Mondlane University in Mozambique as a case study for the development of a research work. The paper presents a proposal to investigate the educational implications of Artificial Intelligence in the way students learn and how the institution teaches and evolves its management processes with the support of artificial intelligence.

2 Literature Review

2.1 Artificial Intelligence and Education

In computer science, the term AI is used to describe computing technologies that allow machines to make decisions that mimic human behavior and intelligence [5]. Beyond the computer science and engineering, according to the dictionary Lexico [6] AI can be defined as: "*the theory and development of computer systems that can perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision making and translation and interpretation*". For Russel & Norvig [7] Artificial Intelligence focuses on the construction of intelligent agents that receive perceptions of the environment and execute actions that affect that environment. Machine Learning (ML) is a subfield of AI, in which statistical methods and computational algorithms are used to teach machines through examples and data experimentation on how to perform specific tasks [8].

Both AI and ML thrive on data. AI needs data to build its intelligence given that big data allows AI to reach its full potential, so it would be fair to say that there is no data-driven AI without big data [9]. From the necessity of analyzing data, two interesting areas of investigation into the use of AI for Education are educational data mining (EDM) and learning analytics (LA). In computer science, data mining is the process of discovering interesting and useful patterns and relationships in large volumes of data. Educational Data Mining (EDM) develops methods and applies statistical, machine learning and data mining techniques to analyze data collected during teaching and learning. According to UNESCO [9] EDM tests theories of learning and informs about educational practice. Learning Analytics (LA) is an emerging discipline that seeks to improve teaching and learning by critically evaluating raw data and generating patterns to characterize student habits, predict student responses, and provide timely feedback. LA supports decision making, adapts readable content, simplifies realistic assessments, and provides personal oversight of student progress [9].

2.2 Brief Context of AI in Education

Reviewing the paper written by Nwana [10] it is understood that research on the use of AI and ML in education has been ongoing since the late 1970s, when the first computer-assisted instruction (CAI) and information systems were developed. According to Chounta [1], in the beginning, AI methods were employed in two ways:

a) Design and facilitate interactive learning environments that support learning. In such environments, students would receive guidance to learn from their experiences while experimenting with interactive computer artifacts. An example of this line of research is the work of Seymor Papert introducing an educational programming language called LOGO for teaching geometry [11], based on a constructionist approach. Seymor Papert's constructionist approach has been criticized for demanding radical changes to the status quo of education;

and b) Design and implement tutoring systems, that are computer systems that "imitate" human tutors and gradually support students in the mastery of skills, adapting instructions in relation to the student's state of knowledge.

Thus, it can be stated that Artificial Intelligence was initially used as a learning tool for students to learn by experimenting with computational algorithms or as a technology to support the personalization of learning environments and the adaptation of instructions to the student's personal needs and goals.

The success of intelligent tutoring system (ITS) was largely due to the fact that these systems were able to track student performance and choose appropriate content to practice skills and promote knowledge tailored to the needs of each student using student models that are implemented using Artificial Intelligence methods, a good example of this can be found in apps like Duolingo [12].

However, despite the positive results demonstrated using ITS, its practice has been criticized for not considering the social aspects of the learning process, for the lack of social interaction and for not promoting the acquisition of social skills.

2.3 Artificial Intelligence in LMS

AI has been part of many e-learning platforms for quite some time, helping students learn more efficiently using various multimedia resources [2]. According to Aldahwan and Alsaeed [13], there are several AI approaches, such as Fuzzy Logic (FL), Decision Tree, Bayesian systems, Neural Networks, Genetic Algorithms, and Hidden Markov Systems, used in adaptive education systems. According to Chen and Lin [14] Artificial Intelligence research in education, impacts 4 areas namely: Education Administration, Teaching, Learning and student and teacher performance evaluation.

a) Education administration focuses on enabling instructors or teachers to perform their administrative functions, such as grading and providing feedback to students more effectively.
b) In teaching AI serves instructional purposes or as a pedagogical tool that is used to facilitate interactions between teachers and students in a teaching environment.
c) In learning AI enables tracking of learning progression, including knowledge, understanding, and uses the data to enhance system features and customize content according to students' needs and abilities, which motivates students.
d) In assessing student and teacher performance AI solutions can better analyze study data, helping instructors create personalized learning plans for each student and reduce human bias which is also an emerging issue for AI in education.

3 Proposed Work and Methodology

Eduardo Mondlane University (UEM) is a Mozambican public institution, founded in 1962 and the first and oldest institution of higher education in Mozambique [15]. It currently has around 40,000 students distributed among the Bachelor, Master, and PhD degrees [16]. At UEM, in general, the use of virtual environments for teaching and learning processes has gone through several developments over the last years, from which several initiatives for training teachers and students stand out. In 2002, UEM implemented distance learning (DL), having created in 2004 the Distance Learning Center (CEND) and started its operationalization in 2009, becoming the first higher education institution in Mozambique to offer remote and online courses, [17]. The interest in the use of these platforms quickly surpassed the exclusive view of distance education and began to attract the attention of face-to-face teaching, where several actors within the institution agreed to use them to support and reinforce face-to-face teaching and this was a crucial aspect in ensuring of continuity of the teaching and learning process during the COVID-19 pandemic [18].

Currently, despite not being centralized, all faculties have support systems, and the new challenges demand a change from UEM and the Mozambican education system so that they can address new educational needs [19].

We propose a work with the objective of evaluating the impact of Artificial Intelligence in a learning management system (LMS) in the context of higher education at UEM. To achieve this objective, the following activities will be developed:

i. Identification of the main roles that AI can play in the context of the Mozambican higher education system using UEM as a case study
ii. Evaluate the main AI techniques and algorithms, applicable in the context of the existing education management systems at UEM and how they can support the process of evaluating the main stakeholders
iii. Test Artificial Intelligence and machine learning solutions and assess the impact they can have on students, teaching staff, and academic management.
iv. Assess the main ethical and data privacy challenges associated with the use of Artificial Intelligence in the context of Mozambican higher education and what approaches can be implemented to overcome these challenges.

The introduction of Artificial Intelligence in Education, along with new opportunities and promising potentials, as described in the section above, has also introduced challenges that could potentially impede its growth and impact. This work at UEM will focus on the following challenges:

a) **Pedagogical challenges**

Computational approaches should, on the one hand, focus on personalization and adaptation to meet student needs, but, on the other hand, one should consider communication and promote collaboration and the acquisition of social skills that will enable learning in a global social arena. Teaching staff must learn new digital skills to use AI in pedagogical and meaningful ways, and AI developers must learn how teachers work and create sustainable solutions in real-life environments.

b) **Ensuring inclusion and accessibility**

Least developed countries such as Mozambique are at risk of experiencing new technological, economic, and social divisions with the development of AI. Some key obstacles, such as basic technological infrastructure, must be faced to establish the basic conditions for the implementation of new strategies that take advantage of AI to improve learning [9]. According to Abou-Zahra et al. [20], artificial intelligence has the potential to be a watershed in digital accessibility, through AI implementations based on pattern recognition.

c) **Privacy and data protection challenges**

AI methods in educational contexts rely heavily on keeping detailed records of personal data (demographic and historical data) and student activities and using this data to provide adaptive and personalized support tailored to individual student needs. However, the unsolicited and non-transparent collection and use of private data has often been criticized and raises ethical and legal considerations, especially since several countries in the world have established laws for data protection. According to Slade and Prinsloo [21], ethical and privacy issues in the analysis of teaching and learning include conditions for data collection, informed consent, non-identification of data, transparency, data security, data interpretation, as well as classification and management. of the data.

For the development of works of this nature, there are many methods aimed at the design and construction of artifacts, but one has emerged as a differential methodological proposal to face the challenges that involve the use of technology in education: Design Science Research (DSR). According with Dresch et al. [22], this methodology, used more commonly in studies in information systems, administration, engineering, and computing, has gained ground as an alternative to studies in education that involve the development of artifacts and require a more interdisciplinary and collaborative approach. The proposed work will have the following key steps:

1. The work will start with a systematic review of the literature to collect information about Artificial Intelligence in Education and the context of Higher Education in Mozambique and UEM using the methodology proposed by [23].
2. Based on activity 1, further research will be carried out to determine what is the status of AI in Education before trying to obtain results in the project. This initial phase is traditionally called the "state of the art". In the state of the art we will study the research works that have been developed in the area of Artificial Intelligence in Education. We will assess emerging trends as well as challenges associated with the research subject.
3. Technological Analysis of AI Solutions in Education and UEM will focus on understanding the types of technology around the research project, as well as those existing in the case study environment, to recognize their advantages and disadvantages. Therefore, this segmented analysis, but at the same time integrated, will lead to a decision-making process in which the goals, requirements and limits of the project are established. At this stage, interviews and surveys will be carried out with various actors of the education system at UEM to obtain their perceptions about their teaching challenges and their perceptions about Artificial Intelligence.

4. Design and implementation of experimentation artifacts in the UEM environment will consist in the development of Artificial Intelligence solutions that are compatible with the LMS systems in use at UEM as identified in the previous step. The idea behind this phase will be to be able to build artifacts that allow understanding the impact of Artificial Intelligence in the context of UEM LMS systems.
5. Analysis of results and Revisit to artefacts. Final reflection where the analysis of the research results will be made, and comparisons will be made to the existing theoretical models and empirical studies. Based on this analysis, the artifacts will be revisited so that they are better aligned with the needs of the case study domain, and, in this way, a final reflection will be made in relation to the research carried out.

4 Conclusions

In this position paper, we provide an overview of the most important AI and ML practices used in educational contexts, with a focus on LMS portals aimed at supporting education. To that end, we provide definitions and descriptions of the terms that have been referenced in this article, a brief historical overview of AI and ML in education, and an overview of the common goals and practices of using computational methods (AI and ML) in educational contexts. The aim of this paper was to present an overview of a proposed research project at UEM to assess the impact of AI on an LMS using the DSR methodology. In this sense, the research challenges associated with UEM were presented, to find the concepts that relate these areas and explore the possibilities in the research project. There are several research opportunities available that need to be addressed to broaden our theoretical and empirical knowledge in this field.

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A Review of Conversational Agents in Education

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Abstract. The use of mobile conversations is increasing all around the world. A conversational agent (CA) is mostly useful due to the fast response times and their simple nature. Recently, we have seen the development and increasing use of dialog systems on the Web. A conversational agent (CA) is a system capable of conversing with a user in natural language, in a way that it simulates a human dialog. Examples of CA can be found in several areas, including healthcare, entertainment, business, and education. In this paper a state of the art review of these dialog systems is presented, comprising different categories, different approaches and trends. The purpose of this work is to identify and compare the main existing approaches for building CA, categorizing them and highlighting the main strengths and weaknesses. Furthermore, it seeks to contextualize their use in an educational context and to discover the issues related to this task that may help in the choice of future investigations in the area of conversational natural language processing in educational context.

Keywords: Conversational agents · Education · Natural language processing

1 Introduction

Artificial Intelligence (AI) applied in education is expanding quickly. Some of the most popular AI technologies, like Conversational Agents are being used to support teaching and learning activities in the classroom or at home [1].

Conversational agents (CA) or dialog systems, also called chatbots or chatterbots, have become increasingly common. Language-based HMIs, like rirtual assistants or chatbots, provide information without time-consuming queries. Moreover, they hide the complexity and size of the information behind [2]. Applications of chatbots range from personal assistants on cell phones, sales bots on e-commerce websites, information retrieval, helpdesk, customer support and digital assistants, teaching-learning process support, and others. These systems are intended to carry out coherent conversations with humans in text or speech or both, in natural language. The creation of chatbots dates back to the ELIZA conversational system, which emulated a psychotherapist [3]. Over the years, new Artificial Intelligence (AI) techniques have been applied to the construction

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of these agents, so that examples of systems can be broadly categorized into three paradigms or "generations": the first, based on the combination of patterns and grammar rules; the second, grounded in production rules and artificial neural networks; and the third, which makes use of AIML markup languages [4]. However, the development of intelligent conversation with agents is still an unsolved research problem that raises many challenges in the artificial intelligence community [5]. This paper aims to identify and compare the main existing approaches to build chatbots, categorize them, compare them and highlight the main strengths and weaknesses. It also seeks to contextualize their use in an educational context. The main goal is to discover the issues related to this task that may help in choosing future research in the area of conversational NLP in an educational context.

2 Categories of Conversational Agents

CA can be categorized according to different characteristics, such as the interaction type, the domain of application, its purpose and the response generation models. The considered characteristics can consider the main learning strategy of the CAs and the contextualization capabilities of the model. In general we can classify CAs, based on different aspects [6]:

- Mode of interaction
- Goals
- Design approach
- Knowledge domain
- Regardless of how the Response Generation is done, these Chatbots share the same basis: analyze what the user says, interpret that analysis, and finally provide a response.

3 Approaches in the Implementation of Conversational Agents

This section discusses how CA can be developed, highlighting rule-based CA and AI-based CA. In AI-based CA, a distinction will also be made between information retrieval CA and generative CA. The pros and cons of each approach are also discussed. It should be noted that it is possible to use combinations of different Models in order to produce as optimal results as possible.

3.1 Rule-Based

Initial CA were based in rules. These approaches are generally simpler, but less broad in scope due to the lack of capabilities in responding to difficult questions [7]. Rule-based CAs reply to queries through pattern matching. In this way, they are insensitive and unable to adapt to unknown patterns. In addition, pattern-matching rules can be difficult and time-consuming to produce and maintain. Pattern matching rules are specific to a domain, and not easily transferable among different contexts [7].

3.2 AI-Based

Unlike rule-based models, AI based approaches usually rely on ML models and extract information by learning from previous knowledge of through interaction with humans. In order to accomplish such task, it is required to train with an ML algorithm that can learn a model based on training samples. Using ML algorithms removes the need to manually outline and code new sample matching rules, making chatbots greater and much less depending on a specific domain knowledge. [7]. These models can be subcategorized into models based on Retrieval Information and Generator models.

Information Retrieval (IR) Based

Having a dataset of Question-Response(Q-R) pairs, the IR-based model will search the Q-R dataset for the pair (Q',R') that best matches Q and returns R as the answer to Q [5]. Through this process, it enables reflecting training samples. Many search baseline models have been proposed to accomplish this purpose. [8]. Various works have addressed *Term Frequency-Inverse Document Frequency* (TF-IDF) retrieval models as a way to create CAs. For example, in [9] this approach is used to create a model directed to customer assistance and suggestion of products. Authors propose the application of Rhetorical Structure Theory [10] as a may to represent the characterization of connections among different replies. Among the used open domain datasets that have been most widely used to create the dialogue systems for generalist IR-based chatbots are *WikiAnswers*, Yahoo Answers, and Twitter conversations [7].

Generator Model-Based

Generator templates, create new answers for sentences according to the human interaction. Completely new sentences can be generated to respond different queries. Accomplishing this requires such models to learn how identify text structure and syntax, which is a difficult task. Consequently, results may lack consistency and even elegance in the generated texts [11]. Generators are usually based on sentences drawn from conversations. The algorithm learns from the data it is given. Its goal is to enable algorithms to generate good, linguistically correct answers based on input texts. Such models are generally based on deep learning (DL) algorithms that consist of encorder/decoders. [12].

Standard Models

Sequence-to-Sequence (Seq-to-Seq) models are the standard for chatbot modeling [7]. These models are fit for machine language problems; however, they also present good performance in natural language creation. The typical approach is using encoders and decoders [12]. This type of approach has several advantages. It is able to learn from data of different natures, domains and contexts, i.e. different domains, rather than one specific domain. This model does not require domain-specific knowledge to yield valuable results, but can be adapted to work with other algorithms if domain-specific knowledge needs to be further incorporated. Hence becoming a straightforward, but dynamic model, which may applied to very distinct PLN problems [13]. However, the main problem is that the size of the contextual information is restricted to a single vector, which means that when the size of the input text increases, there is a much higher chance that information, possibly relevant, will be lost. As a consequence, sequence models under-perform when analysing long sentences and often generate confounding responses. Additionally, Seq-to-Seq models address single response at each time, hence often outputing inconsistent conversational order. [11].

Transformers

Transformers are the new trend in automatic/intelligent language models [14]. Transformers learn how to measure the importance of different pieces of data/text. They also support training parallelism, which allows dealing which much bigger pieces of data than before. These models have given birth to some of the most famous pre-trained systems such as BERT (Bidirectional Encoder Representations of transformers) [15] and GPT (transformer pre-trained generator). These models have created, and have evolved, using large language datasets, such as the Wikipedia and Common Crawl corpuses. However, they can still be refined for ad-hoc problems [16]. Other models were developed to address specific challenges, e.g. Reformer [17] and Transformer XL [18].

4 Evaluation Methods

A variety of CA evaluation methods have been used (Table 1). These usually follow the ISO 9214 usability guidelines [19]. The most popular methods for evaluating CAs are those based on efficiency. Other methods used are those based on satisfaction and effectiveness [20].

Table 1. Methods for evaluating chatbot against ISO 9214 [20]

ISO	Effectiveness	Efficiency	Satisfaction
4.1	Performance	Functionality Humanity	Affection, Ethics, Behavior, Accessibility
4.2	Content Evaluation	Functionality evaluation	User satisfaction
4.3	IR Perspective	Language Perspective AI Perspective	User Perspective
4.4	Smart Conversation	Functionality	Chatbot Interface Chatbot Personality
4.5	Domain Coverage	Coherence Conversation breadth Engagement Depth of conversation	conversational UX Engagement

5 Conversational Agents in Education

Many works can be found on CAs applied in teaching and learning [21, 22], assessment [23], administrative service delivery [24], consulting [25] or research and development [26].

The main advantages of using CA in education include [27]: content delivery, for example the ability for teachers/tutors to provide information in an online platform; quick and easy access, stimulus and engagement of learners. CAs in education also allows providing instant support during individual learning by supporting learners to facilitate activities e.g. delivering homework and evaluations [1], replying e-mails [28], adaptable to students' actions and emotions [29], and fast responses to their queries [30]. Future paths for CA research in aspects related to education include the development of ethical and functionality principles and usability testing. This denotes that the framework for chatbot development and implementation as well as design and content functionality needs to be improved. [27].

6 Conclusions

The development and use of conversational agents is increasing rapidly in multiple application domains. These agents are emerging in the form of virtual assistants, chatbots and other language-based interfaces, interacting with humans as digital assistants, sales bots, customer supporter, among many others. This paper has analysed how these systems are able to carry out coherent conversations with humans in text or speech or both, using natural language. For this purpose, while focusing on the application of conversational agents in education, the paper has identified several of the most promising approaches for the implementation of conversational agents, has reviewed how the performance evaluation takes place, and identified some relevant paths for future research and development, which include the development of functionality and ethical principles in chatbots, and the improvement of usability testing.

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Virtual Assistants Applications in Education

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Abstract. Due to the rapid development of artificial intelligence, popular Virtual Assistants like Amazon Alexa or Google Assistant, can be applied to a wide variety of business areas. One area in which Virtual Assistants can be very useful is in Education, specially due to the pandemics that is occurring during the last years, as it can provide to students, teachers and staff an alternative administration tool as well as introduce new learning processes in classroom or on online classes. This work reviews and analyses some applications of Virtual Assistants in the education process. The reviewed work relies mainly on three categories: Student engagement with academic life, Education process during lessons and Learning of foreign languages. The presented solutions generally have great potential but the majority are simple proof of concepts and need more development and proper tests to enable retrieving more accurate results.

Keywords: Virtual assistants · Education · Learning

1 Introduction

In the last years, Intelligent Virtual Assistants such as Amazon Alexa or Google Assistant have gained great relevance in the market. This traditionally occurs mainly in personal and home assistance; however, in recent years, several solutions have been developed and used by teachers and students in the educational environment [1].

A virtual assistant is a conversational agent that can execute action based on instructions or queries, which have a set of intents, previously trained, that can be triggered by a human or by a system and each of those intentions do a particular task. Also, Virtual Assistants can be proactive and give user useful information based on his context. With the rapidly evolution of speech recognition and natural language understanding, virtual assistants are able already to be applied in various fields such Education, or Industry. Various platforms and frameworks like Google Dialogflow or IBM Watson already can provide to users, services that make able to create high customizable solutions with great accuracy [2].

During the last ten years the way how, humans learn is changing. With the increase of accessibility of the Internet has created massive opportunities to various non-traditional education methods. Online learning, with the help of Covid pandemics, has gradually

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become part of teaching process. This type of education brings various down sides for example the missing of face-to-face contact between teacher and student that make difficulties for teachers to interact and receive feedback from the students and how the students are evaluated. However, this type of education brings various benefits such as Accessibility, because make possible to students, with or without disabilities, access information such as presentations anytime. Because this availability of information anytime, allows students to learn in any location at any time of the day [3].

In education, specifically in online learning, there are some problems with learning effectiveness, for example. The great potential of Virtual Assistants to support students and teachers can be exploited to support these during their courses and lessons by providing new functionalities to the existing platforms. Virtual assistants that are conversational agents can answer various questions to several students at the same time and understand feedback from the users so it's perfect to assist teachers, students, and their lectures in schools around the globe, be these in person or online. These virtual assistants can be very useful in various situations in academic life because cannot only aid in students learning process but in student engagement in the academic life, like provide information about the student schedule or evaluation dates.

In this work we review several relevant applications of Virtual Assistant in Education. First, we analyse works that have applied Virtual Assistants in education context and afterwards we present some use cases where Virtual Assistants can be successfully applied to enhance student engagement and performance.

2 Methodology

This work has conducted a search of papers where solutions for various use cases using virtual assistants in the education context are reported. The search has been performed by setting a query to agile the search of information in various databases such as ACM, Scopus, IEEE Explorer and Google Scholar. The query constructed to search these works is ("virtual assistants") AND (("education") OR ("Learning")). Papers were selected based on the date of publication, which has been defined not to include papers with more than five years, that are not available in English as well as were only selected the papers with "virtual assistants" and "education" or "learning" or "teach" in the title and abstract of the paper. There Were also excluded some papers that cannot be accessed by the federation account available at Universidade de Trás-os-Montes e Alto Douro. Figure 1 depicts the distribution of these papers by main focus area.

After this search, in a first step, the abstract and the introduction of the selected papers were reviewed and analysed, with the objective of organizing the papers in categories to further help with the analysis of the identified use cases. (See Fig. 1) Afterwards, for every category that was defined, it was explained how this general application is important in the education context and are described some specific papers that related a use case of Virtual Assistants integrated with the specific general application. For each use case, the objectives of the work, the implementation of the solutions and the results obtained are analysed.

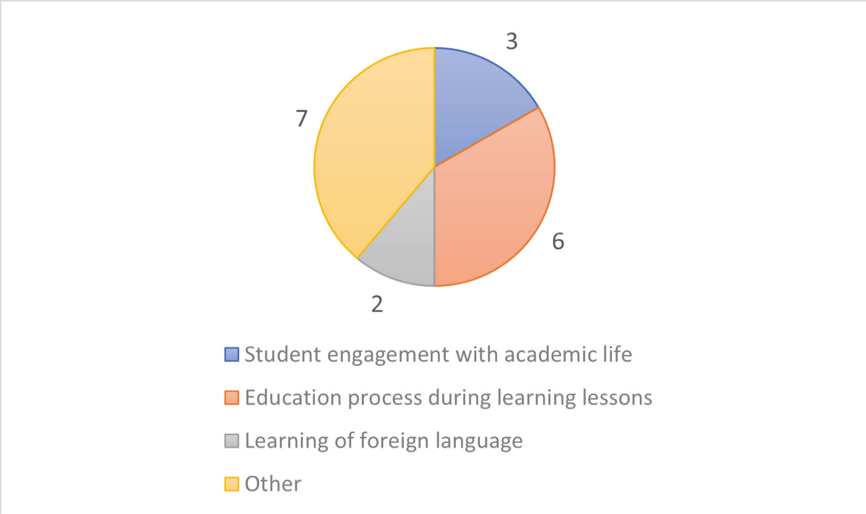

Fig. 1. Papers distribution

3 Fundamentals of Virtual Assistant Construction for Education Applications

To build a virtual assistant capable of responding the user expectations is important to make a proper specification of the solution to be made. Virtual Assistants have various requirements that must be fulfilled like where and how the user will communicate with the assistant (User Interface), how the assistant will understand the user intentions (Application Core) as well as how these assistants can communicate with other services to access data (External data source and services) [4].

In the literature we can found some architectures for example the [5], where the authors designed a modular ecosystem to develop a Virtual Assistant that allow interaction via text, voice, and image with the user. This proposal was focused on a solution to support teachers, students, and IT staff in the education process.

This proposal is a cloud-based modular ecosystem based on the basic general architecture of virtual assistants and chatbots presented by other authors and count with five layers:

– Infrastructure: that represent the starting point and involve the devices used in the interaction between the user and the solution. These are devices that support text, voice and image, inputs, and outputs.
– Technologies: In this layer is included the Big Data to acquire and process various amount of data and Cloud Computing necessary to provide and execute the service anytime.
– AI Elements: This layer represents the fusion of the data (Big Data), the algorithms and the computing power of the cloud computing feature.

– Technical Direction: This layer plays a key role in developing the assistant's logic and intelligence. Are included the Speech Processing, Natural Language Processing, Machine Learning and Computer Vision modules.
– Application: This layer is the final service formed by the other layers that focus on designing a user interface that can be used by various ways (voice, text, …).

This ecosystem proposal is a reasonable option to take in consideration because fulfil the basic requirements that a Virtual Assistant solution need to ensure, like the User Interface that is addressed by the Application and Infrastructure layers, the Application core that is addressed by the AI Elements and Technical Direction layers, as well as External data sources that is addressed by using the Big Data and cloud computing technologies.

With the growth of Virtual Assistants like Google Assistant or Alexa have emerged various platforms where developers can build their custom solutions based on premade and easier to implementation modules provided by these platforms. Various major tech companies have developed their platforms like Google with the Dialogflow or IBM with the Watson.

These platforms can also be used in the education context like in [6] where the main purpose of this paper is to present a methodology that guide an implementation of Virtual Assistants to be reproduced in different educational contexts like study chatbots as tools for learning. The methodology used in that paper was divided in two parts:

– Knowledge abstraction: focused on the gathering and analysing data relevant to the virtual assistant target (in case of this paper the virtual assistant is focused on providing content of a certain course). This part includes the Data gathering that will be obtaining the content of the virtual assistant, the Data manipulation necessary to organize the data to be manipulated by the developers and Data augmentation that is very important to train the natural language processing model provided by Dialogflow.
– Response Generation: that depends on the data collected and structured on the previous part and is basically feed the Dialogflow platform with the data gathered and register the possible responses that can or not include third party integration.

Other aspect that is highlighted by the authors is the flow of conversation and decision trees. These decision trees are used to implement the structure of a virtual assistant. The decision trees contain various nodes connected, and which of this node contains an answer to a particular query.

These platforms to build Virtual Assistants are a good approach to developers that do not have experience in programming, because is possible to build a Virtual Assistant with little code needed. However, to be able to build in these platforms it is necessary to have the data necessary very well structured to be able to feed these platforms properly.

4 Applications of Virtual Assistants in Education

After a succinct reading of the preselected papers gathered in the search phase, were defined three categories that reflect relevant applications of Virtual Assistants in Education. These are:

– Student engagement with academic life.
– Education process during lessons.
– Learning of foreign language

However is important to note that these categories does not reflect all the literature found, as we can see in column "Others" in Fig. 1. The other works found are mainly related to revisions and surveys of virtual assistants and chatbots in education. Were found another papers related to the learning performance of students with help of this kind of solution as well as benefits for people with disabilities.

4.1 Student Engagement with Academic Life

Table 1. Relevant related projects

Reference	Technologies used	Tests with people	Provide information about courses (schedule…)	Solve Administrative problems	Prototype created
[7]	LUIS.AI	X		X	X
[8]	JADE LEAP		X		X
[9]	IBM Watson		X		

As a result of the pandemic that the world faces, the education as well as, the relationship between students and the school environment have changed. Before pandemic all the administrative related problems related with the student engagement with the school, like schedule management, exams scheduling, or other administrative problems, were treated in local and in person between the students, teachers, and non-teaching staff, but suddenly passed to online. This extreme change has brought some problems mainly related with the exchange of important information between all the authors involved.

Various projects have emerged to combat this problem, as presented in Table 1 and with the improvements of chatbots and Virtual Assistants the projects that implement these tools can be very useful and efficient in solving the related problems.

In [7] the authors proposed a solution that is adapted to respond to the problems related to administrative and courses contents in private universities. Related to the implementation on the prototype, the work was divided in several teams assigned to do different tasks like, the Customer services that must define the training texts, the IT that must do the integrations and handle with web services or Marketing that must define the chatbot personality and tone. This work focused on the questions related to the admission of students in IT Engineering. The data necessary to feed the assistant (knowledge) was retrieved from directors, coordinators, teachers and all the people involved. Were prepared questionnaires, that were responded by the people involved and the data collected was categorized, stored and the knowledge base was elaborated. The chatbot was created and integrated in various chat messages such as Facebook or

WhatsApp for better engagement with the users. After the solution implementation were executed tests in a partner university in Ecuador. In the first evaluation the results were not too promising and 50% of users considered the solution did not clear their doubts. The main problem identified was the lack of training of the Chatbot, but after some improvements were executed new tests and was obtained a lower percentage of bad ratings. With these last results the authors demonstrated the effectiveness of the solution implemented.

In [9] the authors implemented a similar assistant to provide information about the content and organization of a certain course. The authors focused on the architecture of the solution that contains the Front-end module (implemented on Slack), the Server module containing the information used in the solutions and all the methods necessary to do the pre-processing and post-processing of the message and the Assistant module that is responsible to understand the user message and their intention. The Assistant module was implemented with the help of IBM Watson Assistant. Since this work was mainly focused on designing the architecture of the solution and only was implemented a simple solution, tests were not performed with other people.

In [8] the authors present a solution to be implemented in a virtual learning space. A virtual learning space can be defined of various types of software components for planning, preparation, organizing and delivery e-learning services and contents like lessons materials. Were developed two Personal assistant, one for teachers and other for students and are responsible for the communication between the users and the Virtual Learning Systems. In this work the assistants were built as multi-agent systems and these assistants will help the users in tasks related to finding information, planning calendars, and managing the education process. Was choose the JADE-LEAP framework for developing the agents that is an extension of Java Agent Development Environment. The work in this paper is mainly related to the architecture of the assistant so the authors does not present any results of their implementation.

4.2 Education Process During Learning Lessons

Another important section where Virtual Assistants can be very useful in the education context are in the learning process, whether in the classroom or in online classes. The authors of [10] have enumerated various roles that conversational assistants can play in teaching/learning processes like:

- Intelligent tutoring systems: customizable learning environments based on the analysis of the student responses and their browsing trail through the digitized content.
- Improve student participation: take advantage of using instant messaging systems that are commonly used by students.
- Teaching assistant: assist in the executing the most repetitive tasks.
- Mentoring functions: provide students with information in an immediate way and guide the students to search for the information.

In the literature exist various examples of virtual assistant application on these areas as depicted by Table 2. In [11] where the authors design the "EconBot" that is to be used by an Economics class with the objective the student for the class exams. The process of creating the solution and putting it into operation has two stages: The chatbot design that consist in the solution design and specification. The authors decided to use a commercial platform for the development of the conversational assistant. As the authors refer the assistant was not developed at the first stage by professional people so were only defined three modules: The trivial conversation module with all the trivial conversation examples like greetings, goodbye, etc.…; The subscription form to the notification, necessary to students be able to subscribe to receive messages; The support and review content module that was implemented to send exercises and questions to the students as well as explanatory content. The second stage was dedicated to implement the administrative module that is responsible of administrative issues like office hours or exam dates. These second stage also included the implementation of the first module totally related with the Economics class, the Microeconomics module where were included by teachers' various books content. The authors have demonstrated the prototype to this class students and was very well received by the students, however with some connection problems. The authors enhance the use of this solution in make up the absence of student care functions in periods such as vacations.

Table 2. Main related works

	Technologies used	Tests with people	Teacher assistance	Student assistance	Mentoring functions	Improve student participation	Prototype created
[11]	Python	X		X			X
[12]	-	X	X		X		X
[13]	Double Agent	X		X		X	X
[14]	IBM Watson	X		X	X		X
[15]			X	X	X		
[6]	Dialogflow	X		X			X

In [13] the authors implemented a Virtual Assistant with help of Double Agent project that is used to add animated and interactive characters to Windows Applications. The target of this assistant is the e-learning and multimedia for education area with the aim of strengthening the teaching-learning process of children through reading and writing. The solution created was tested with a group of 338 students from 3rd to 5th grade and 12 teachers. The results, based on the users, were good in various parameters like Usability, Objective and Didactic coherence or in Pedagogical and functional aspects.

In [14] the authors implemented a Virtual Teaching Assistant called Jill Watson with the objective to operate in online discussion forums by answering frequently asked questions, post weekly announcements and respond autonomously to students introductions. For the development it was used the IBM Watson and already were implemented some versions of this solution. The solution was tested by various students and relative to the version 3 of the solution the students reactions have been “uniformly and overwhelmingly positive”.

In [15] was proposed a collaborative learning environment using Virtual Assistants mainly to support teachers with student emotions detection. The objective is to adapt the view of emotions in order to identify learning emotions of students and to integrate this detection in the learning process management.

In [6] apart from the main objective that was to define a methodology for development and implementation of Virtual Assistants in Education, the authors present a a case study applied to an university with the simple objective of create an assistant that answers predefined questions. With the help of Google Dialogflow it was simple to implement the solution, however can be considered very simple, because does not have much interactions. According to the authors the prototype receive approbation of the students manly due to “it’s accessibility and well structured data”.

In [12] the authors proposed a Virtual Assistant to help students in doing experiments in a web-based simulation laboratory. According to the authors this solution is introduced to compensate for the student’s remoteness as well as to sustain learning by providing feedback or by proposing challenges to test the confidence of the students. This assistant also is used to help the assistants in charge of supporting and evaluating the students. Was proposed an Intelligent Tutoring System that have three agents: Real Assistant (RA); Real Instructor; Virtual Assistant with the objective to provide feedback during the evaluation process. The Virtual Assistant is designed to give regular feedback on the structure of the laboratory journal produced by students and on the semantic of the results and analysis. The Virtual Assistant can give feedback to the students related to their work done and the frequency and type of questions that are asked to the assistant are used to evaluate the student’s behaviour. To evaluate the laboratory journal, it was analysed the consistency of the document that is in XML with the DTD of the laboratory journal. After executing some tests with the students, the authors conclude that the virtual assistant give more freedom and less constrains to the students seeking for feedback.

4.3 Learning of Foreign Language

With the improvement of concepts such as Artificial Intelligence or Machine Learning, various devices such as Google Home, Alexa or Siri can become a teacher’s assistant during the language classes and be able to completely transform the classroom. These virtual assistants can play an important role for example in the interaction with each individual student. Table 3 presents some of the main works related to this subject. In [16] the objectives of the authors were to assess the ability of Amazon Alexa to understand L2 English utterances and to investigate students’ opinions of the Alexa. The bounded system was a group of four EFL (English as foreign language) students at a Japanese university that have approximately 20 min of interaction with the Amazon Alexa. This study investigated the accuracy of Alexa to understand L2 utterances under two conditions: learner-generated commands and interactive storytelling. By analysing the results, the authors refer that the comprehensibility of command performance was poor, with Alexa only understanding 50% of students’ commands. This low rate is justified by misunderstood commands, wake word errors and commands which were not understood by

Alexa. However, the rate of comprehensibility was higher during interactive storytelling (94%). This high rate is justified because the Alexa was programmed to listen for specific words and designated the choice that most closely resembled one of the predetermined responses. Analysing the students' opinions of Alexa to improve language learning, all four students noted that incorporating multiple language support, specifically the native language of the users, could have led to better usability of Alexa. In [17] the authors have the objective of identifying ways to incorporate Artificial Intelligence in classroom language learning. The authors examined the use of multiple IPAs (Alexa, Siri, and Google Assistant) with primary school EFL students over nine months. The authors observed that these AI technologies can give correct responses but often too fast and far easier for students understand and make use of the responses, but generally students quickly learnt what was not likely to get a satisfactory answer and hot to phrase questions in ways that were more likely to be answered. According to the authors the interactions with the assistants made English speaking more meaningful and often joyful. Other conclusion referred by the authors was the inaccurate voicerecognition when students speak simultaneously that can result in inappropriate search results.

Table 3. Main related works

	Technologies used	Tests with people	Using commercial solutions	Using custome made solutions	Prototype created
[16]	Amazon Alexa	X	X		
[17]	Alexa, Siri, Google Assistant	X	X		

4.4 Other Work

Apart for the works found in the areas previously mentioned also were found some papers relative to other areas. A big piece of this works are reviews and state-of-the-art analysis like [18–20].Other paper found is dedicated to people with disabilities [21].

Also was found a comparison between commercial, voice based Virtual Assistants (Amazon Alexa, Google Assistant and Microsoft Cortana) in a Indian Higher Education school [22] where 100 students ask a defined set of questions needed to be responded by these assistants. The authors conclude that simple queries can be taken by virtual assistant but in other complex areas, where counseling or mentoring are required by the student, the performance of Virtual Assistant eventually weakens.

Other aspect that is reported by some authors is the analysis of performance of chatbots and Virtual Assistant in Education. In [23] the authors investigated the impact of a chatbot-based micro-learning system on students learning motivation and performance. The participants of this study were first-year university students. Was made a comparation scenario between traditional learning class where students simply listened to the instructor delivering content through lectures and the chatbot learning class where students interacted with the chatbot-based micro-learning system autonomously to acquire the knowledge. Analysing the results indicates that students' performance improved over two environments, and there is no significant learning performance difference between the two groups. So, the chatbot-based learning system is comparable to traditional teaching without compromising learning performance and has the added benefit of promoting stronger learning motivation. This study reveals that chatbot-based micro-learning strategies comprise a promising technology and are effective in supporting learning among university students.

5 Discussion

In this work we search and analyse some use cases of virtual assistants applied in the education context. Three categories of applications were analysed, these are: student engagement with academic life, education process during lessons and learning of foreign language that somehow can reflect the use cases founded in the previous search that was made.

An aspect that is transversal to all categories is the architecture of the virtual assistant. Various authors have defined various key features (modules) that should be taken in consideration when building a solution, such as User Interface that is related with the human-machine interaction, the Application Core that is related to the main functionalities of the assistant (Speech Recognition, Natural Language Processing) and the External Data source and services that is related to the communication and integration with other services. The architecture plays an important role in a virtual assistant development because can give the guidelines for building a proper and effective virtual assistant. The architectures that were described and analysed in this work, in some way follow and implement the key modules, however each architecture does the necessary adaptions to their problem. As seen in [6] where the authors use a commercial platform to build a solution, we can see a simple architecture, compared to [5], to implement the solution because this kind of platforms already provide the main components that are the machine learning algorithms, that can be used in various situation and is only important to focus on the preparation of the relevant data as well as the conversation flows.

Virtual assistants can provide a very rich way of communication between students, teachers, and academic staff. During the pandemics the relationship between these actors have changed to fully in person to online. This extreme change has brought some problems related to the communication of relevant information, so various solutions emerged to solve the problem. The solutions in general focus their attention in providing information fast mainly by instant messaging platforms like WhatsApp. As seen in [7] and [8] the solutions have in focus the relationship with the student by providing information about the courses content, exam scheduling, classes scheduling or other relevant information to the student.

Related to the education process, Virtual Assistants can also provide essential help in different sub areas like Teaching Assistant or Mentoring functions. The solutions reviewed in our work can rely, in one hand, by providing the necessary content of a course, like theoretical and practical information as well as exercises to evaluate students.

On the other hand, by providing constant help and feedback during classes in order to help and replace some repetitive work of teachers and to provide a constant "virtual teacher" to the students at any time.

Related to the learning of foreign languages using Virtual Assistants the work found rely on making experiments using popular Virtual Assistants like Amazon Alexa or Google Assistant. The work done show that virtual assistant can contribute positively in the learning process however this virtual assistant have some limitation in case of the native language of the student is not available.

By analysing the results of the studies referred in this work reveal that the introduction of virtual assistants was in general very welcome by students, giving the high percentage of satisfaction. These type of solution also can increase the motivation and engagement of the students because provide a very different way of learning.

6 Conclusions

This work has reviewed and analysed applications of virtual assistants in the education context. The identified virtual assistants' applications can rely mainly in two main categories: student engagement and administration in the education context as well as virtual assistants' applications in the classroom and in the learning process.

Regarding the architecture and implementation used in the building process of the solutions, these applications followed a compromising architecture. However, the implementation were very basic and mainly focused on building a proof of concept. IBM Watson and Dialogflow are the most used commercial platforms by authors and developers to build their solutions.

In terms of tests and results presented by the authors, we can conclude that these solutions need to be more intensively tested for longer periods and with the engagement of more people. These proper tests are important to return more trusted results and conclusions.

Finally, there are various areas related to education where virtual assistants can be further investigated, like application in sports education as well as help for disabled people.

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The Impact of Artificial Intelligence on Chatbot Design

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Abstract. Artificial intelligence is transforming the way chatbots are created and used. The recent boom of artificial intelligence development is creating a whole new generation of intelligent approaches that enable a more efficient and effective design of chatbots. On the other hand, the increasing need and interest from the industry in artificial intelligence based solutions, is guaranteeing the necessary investment and applicational know-how that is pushing such solutions to a new dimension. Some relevant examples are e-commerce, health or education, which is the main focus of this work. This paper studies and analyses the impact that artificial intelligence models and solutions is having on the design and development of chatbots, when compared to the previously used approaches. Some of the most relevant current and future challenges in this domain are highlighted, which include language learning, sentiment interpretation, integration with other services, or data security and privacy issues.

Keywords: Artificial intelligence · Chatbots · Conversational agents · Natural language processing

1 Introduction

Chatbots are used in a variety of applications outside of mimicking human interaction and entertaining people, including education, business and e-commerce, healthcare, and entertainment [1]. Productivity is the most popular use of Chatbots. Other reasons include enjoyment, social interactions, and novelty interaction. Also, because chatbots cut costs and can serve many people simultaneously, they have become increasingly popular in business. Chatbots are more enjoyable and appealing to customers than static content searches in frequently asked questions (FAQs) lists, which is why they are becoming increasingly popular in business. They provide users with a more engaging answer to their questions than the than the plain-text answer provided by FAQs [2].

In addition to pleasant interaction, chatbots also offer a variety of other benefits for businesses. Chatbots can help companies reduce costs, increase productivity and

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improve the customer experience. Chatbots are becoming increasingly popular in business because they offer an efficient solution to many problems faced by businesses. [3, 4] Artificial intelligence has been developing over time, and with it we have seen increasing changes in the labor market. As technology advances, chatbots are gaining space in the communication between companies and consumers, facilitating an interaction. In this article, we will deal with the impact of artificial intelligence in the design of chatbots, analyzing the benefits and possibilities that this technology brings to this sector.

Artificial intelligence is transforming the way chatbots are created and used. Before, chatbots were programmed with pre-defined answers, which limited their interactions. With artificial intelligence, chatbots can be trained to interpret and respond naturally to user messages, as if it were a real person speaking [5].

With the advent of virtual assistants like Siri and Cortana, as well as the growing popularity of chatbots, we are starting to see a future where humans and machines interact more seamlessly than ever before. [6] This change could have a profound impact on the way we work and live our lives. In order to understand what is happening, we must first look at how humans interact with machines.

2 Why Are Natural Language Interfaces Necessary?

For [7] the way humans communicate with machines is very specific. Commands must be followed exactly, or they do nothing. This can result in errors when commands are not given correctly, which limits the potential for human-machine conversation. NLI attempts to solve this problem by allowing the user to express themselves naturally, rather than carefully following formatted commands.

It further states that with the ever-increasing number of tasks that humans are expected to complete each day, adding more complexity would be infeasible without some method to simplify these tasks. Natural language interfaces provide a way for users to interact with complex software using simple conversation [8].

3 Why Now?

Advances in computing power and software engineering have led to the ability to process large amounts of information, as well as store and collect it. [9] This is necessary for a natural language interface to function effectively, so the technology has only just become possible.

The increased use of smartphones and tablets has also led to greater familiarity with touch-based interactions. This means that as these devices begin to replace PCs as the primary computing device, users will be less intimidated by voice-controlled software.

4 Benefits of Artificial Intelligence in Chatbots

The benefits of artificial intelligence in chatbots are diverse, and Adamopoulou Moussiades, [10] highlight the following:

- Increased productivity: Artificial intelligence allows chatbots to answer multiple questions at the same time, which increases the productivity of the productivity of the company.
- Greater customer satisfaction: Chatbots trained with artificial intelligence are able to respond more naturally to customer questions, which customers, which satisfies them and makes for a more pleasant experience.
- Cost reduction: Artificial intelligence allows chatbots to solve complex problems without the intervention of a human being, which reduces company's costs.
- Increased efficiency: Chatbots trained with artificial intelligence can solve complex problems without the intervention of a human human intervention, which increases the company's efficiency.

5 What Are Chatbots ?

Chatbots are software designed to simulate a human conversation through text or voice [10] Chatbots are becoming increasingly popular in organizations because they are an easy way to interact with their customers. In addition, they can be used to solve complex problems without the intervention of a human being.

According to Kumar Ali [11], there are two main types of chatbots:

1. Rule-based chatbots: They are conditioned to answer certain questions that have been created from the beginning. Users are only allowed a limited number of input options in this type of Chatbots. The advantage of this type of chatbots is that they are easy to create and implement, but the disadvantage is that they are easy to create and implement, but the disadvantage is that they are limited in terms of responsiveness.
2. AI Chatbots: These are designed to interact with users like a genuine person, and have the ability to maintain context and word dictionary. In addition, this type of chatbot requires a complex number of logical adaptations. The main difference between this type of chatbots and the previous ones is that they are able to understand the context of the conversation. In addition, they can be trained to be more flexible and customizable.

6 The Relevance of Artificial Intelligence in the Creation of Chatbots

Artificial intelligence is an emerging field of study that focuses on creating machines capable of performing tasks that the normal mind would require human intelligence. Artificial intelligence is already being used to create more realistic chatbots. There are several reasons why companies may choose to use artificial intelligence in their chatbots.

One reason is that intelligent chatbots can provide a more human experience to their users. This is because intelligent chatbots learn how people behave and interact, and then mimic this behavior. This means that chatbots can adapt to changes in user behavior and provide a more natural experience.

Hung et al. [12], point out that the other reason organizations may choose to use artificial intelligence in chatbots is that this technology allows them to be more personalized. Because intelligent chatbots learn about their users, they can provide a more personalized experience. This means that chatbots can provide more relevant answers to users' questions and can also suggest new products or services that may be of the user's interest.

The same authors add that artificial intelligence may also allow chatbots to be more useful. Because chatbots can learn about their users, they can provide more useful answers to users' questions. In addition, chatbots may also be able to perform tasks that are useful, such as scheduling a meeting or booking a hotel.

Ferreira et al. [13], add that artificial intelligence can also allow chatbots to be faster. As intelligent chatbots learn how people behave and interact, they can mimic this behavior. This means that chatbots can provide faster answers to users' questions. This speed is mostly due to the fact that chatbots do not need a pause to think about answers, as is the case with people.

7 How Artificial Intelligence Impacts Chatbot Design

Artificial intelligence is becoming increasingly important for chatbot design. It can help chatbots adapt to changes in user behavior and provide a more natural experience. In addition, artificial intelligence can also enable chatbots to be more personalized and useful. However artificial intelligence should not be used as a replacement for human design. Instead, it should be used as a complement to help designers create better and more useful chatbots [14].

Artificial intelligence is impacting chatbot design in such a way that it allows chatbots to respond naturally to customer questions. According to Luo et al. [14], chatbots were initially programmed with pre-defined responses, which limited their interactions. With artificial intelligence, chatbots can be trained to interpret and respond naturally to user messages, as if it were a real person interacting.

8 Conclusions and Future Work

To conclude, artificial intelligence is becoming increasingly relevant not only in the design of chatbots, but also in the creation of other automated systems. Artificial intelligence allows chatbots to be more realistic, personalized and useful. In addition, an artificial intelligence can also allow chatbots to be faster. As artificial intelligence continues to evolve, it is likely that these advantages will likely increase.

Nevertheless, it is worth remembering that and there are challenges, and one of them is that with the implementation of AI interfaces in chatbots, they typically require intensive model training and a large amount of data. The learning ability of artificial intelligence is essential if chatbots are to be trained to handle the nuances of human communication. However, acquiring this data can be a long and expensive process, particularly if the data is dispersed across multiple sources, although there are already trained AI models such as of GPT-3 available for use and integration [15]. In addition, maintaining an IA interface can require a great deal of effort, as interfaces are bound to evolve as the domain changes.

There are several research challenges that still need to be resolved before artificial intelligence is fully adopted as the sole method used in designing chatbots. According to Hristidis [16], these challenges include:

– Language learning: AI chatbots do not yet communicate perfectly in all languages, which limits their use for some countries.
– Sentiment interpretation: AI-enabled chatbots still have trouble interpreting users' feelings, which can lead to incoherent interactions.
– Costs: Acquiring and processing the data required for training artificial intelligence can be expensive.
– Integration with other services: Chatbots with artificial intelligence are not yet fully integrated with other services, which limits how their capabilities.
– Security: Data security is a big challenge for AI chatbots, since they can store sensitive information.

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Correction to: On Modeling LMS Users' Quality of Interaction Using Temporal Convolutional Neural Networks

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In the originally published chapter 11 the name of the Author was misspelled. The Author's name has been corrected as "Sofia J. Hadjileontiadou".

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