Daniel Burgos · Marta Cimitile ·
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Christian M. Stracke (Eds.)

Communications in Computer and Information Science 1091

Higher Education Learning Methodologies and Technologies Online

First International Workshop, HELMeTO 2019
Novedrate, CO, Italy, June 6-7, 2019
Revised Selected Papers

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Preface

This volume of *Communication in Computer and Information Science* (CCIS) contains the post-proceedings of HELMeTO 2019, the First International Workshop on Higher Education Methodologies and Technologies Online. The event was successfully held at the headquarters of the eCampus University, Novedrate (CO), Italy, during June 6–7, 2019. HELMeTO 2019 aimed to bring together researchers and practitioners working in *Higher Distance Education Institutions* or studying *Online Learning Methodologies* to present and share their research in a multidisciplinary context. The workshop provided a forum for the discussion of new research directions and applications in these fields, where different disciplines effectively met, divided into two main tracks: Online Pedagogy and Learning Methodologies, and Learning Technologies, Data Analytics and Educational Big Data Mining, together with their applications.

Some examples of the discussed interdisciplinary topics are: pedagogical framework studies, learning models, learning outcomes, online learning communities, blended learning, online peer assessment, social learning, evaluation for online education, assessment methods in online and blended learning environments, assessment and accreditation of courses and institutions, computer-aided assessment, community building, context dependent learning, course design and e-learning curricula, digital libraries for e-learning, distance and e-learning in a global context, e-learning platforms and portals, e-testing and new test theories, distance education, immersive learning, learning organization, mobile learning (m-learning), simulated communities and online mentoring, supervising and managing student projects, teacher evaluation, security aspects, standards and interoperability, ontologies and metadata standards, theoretical bases of e-learning environments, Web-based learning, wikis and blogs, educational Big Data mining, learning analytics, prediction of the students' performance, design of proper retain strategies exploiting learning analytics, and educational Big Data.

HELMeTO 2019 received 39 total submissions, 29 of which were selected for presentation at the workshop as either long or short talks. We accepted 17 high-quality papers (43% of the original submissions) for publication in an extended version in this post-proceedings volume (15 long papers of more than 12 pages and 2 short papers of more than 8 pages), after a single-blind review round performed by at least three Program Committee members.

Submissions and participants in HELMeTO 2019 came from seven different countries, including Greece, India, Spain, Italy, the UK, Colombia, and Pakistan, immediately making HELMeTO an international event. Following this ever-increasing international spirit, future HELMeTO editions are also expected to be held outside Italy.

Many people contributed to this successful edition. We express our gratitude to the authors for submitting their works, to the members of the Program Committee, coming from eight different countries (Italy, Spain, the Netherlands, the UK, China, the USA, Germany, and New Zealand), for devoting so much effort to reviewing papers despite a tight schedule, and finally to the invited speakers of the two HELMeTO main tracks and the special track on "The Challenge of Online Sport and Exercise Sciences University Programs."

Our gratitude also goes to the eCampus University for offering the venue for the event, which allowed the workshop to be held in a technological and green atmosphere, and to SIREM, Società Italiana di Ricerca sull'Educazione Mediale. We would also like to mention Rosanna Di Nuzzo for being a constant source of fruitful inspiration, help and ideas for HELMeTO itself.

June 2019

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Contents

Online Pedagogy and Learning Methodologies

The 'Sophisticated' Knowledge of *e-Teacher*. Re-shape Digital Resources for Online Courses

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Abstract. The following exploratory study aims to investigate the e-teacher's adaptation of multimedia teaching materials and deepen how the specific disciplinary contents have been digitally mediated to promote students' learning. It took place structuring a single case-study through the Yin's procedures for multiple-case-study protocol: definition of the units of analysis, selection of the comparable 'entities', data analysis and triangulation. This method allows to analyze qualitative and quantitative data regarding the digital contents of the online course 'General Didactics and Educational Technologies' in the degree L-19 'Sciences of Education' at Giustino Fortunato University of Benevento. The opening analysis presented has been carried out on the visual material setting three 'units of analysis': *content*; *disciplinary content*; *digitalized disciplinary content*. The results allow to obtain information about the process of 'mediatization', realized by the e-teacher, and guidance information for the study on the effectiveness of the *digitized disciplinary contents* used and on the effect they have on learnings of students.

Keywords: E-teacher · Multimedia teaching materials · TPACK

1 Introduction. The Quality of Teaching Online Courses

Documents and researches (MIUR, DM n. 47/2013; ANVUR 2017; Barrable et al. 2018) confirm that in order to respond to students' expectations and well-being it is necessary to invest in the quality of the educational offer and services, not only in terms of counselling but also regarding the teaching strategies: among these, a specific focus is to be done on the quality of the digital resources of online courses.

According to the last 'Grade Increase' report by the Babson Survey Research Group (BSRG 2015), the student's enrollment in online courses increased at a faster pace between 2015 and 2016 compared with the previous three years. Students, moreover, are increasingly choosing local online degree programs, as they prefer

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'hybrid' learning over 'on-line' oney[1]. This would be the 14th consecutive year that Babson has registered an increase in online enrollment, even in bad economic times. The previous BSRG's survey (2015) recorded the year increase of 3.9% of the number of students in on-line courses, compared to the rate of 3.7% of the previous year. More than one in four of the U.S. students (28%) attended at least one distance learning course (for a total of 5,828,826 students). Also the percentage of academic leaders who rate learning outcomes in online education as the same or higher than those in face-to-face education is stable at 71.4%. In order to continue to maintain such standards, however, it is increasingly necessary to invest in quality services and learning opportunities for students – as known, MIUR, DM n. 47/2013. The Ministerial Decree n. 47/2013 containing rules for self-assessment, initial and periodic accreditation of university's venues and courses – for state, special-order institutes, legally recognized non-state and online universities - make it clear that the National Agency for University and Research Evaluation (ANVUR) verifies the requirements for the analysis of the 'results of the monitoring and quality control activities of the teaching and research activities' carried out by all those involved in the university's quality system, in addition to the 'structural' data (i.e. the information contained in the SUA-CdS, that is the consistency between the objectives of each course and the expected professional profiles. Among the technical requirements for the periodic accreditation of study courses, specific to distance courses (ANVUR 2017) are the assessment of student learning outcomes, system integration (e-learning teaching and other services of University), the quality of didactic integration (relative to student-tutor interactivity) and technological solutions, as well as the qualification of academic and service staff and the quality of the multimedia teaching material. Given the special didactic feature of the online universities, it is no coincidence that among the requirements (see 9.1, 9. 'The requirements and quality indicators of the offices, teaching, research and third mission') there is the 'recruitment and qualification of the teaching staff' (including the tutors) that play a crucial role and highlighted as a 'point of attention'. This qualification should take place through 'training activities in terms of methodological and technological updating for the production of multimedia content, for the management of distance learning activities and for the use of technologies'. This aspect is already mentioned in the document (see 6.2.1, 'Additional technical requirements for periodic accreditation of distance study courses', 6.2 'Quality requirements for accreditation of universities and CDS') in the point of attention on the 'Qualification of the personnel and endowment of the didactic material for the online CDS': in order to adopt technologies and the substitutive methodologies of the 'face-to-face' learning, is necessary 'planning and carrying out training and updating activities for teachers and tutors for online teaching and support for the provision of multimedia teaching materials'.

The ANVUR guidelines interpret and contextualized the European suggestions retrieved in the document 'Standards and Guidelines for Quality Assurance in the European Higher Education Area' (ENQA 2015). In this document there is an

[1] Another study by the National Survey of the Online and Digital Learning Canadian Digital Learning Research Association (2018) confirms that the students' learning outcomes - taken as a Quality data, compared to face-to-face courses and on-line courses - is 18% superior compared to 'face-to-face' and 10% compared to online.

interesting aspect regarding the qualification of teachers and the provision of quality teaching materials and left somewhat implicit in the ANVUR guidelines: the ‘personalization’ of learning situations and materials, detectable in points 5 and 6[2]. University institutions ‘should ensure the competence of their teachers’ as ‘the role of the teacher is essential to create a high quality student experience and allow the acquisition of knowledge, skills and abilities’ (see point 5 - *Teaching staff*). This is defined as an ‘evolving’ role, not only on the characteristic of technological mediation of teaching but, above all, the ‘diversifying student population and stronger focus on learning outcomes’ (ENQA 2015, p. 13). The document recommends to train and support[3] a new class of e-teachers that achieves student-centered learning through continuous professional development, commitment to scientific activity ‘that strengthens the link between education and research’, the choice to innovate ‘teaching methods and the use of new technologies’. In point 6 ‘Resources for learning and support for students’, the personalization of programs and materials is even more explicit: ‘institutions should have appropriate funding for learning and teaching activities and ensure that adequate and readily accessible learning resources and student support are provided (ENQA, 2015, p. 14). Support services - such as libraries, study facilities, human support (i.e., tutors, counsellors) for a diverse student population (such as mature, part-time, employed and international students as well as students with disabilities) are recalled. National and international documents seem to agree in re-describing the relationship between the elements of the teaching-learning process of online courses: although the aim is always to raise the students’ learning outcomes, these would be favored by greater respect for the specific needs of the students and professional preparation of teachers. Already claimed by research (Guri-Rosenblit 2018; Gros 2011; Alexander et al. 2017; Bates and Sangra 2011; Educational Testing Service 2009; Ubachs et al. 2017; Wilson et al. 2004), this aspect directs the reflections on knowledge and competences of the e-teacher and allow to extend the descriptive model of the teacher’s knowledge about the things to teach (*content*), to whom to teach (*student*), the way to do it (*teaching strategies*) – see TPCK (Technological Pedagogical Content Knowledge). It is well known that the e-teacher of an online university course already uses devices specially set up to meet and support e-student learning (Limone 2007) - as online forums, e-tutoring, virtual rooms (Heching et al., 2015; Zhu et al. 2014). It would be useful to focus the investigations on a specific aspect of the e-teacher’s knowledge – the ability to select, modify and produce digital content, useful

[2] The guidelines are articulated in quality assurance policy; design and approval of programs; student-centered learning, teaching and evaluation; student admission, progression, recognition and certification; staff of teachers; resources for learning and student support; information organization; public information; ongoing monitoring and periodic review programs; external and cyclical quality assurance.

[3] ‘Higher education institutions have primary responsibility for the quality of their staff and for providing them with a supportive environment that allows them to carry out their work effectively’ (ENQA, 2015, p. 13): provide transparent and equitable processes for the recruitment, offer opportunities and promotes the professional development of teaching staff, encourages scientific activity to strengthen the link between education and research and innovation in teaching methods using new technologies.

for the e-students' learnings - as subtract placed in national and international documents (ENQA 2015; ANVUR, 2017).

2 The E-Teacher's Knowledge

Guri-Rosenblit (2018, Guri-Rosenblit and Gros, 2011) pointed out that 'the discourse on the implementation of the digital technologies in higher education settings focuses mainly on students' learning rather than on professors' teaching' (2018, p. 93). The low attention paid to the crucial role of teachers in online settings reinforced the teacher's 'innate skepticism' (a preconception) on the opportunities offered by technologies and the lack of knowledge about the possible adaptation of learning supports. E-learning is today a dominant learning model but technology alone is not sufficing (2008, p. 95). E-students are increasingly in need of digitally skilled academic staff (technicians, e-teachers, e-tutors) and, for this reason, universities providing online courses must be able to develop new profiles for their staff to be trained, evaluated, and accounted for. Guri-Rosenblit (2018) outlines the studies that have deepened the roles and tasks that teachers should undertake when they use new technologies in teaching (Alexander et al. 2017; Bates and Sangra 2011) and online teaching (Educational Testing Service 2009; Ubachs et al. 2017; Wilson et al. 2004). The first study (Wilson et al. 2004) depicted the following tasks:

- 'provide the infrastructure for interaction and work, including syllabus, communication tools, and information resources
- model effective collaboration and knowledge construction
- apply instructional strategies
- supervise student activities
- monitor and assess learning, providing feedback, remediation, and grades
- troubleshoot and resolve problems, including meeting needs of hard-to-reach students
- establish trusting relationships with students' (2004, p. 9).

This seems to be a long list of tasks 'which most of the professors have not been prepared for in their socialization processes into the academic world' (Guri-Rosenblit 2018 p. 95)[4]. The Educational Testing Service (ETS), afterwards, developed the *ICritical Thinking* certification program (Educational Testing Service 2009), a list of seven task, useful for representing the essential digital literacy needs of e-teachers in order to prepare students with applied computer literacy skills. These tasks are:

- *define* ('understand and articulate the scope of an information problem in order to facilitate the electronic search for information');
- *access* ('collect or retrieve information in digital environments');

[4] Guri-Rosenblit points out that 'most academic faculty are not well-equipped to guide students in developing the digital competencies they need' (p. 95) e refers to the Stanford History Education Group (Wineburg et al. 2016) on history scholars 'who were trained over decades to look closely and critically at texts. Yet, many could not navigate a simple problem of web credibility' (p. 95).

- *evaluate* (‘judge whether information satisfies an information problem by determining authority, bias, timeliness, relevance, and other aspects of materials’);
- *manage* (‘organize information to help others find it later’);
- *integrate* (‘interpret and represent information using digital tools to synthesize, summarize, compare, and contrast information from multiple sources’);
- *create* (‘adapt, apply, design and construct information in digital environments’);
- *communicate* (‘disseminate information tailored to a particular audience in an effective digital format’) (Educational Testing Service, 2009, p. 3; Guri-Rosenblit 2018, p. 95).

Comparing with the previous one (Wilson et al. 2004), the ETS’s list is more focused on the e-teacher’s mediation role between contents and students - such as search, find, critically select and make sense to the information available through digital technologies; it refers to ‘integrated’ but diversified tasks: from making information available (*access*), to mediating them on the base of contents’ meanings (*evaluate* and *manage*), structure of knowledge (*integrate* and *create*) and characteristics of the students (*communication*). Focusing on the last three tasks - *integrate*, *create*, *communicate* - it is possible to grasp the aspect closely linked to the ‘sophisticated’ (Agrati 2019) mediation (Damiano 2013) and mediatization (Rezeau 2004) work, performed by the e-teacher. In the task of *integration*, the e-teacher represents information and re-elaborates it in a synthetic form by comparing it with other sources, useful for extending the knowledge of e-students and the ability to understand its internal connections.

In the task of *creation*, the e-teacher actually creates *new entities of knowledge* other than the information found in textbooks or common online sources as these are originally designed to be easily apprehended by students. In *communication* task, the e-teacher adapts the *new created entities* due to the typology of students - mature, part-time, employed, with other couture, with disabilities etc. - see ENQA 2015).

This focus also allows to discuss the well-known descriptive model of the techno-pedagogical knowledge (Technological Pedagogical Content Knowledge) of teachers as it highlights the adaptation component - typical of e-learning processes and not adequately developed by the TPACK authors (Koehler, Mishra, and Yahya, 2007; Koehler and Mishra, 2009; Koehler, Mishra and Cain 2013), in the first instance.

2.1 From TPACK to ‘Sophisticated’ Knowledge

The Technological Pedagogical Content Knowledge (TPACK - Harris et al. 2009; Koehler, Mishra and Yahya 2007) is a conceptual model that describes knowledge and skills by teachers in teaching trough technological mediators (on-line settings, technological devices etc.)[5]. The complex ‘techno-pedagogical content knowledge’,

[5] The components of TPACK are based on that already identified in by Shulman (1986, 2004): Technological knowledge (‘knowledge of the technologies and skills necessary to operate with them - TK); Pedagogical knowledge (‘Teaching/learning processes and practices, methods and approaches’ - PK); Knowledge of content (‘teachers’ understanding of the semantics and syntactic organization of a discipline’ - CK, Starkey 2010).

used – many times consciously - by the teacher in the difficult work of pedagogical translation of the disciplinary contents through the technologies, is thus represented by three intersections (Fig. 1):

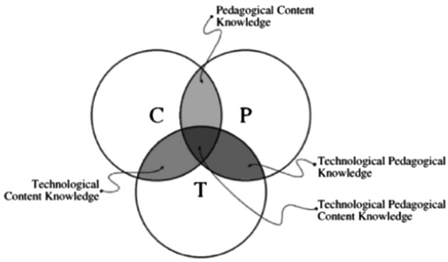

Fig. 1. The TPCK model (Mishra and Koehler 2006, p. 1025)

a. Technological Pedagogical Knowledge (TPK) - between technological devices and specific pedagogical strategies (Kurt 2018; Terpstra 2015);
b. Pedagogical Content Knowledge (PCK) - between pedagogical strategies and specific disciplinary contents (Kurt 2018; Shulman 2004);
c. Technological Content Knowledge (TCK) - between technologies devices and specific disciplinary contents (Kurt 2018; Mishra and Koehler 2006).

As the ETS's list suggest, a *greater effort* is needed for the e-teacher (Guri-Rosenblit 2018): re-shape one's own specialized contents ('mediatization', Rézeau 2002; 2004) - through the opportunities of the learning environment) and adapt them to the characteristics and learning needs of students.

The TPACK model would then lack the space for adapting disciplinary content to the specific needs of students: generic pedagogical strategies are not sufficient, but the creation of new 'knowledge entities' is required, suitable for being adopted by e-students (ETS - *create* and *communicate*). In other words, l'e-teacher should develop 'the ability to teach content from the students' point of view' (Ben-Peretz 2011, p. 4), making the most of the possibilities offered by the e-learning environment. An extension of the TPACK, more complex (Damiano 2013) and 'sophisticated' (Agrati 2019), is required in order to describe the e-teacher's knowledge. This could concern: in general, the choice and the provision (ANVUR 2017; *define*, *access*, *evaluate*, *manage* - Educational Testing Service 2009) of digital contents that are effective from the organizational point of view; specifically, the adaptation and the re-shaping (Eilam 2015) of knowledge to be taught on the bases of e-students characteristics (*integrate*, *create*, *communicate* - Educational Testing Service, 2009; ENQA 2015) that are effective from the outcomes learnings point of view. As Guri-Rosenblit (2018), suggests, professional training should be guaranteed then on all levels of the tasks required to e-teachers, in order to avoid these becoming 'disenchanted with both the product and the process' (p. 95) of e-learning and that this disenchantment affects e-students. This complex work of mediation and mediatization consists in adapting the specialized contents of a specific area of knowledge (disciplines) to the specific needs of e-students and thus creating 'new entities' of knowledge useful for entire humanity (Eilam 2015). Academics should therefore have a more flexible relationship with their own discipline, learn more about student characteristics, experiment with advanced learning tools from technology and 'discuss the pedagogy underpinning their uses, in order to be able to facilitate student engagement' (Alexander et al. 2017, Johnson et al. 2016, Wineburg et al. 2016)'.

3 A Case-Study on Digital Contents

An exploratory study is represented below: it aimed at investigate the e-teacher's adaptation of multimedia teaching materials and deepen how the specific disciplinary contents have been digitally mediated to promote students' learning. The exploratory case-study (Stake 1995) started from the question: how does the e-teacher adapt the multimedia materials, functionally to the content to be taught (Oleson and Hora 2013) and to the specific needs of students?

It took place structuring a single case-study through the Yin's procedures for multiple-case-study protocol (2003, 2012) – see Fig. 2, steps already done in bold: definition of the units of analysis, selection of the comparable 'entities' (Bartlett and Vavrus 2007), data analysis and triangulation. This method allows to analyze qualitative (non-numeric, categorical) and quantitative (numeric) data – i.e., field and video notes, writings, audio-video-recording – regarding the digital contents (Bonaiuti 2011; Ganino 2018) of the on-line course 'General Didactics and Educational Technologies' in the degree L-19 'Sciences of Education' at Giustino Fortunato University of Benevento.

The study will continue with a comparison of other case studies to bring out the change in the theory and evaluate the implications for the university organization (Fig. 2).

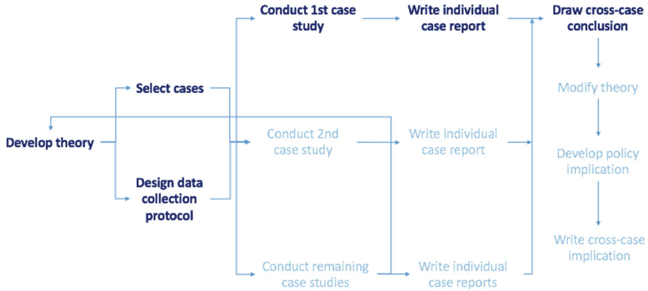

Fig. 2. - Procedures for multiple-case-study. Adapt: Yin (2012)

3.1 Units of Analysis

The opening analysis, presented below, has been carried out on the visual material setting three 'units of analysis': *content* – the essential theoretical content that the e-student needs to know; *disciplinary content* – the representation of this content, provided by the specific discipline; *digitalized disciplinary content* – the adaptation of this 'disciplinary' representation, necessary for the e-learning activity (a video-lesson).

The following analysis concerned the specific theoretical content (relationship Didactic - Pedagogy - *content*). This content has been explained through the well-known representations offered by the 'Poly-referential paradigm' (Laneve 1993) and the 'Ecosystem of disciplines' (Frabboni 1999) (*disciplinary content*).

Comparable 'entities'

These representations have been digitalized by means of static (images and explanatory text) and dynamic (2D animations) supports – i.e. diagrams and graphic organizers included in the video lessons (*digitalized disciplinary content*).

In this way, information about the process of 'mediatization' (Rezeau 2004), realized by the e-teacher, has been inductively derived, in reference to three phases (Educational Testing Service 2009; Guri-Rosenblit 2018):

- *Select-integrate* - choose the disciplinary content and summarize the essential information ('how the contents of the textbooks have been first outlined'). The *disciplinary contents* represent two different ways of understanding the relationship between Didactic and Pedagogy. The 'Poly-referential paradigm' interprets in a formal way the relationship, introducing further analytical levels of distinction - such as 'strategies' and 'epistemology' (*sub-contents*); the 'Ecosystem of disciplines' proposes instead a 'systemic' and empirical reading, recognizing all the disciplines in a functional and useful relationship.
- *Create* – adapt the original representations in a digital format ('how these schematizations have been graphically elaborated') – see Fig. 3a and b. For the *first disciplinary content* ('Poly-referential paradigm') an animated graphic has been created, that makes the two levels of sub-content ('strategies' and 'epistemologies') clear through the appearance of shapes and colors at different times in post-production; for the *second disciplinary content* ('Ecosystem of disciplines') a static and evocative image[6] of a natural ecological system has been used, supported by an explanatory text[7].
- *Communicate* - tailor the digital format to a particular audience (mature, newbie and employed students) (how these graphic elaborations have been adapted to the e-students' characteristics). Refers the explanatory effectiveness of the representations used and the effect they have on students' learning - as clarified below.

[6] According to the distinction, introduced by Hegarty et al. (1991) and supported by Paoletti (2011), the Fig. 3b is an 'image/diagram' as it represents a concrete referent (*tree*) but also the functioning (*the ecological system*).

[7] According to the 'dual-coding theory' (Paivio 1990), this favors the integration of information and the processing of mental images, above all if usefully activated by the times of appearance of the animation and the space where the text is placed. It is the so-called 'visually integrated format' that reduces the cognitive load (Ganino 2018, p. 119; Mayer 2009).

a. Poly-referential Paradigm

b. Ecosystem of Disciplines

Fig. 3. - Graphical representations of the two *disciplinary content*

3.2 Data Analysis

The explanatory effectiveness of the analyzed graphic elaborations has been obtained through deductive - Mayer’ (2005 p. 69) and Ainsworth’s (2014) analytical criteria - and inductive procedures - e-students’ answers to questions regarding the same content in tests (Tab. 1). The generative theory of multimedia learning (Mayer 2002, 2005) and the studies on the communicative function of the different types of images (Clark and Lyons 2010) for teaching remain that the choice and the adaptation of mediators must favor in the students the construction of an ‘integrated’ memory model that brings together verbal and pictorial information and previous knowledge. The animated graphic for ‘Poly-referential paradigm’ and the evocative image for ‘Ecosystem of disciplines’ have been analyzed trough the deductive Mayer’ (2005) criteria. – see Tab. 1.

Table 1. Five kinds of knowledge structures (Adapt: Mayer 2005, p. 69.)

Type of structure	Description	Representation	Example
Process	Explain a cause-and-effect chain	Flow chart	Explanation of how the human ear work
Comparison	Compare and contrast two or more elements along several dimension	Matrix	Comparison of two theories of learning with respect to the learner, teacher, and instructional methods
Generalization	Describe main idea and supporting details	Branching tree	Presentation of thesis of the major causes of the American Civil War along with evidence
Enumeration	Present list of item	List	List of the names of twelve multimedia design
Classification	Analyze a domain into set and subsets	Hierarchy	Description of a biological classification system for sea animals

In particular, the studies of Ainsworth (2014) allow to understand the pedagogical functions (see Description list in Table 1) of the mediators’ type of structure - already identified by Mayer - and, thus, better understand the representative effectiveness for the learnings of students. From the point of view of the mentioned analytical criteria:

- the Poly-referential Paradigm (Fig. 3a) recalls the *enumeration* and *classification* criteria – it represents the list of knowledge domains related to the Didactic, although placed in a circular shape; thanks to the animated graphics, it highlights the sub-groupings of these domains introducing a distinction criterion between ‘intervention strategies’ and ‘epistemology’;
- the Ecosystem of Disciplines (Fig. 3b) refers the *process* and *generalization* criteria – it represents the cause-effects ‘systems’ in which each (disciplinary) element is linked to the others; however, it is also able to explain the weight of each of them (i.e. the methodology as ‘root’ of the tree).

4 Results

As Mayer suggests (2002, 2005), the *digitized disciplinary content*, used in the online training course, can be divided into textual, visual and audio content. The analysis according to the taxonomic criteria shows, among other things: a. the predominance of the graphic text over the written text; b. the different function performed by *digitalized disciplinary content* with respect to student learning.

This last aspect was deepened by comparing, specifically, the results of the students’ texts - which answered the questions regarding. In the students’ answers (n. 12) regarding the disciplinary content, taken as target in this study, is possible to note an increase compared to the average of the total answers (Table 2).

The *digitized disciplinary content* of ‘Ecosystem of disciplines’, responding to the criteria of *process* and *generalization* (Mayer 2002) is more effective (+.7) than the ‘Poly-referential paradigm’ (+.3), with the criteria of *enumeration* and *classification*.

Table 2. Triangulation of analysis criteria

Topic	Graphic elaborations (e-topic)	Mayer and Ainsworth taxonomy	e-students’ average test score*
Poly-referential Paradigm	Figure 3a	Enumeration, Classification	8.3 (+.3)
Ecosystem of disciplines	Figure 3b	Process, Generalization	8.6 (+.7)

* deviation from the total average

The further analysis will check if this increase remains constant as the number of answers increases and if it depends on intervening factors, such as the age or status of the students - mature, part-time, employed, with disabilities or difficulties.

However, the results allow to obtain guidance information for the study on the effectiveness of the *digitized disciplinary contents* used and on the effect they have on learnings of students - as expected at the *Communicate* comparable ‘entities’ (par. 3).

On the basis of the data, in fact, it is possible to infer at the moment that: the animated graphics, used for the first *disciplinary content* (‘Poly-referential paradigm’, Fig. 3a), did not directly influence on the increase, compared to the ‘image/ diagram’ - used for the second disciplinary content (‘Ecosystem of disciplines’, Fig. 3b - Hegarty et al. 1991; Paoletti 2011); the representation of a concept by ‘analogy’ (Clark and Lyons 2010) and the text-image integration, used for the second *disciplinary content* (‘Ecosystem of disciplines’, Fig. 3b), have achieved a certain effect on increase.

According to the principles for reducing extraneous cognitive processes, indicated by Mayer (2002), the second digitized disciplinary content (‘Ecosystem of disciplines’, Fig. 3b) would respond, in fact, to the criterion of ‘spatial contiguity’ - whereby words and images corresponding are presented contiguously on the screen.

On the basis of studies on psychological functions (Clark and Lyons 2010), the second digitized disciplinary content would use a ‘by analogy’ representation, which allows students to integrate new contents (‘the ecosystem of disciplines’) based on models already in the memory (‘the ecosystem of a tree’) and therefore to operate transfers that facilitate learning.

5 Implications

Some aspects should be highlighted: some refers the units of analysis set by this study, other - most extensive - the implications regarding the ‘techno-pedagogical’ (‘sophisticated’) knowledge of the e-teacher. The *digitalized disciplinary content* is another thing to *disciplinary content*. About the ‘didactic mediation’ (Damiano 2013; Rezeau 2004) and focusing considerations on online university courses, the opening analysis stated the chance to keep distinct three ‘units of analysis’: *content* – essential theoretical content that students need to know (i.e., relationship Didactic and Pedagogy); *disciplinary content* – representation of this content, provided by a specific discipline (i.e., ‘Poly-referential paradigm’ and ‘Ecosystem of disciplines’); *digitalized disciplinary content* – ‘disciplinary’ representation adaptation to the e-learning activity and settings (i.e., animated graphic of a diagram and ‘image/diagram’ of a ‘by analogy’ representation).

The first, ultimately, refers the consistent with objectives explained in the course’s sheet and profiles of the degree courses (SUA-CdS) and regards more the coordination of the CdS (ANVUR 2017).

The second refers the e-teacher’s ability to choose and select the consistent *disciplinary content* with objectives of the course’s sheet but also functional to the ‘digital setting up’ of e-learning. In other words, the same content (i.e. relationship Didactic - Pedagogy) could be taught through other disciplinary content (i.e. the argumentative debate through opposing theses) but the one most suited to digital form was preferred. This ability is linked, in some way, to the tasks of *define* and *evaluate* of *ICritical Thinking* certification program (ETS 2009; Guri-Rosenblit 2018).

The third relates the e-teacher’ ability to adapt and transform the *disciplinary content* to support the processes of memory and representation, as well as generalization and understanding of the students (Mayer 2002; Clark and Lyons 2010; Paoletti 2011;

Ganino 2018); it is linked to the tasks of *integrating*, *creating* and *communicating* of ICritical Thinking certification program (ETS 2009; Guri-Rosenblit 2018). It is a new and essential skill for the e-teacher that needs (and deserves) specific preparation and training since the basic knowledge and skills are different from the 'canonical' ones of the academic preparation (Oleson and Hora 2013).

The other and broader implication concerns the 'techno-pedagogical' knowledge of the e-teacher, what can be defined as 'sophisticated' (Agrati 2019). The e-teacher thus creates an 'entity', a learning content different from the original that actually helps the student more in memorization and understanding. As anticipated, from a theoretical point of view, the TPACK model does not seem sufficient to describe the e-teacher' knowledge as it lacks the aspect of adaptation and creativity - referred to by the Educational Testing Service (ETS 2009; Guri -Rosenblit 2018) and also highlighted by this case-study. As suggested by *ICritical Thinking* certification (Cruickshank, 1986; Educational Testing Service 2009; Cross et al., 2005; Wilkinson and Bruch 2012), indeed, e-teacher incorporates and integrates technologies into specific contents operating a series of actions as *define, evaluate, manage, integrate, create, communicate*. Can this actions be defined as 'essential' prerequisite for e-teacher (Guri-Rosenblit 2018)? The attention is focused on the ability to elaborate digitized disciplinary contents, in other words, to create new knowledge 'entities' to support students' learning. As mentioned, it is a completely new capacity that has very solid philosophical and communicative foundations - Popper's World 3; de Kerckove and Buffardi (2011) - but above all very complex effects on intellectual and normative statements.

Among the reasons for the reluctance of the academic faculty to use the wide spectrum of possibilities included in online teaching is the concern about intellectual property (Guri-Rosenblit 2018). Academics, on the one hand, are concerned about losing intellectual property on on-line course materials, some of which include innovative ideas and original constructs. On the other hand, the severe copyright laws that have been initiated and formulated over the last decade on the use of others' works in their ongoing teaching discourages some professors from using the new technology in their teaching (Guri-Rosenblit 2018; Alexander et al. 2017).

As already indicated by the national guidelines (ANVUR 2017) and European guidelines (ENQA 2015), this implies that each e-teacher should develop specific competences regarding *integration*, *creation* and *communication* (Educational Testing Service 2009) as well as information on the legal value and intellectual property of multimedia materials. Although these are not 'research' but 'learning' products, they in any case have a recognizable and public identifying property.

The latter and the others discussed are aspects that policies and research must set up correctly and try to discuss possible solutions. In the near future, the interdisciplinary research must be able to offer academic leaders and policy makers useful indications for the elaboration of a profile of technological and digital competences specifically aimed at e-teachers involved in online university courses, whose teaching preparation is among the quality parameters (ANVUR 2017). We know, in general, that 'show' is not 'explain' (Tversky et al. 2007) but 'show', understood as 'effectively represent a learning content', especially for an e-teacher, is already a lot.

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Higher Education and Students with Disabilities: e-Learning for Inclusion at eCampus University

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Abstract. The aim of this work is to describe how eCampus University provides students with disabilities with a flexible e-learning environment that favours inclusion and supports self-determination and empowerment. The article describes some features of the eCampus organizational model that allow for individualized teaching assistance through an extensive network of tutors around Italy; the eCampus VLE offers a broad range of tools that flexibly adapt to special learner needs. Subsequently, an aggregated outline is provided of the students with disability at eCampus, based on the analysis of data collected in the 2014–2018 academic years; the analysis takes into account various aspects, such as gender, Faculty, type of disability, aids and supports, degree of satisfaction. Special attention is paid to the adoption of personalized supporting measures, with reference to various categories of tutorship, the adaptation of examination formats, compensatory tools, and dispensatory measures. Some conclusions can be drawn from these data, and from a variety of suggestions from students, which will be useful to improve the quality of services offered to students with disabilities.

Keywords: Students with disability · Learning disabilities · Inclusion · Online learning environment · Higher education

1 Introduction

In order to cope with the increased number of students with a disability or a learning difficulty, universities strive to implement measures to support academic success and inclusion also for students characterized by special learning needs [1, 2].

Compared to peers without disabilities, students with disabilities and with Specific Learning Disabilities reported difficulty with assignments and had more physical, technological, systemic, financial, or attitudinal problems [3, 4]. The role of the institutions is fundamental in facilitating inclusive opportunities for these students, as well as in minimizing the impacts of factors that might hinder those opportunities [5, 6].

E-learning can be an effective educational approach for people with disabilities as a means to acquire self-determination and empowerment. This can happen thanks to

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flexibility, interactivity, and the customization of a learning pathway. E-learning is also incisive because of its ability to get rid of time-space constraints [7].

The e-learning policy paper for social inclusion, written within the framework of the e-learning action plan of the European Commission makes the education policy of the European Union clear as a further acknowledgment of e-learning as a key point for social inclusion.

2 Features of the eCampus Organizational Model and Tools

Technologies are not the only enabling factor for the transformation of industrial and manufacturing industries into Industry 4.0: people represent, in fact, a fundamental resource for the adoption of the new digital paradigms and the achievement of the expected outcomes. Nonetheless, companies are facing difficulties in finding candidates with updated skills and ready for employment. In this sense, the academic curricula of eCampus University are market oriented. The needs and the interests of the students are always cared about, by offering them real perspectives of professional and human growth. For this reason, eCampus University proposes degree courses and high-level Master degrees that give the students all the required skills and ensure them integration, with the final objective of training new specialists for the actual world. All eCampus courses are fully offered online, together with professional and classroom-based teaching.

As well as its headquarters, eCampus University is present throughout the country: not only can the courses it offers be taken from anywhere at any time, but it also possesses an extensive network of tutors around Italy, who offer individualized teaching support and advice to students. These are clear advantages for students with special needs, who can get support locally and are not required to travel long distances to undergo exams.

Given the framework described above, the eCampus Virtual Learning Environment (VLE) offers a number of services and tools to support students with disabilities. In the following, we will highlight specific features of the eCampus eLearning platform and of the underlying organizational model that support particular learner needs and improve the learning processes.

In the general architecture of VLE platforms proposed in [8] the highest layer, namely the application-specific one, identifies the functions representing users, courses and didactic resources:

- user profile management, including students portfolios and grades, system usage statistics, working groups, assignments and so on;
- course management: creation, customization, administration and monitoring of courses;
- educational resource delivery: tracking of learning material usage, assessment results;
- administrative management: registration, authentication, student records and logs, access rights, views, etc.;
- learner support: private and shared annotation spaces, bookmarks, notepads, statistics, recommendations, help-desk.

These are the software components learners mostly interact with, and the context where services and tools to support students with disabilities are to be located.

The eCampus VLE features a broad range of functions, some of which are particularly interesting from the perspective of adaptation to special learner needs:

- **Software and tools for hearing and speech impaired students**: speech synthesis and recognition, browser extensions to improve the accessibility features of the platform.
- **Lessons**: the learning resources consist of lessons and study sessions based on slides, digital documents and videos. All the interactions between the learner and the resources are tracked, in conformity with the SCORM Runtime Environment specifications.
- **Tests**: formative and summative evaluation of the learner's progresses are carried out online, and the results are recorded in the learner's profile.
- **Monitoring tools**: besides lesson and test delivery, all learners' online activities are tracked, including login and logout to the platform, document up-and down-load, contributions to asynchronous (forums) and synchronous (chat) communication and sharing channels.
- **E-portfolios**: exam results, essays and other student-produced material.
- **E-tivities**: concept maps, wikis and other collaborative and cooperative tools.

All these functions produce a large amount of data that can be handled by both predictive and descriptive models: this is particularly relevant to provide suggestions, recommendations and indications to learners with special needs.

3 Sample Description

The descriptive/interpretive analysis below aims to provide an outline of the students with disability population at eCampus online university. In particular, the expression "student with disability" referred to the Article 3 of the Italian law number 104/92 ("Framework Law for assistance, social integration and rights of the handicapped"), that defined an "handicapped person" (the outdated term used to identify a person with disability[1]) as someone "having a permanent or a progressive physical, mental or sensory impairment that determines difficulties in learning, social relations and work integration, in such a way as to determine a process of social disadvantage or marginalization". Instead, the expression "students with learning disability" referred to the Italian Law number 170/2010 that has recognised dyslexia, dysgraphia, dysorthography and dyscalculia as Specific Learning Disabilities (Disturbi Specifici dell'Apprendimento, DSA), that are associated to adequate learning abilities, without sensory or neurological deficit.

When students with disabilities or with learning disability enrol at the eCampus University, they are required to fill in a data form specifying the type of disability and the aids and tools required. The eCampus University disability and learning disabilities

[1] It is only since the introduction of the UN Convention on the Rights of Persons with Disabilities, approved by the United Nations in 2006 and ratified in Italy in 2009 by a low, that the used of the expression "persons with disabilities" became mandatory.

office collected the data below during 2014-2018 academic years, and treated them anonymously in compliance with the Italian privacy legislation. Students accessing the service increased from 8 in 2014 to 95 in 2018.

During the considered period, a total of 290 students accessed the service, 158 females (54.48%) and 132 males (45.52%). 147 (50.69%) of them were psychology students, 46 (15.86%) literature and philosophy students, 41 (14.14%) law students, 34 (11.73%) engineering students, and 18 (6.21%) economics students (see Figs. 1 and 2).

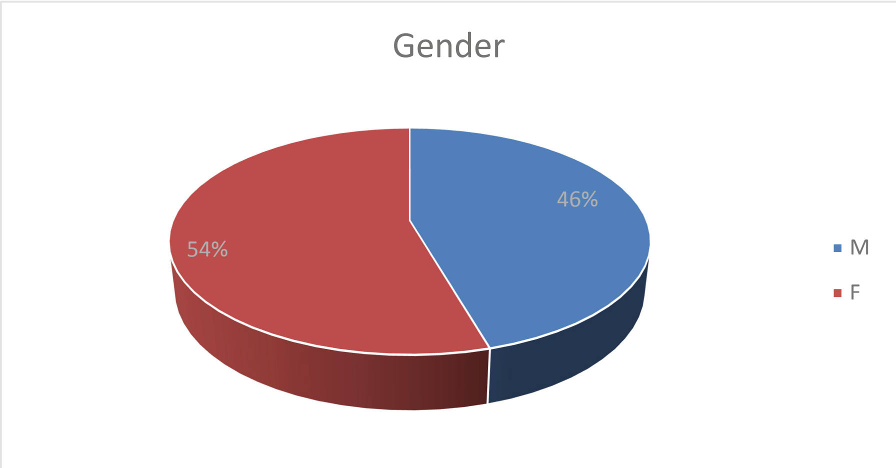

Fig. 1. The sample characterization: gender

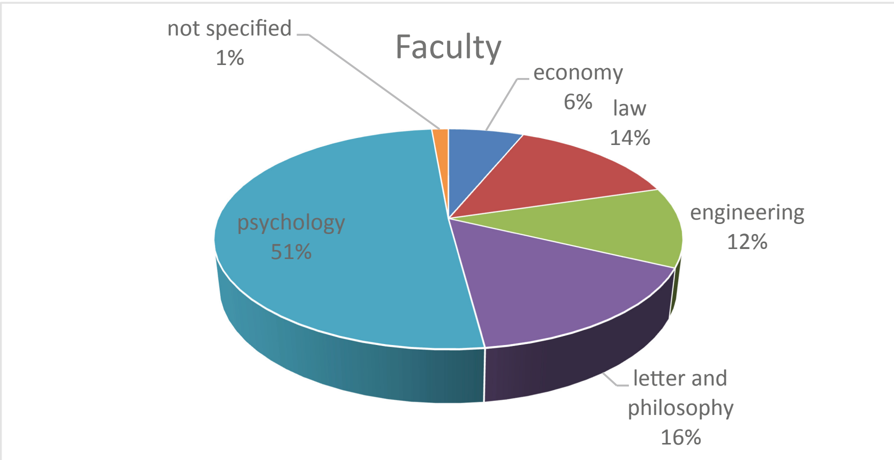

Fig. 2. The sample characterization: Faculty

Subjects were grouped according to the type of disability into: students with disability ("permanent or a progressive physical, mental or sensory impairment", Law 104/1992) and specific learning disorder students (dyslexia, dysgraphia, dysorthographia and dyscalculia). 156 (53.79%) were specific learning disorder students; in particular, 114 (40.14%) were characterized by a comorbidity between at least two learning disorders (e.g. dyslexia and dyscalculia); 13 (4.58%) were students with a diagnosis of dyslexia, 8 (2.82%) of dyscalculia, 6 (2.11%) of learning disorder not otherwise specified and 2 (0.70%) with dysgraphia. The others 134 (46.21%) were classified as students with disabilities. About 27% of these students suffer from neurological problems, about 10% experience sensorial impairments (visual or hearing problems), 4% have mental impairment, 3% have psychic problems (schizophrenia, anxiety disorders), another 2% suffer from autism or behavioural problems, and the rest have other medical problems or other rare or complex conditions (see Figs. 3, 4, and 5).

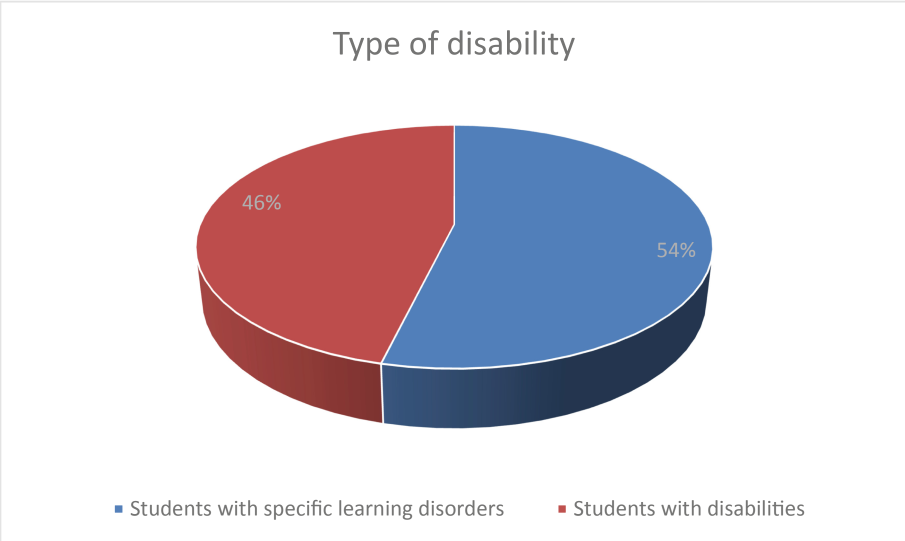

Fig. 3. The sample characterization: type of disability

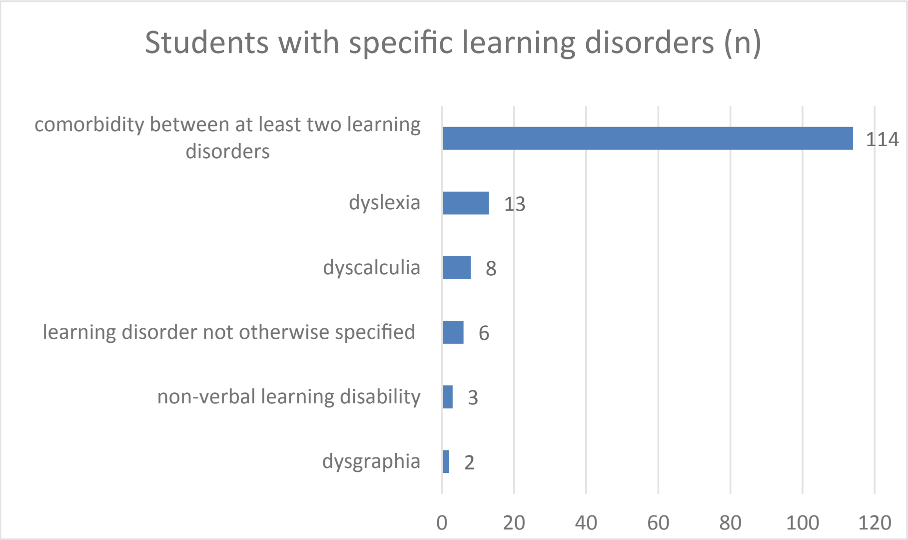

Fig. 4. The sample characterization: type of specific learning disorders

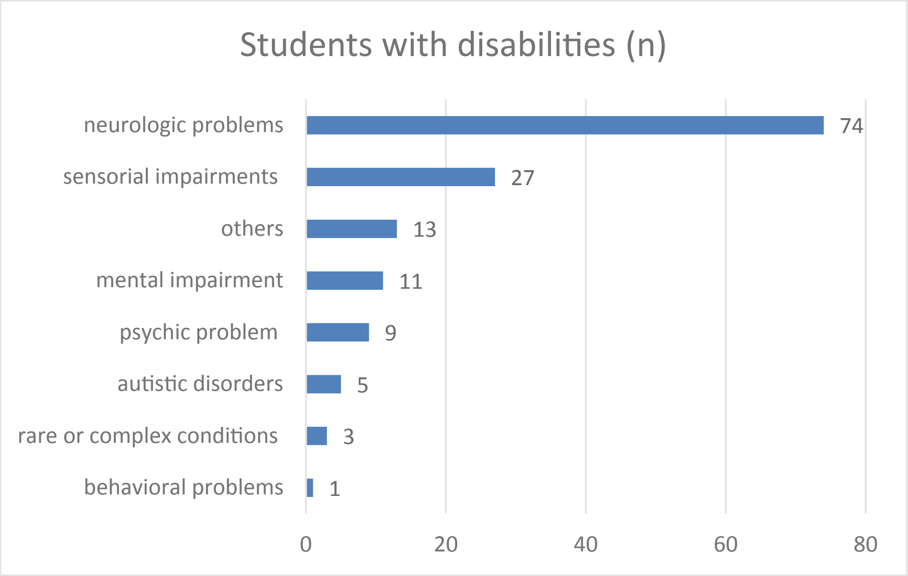

Fig. 5. The sample characterization: type of disability

To have examinations adapted to their needs, students with disability or learning disabilities may require aids and supports. The descriptive analysis (see Figs. 6 and 7) provided an overall view of the support required by students, and took into consideration the following elements:

- the categories of tutorship (for writing, for reading, accompanying tutor),
- the adaptation of the examination format (extra time, enlargement of the text in the written assignment),
- compensatory tools (oral integration written note, use of the computer for writing the task, evaluation of the contents produced without taking into account any spelling and grammatical errors present in the paper, calculator use, conceptual maps, forms),
- dispensatory measures (only oral exam, no listening test for English exam).

Data suggested that students with learning disabilities are more likely to receive compensatory tools, especially the permission to use conceptual maps during the exam. For what concern students with disability, adaptation of examination (extra time) is the aid they received most frequently.

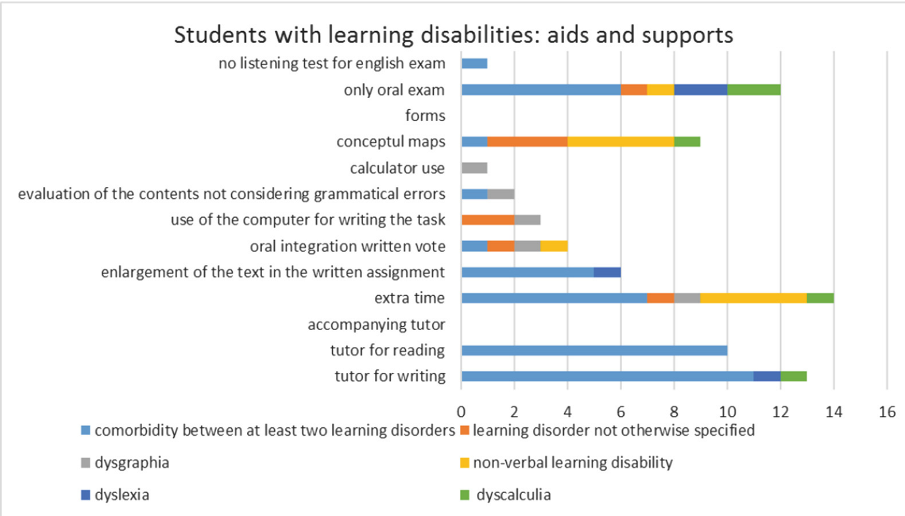

Fig. 6. Distribution of aids and supports by type of learning disabilities

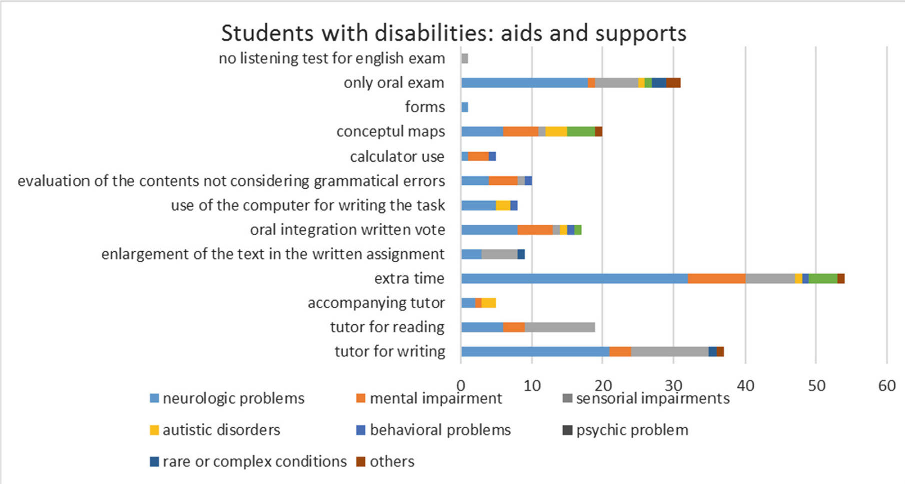

Fig. 7. Distribution of aids and supports by type of disability

4 Satisfaction Survey

In order to investigate the experience and the degree of satisfaction of students with disabilities and learning disabilities about the services received, an anonymous questionnaire was given to all these students enrolled in the current academic year (from 1st August 2018). Only 24 students filled in the questionnaire; 13 (54.2%) of them were female, with an average age of 24,4 years (range 18–45); 50% were enrolled in an undergraduate eCampus University course. 70.8% (N = 17) are students with learning disabilities, and 29.2% (N = 7) are students with disabilities.

With regard to their degree of satisfaction about the service offered by the University (see Fig. 8), 9 students (37.5%) replied that they were satisfied enough, 7 (29.2%) very satisfied, whereas 5 a little satisfied (20.8%) and 3 (12,5%) not at all. Moreover, we also asked the students how adequate and functional they evaluate the tools for conducting the exams in relation to their needs (see Fig. 9). 70.9% (N = 17) students are rather or very satisfied, and only 7 students are not satisfied (29,2%). These unsatisfied students mainly complained about some aspects related to the way they study (i.e. "I think, a simplification of the concepts we have to study is needed"), not so much about the tools available to them to take the exam.

Other questions aimed at the evaluation of specific tools of study. Most of the students (83.3%; N = 20) reported that the online university model is functional for their needs (see Fig. 10); 21 (87.6%) declared that learning materials can be used without difficulty ("usability/availability"); most students (70.8%; N = 17) consulted believe that the exercises proposed by the University courses are already structured in a functional way with respect to their difficulties. Furthermore, students believe that the tools to contact teachers (the electronic mail system and the virtual office) are helpful in consideration of their needs. Finally, some students provide suggestions in order to improve the university service. In particular, their attention is focused on the simplification of the online study platform offered by the university; students also highlight the need for an increase of teachers' sensitivity and awareness towards disability and suggest that teachers should undergo specific training on how to support learners with disabilities.

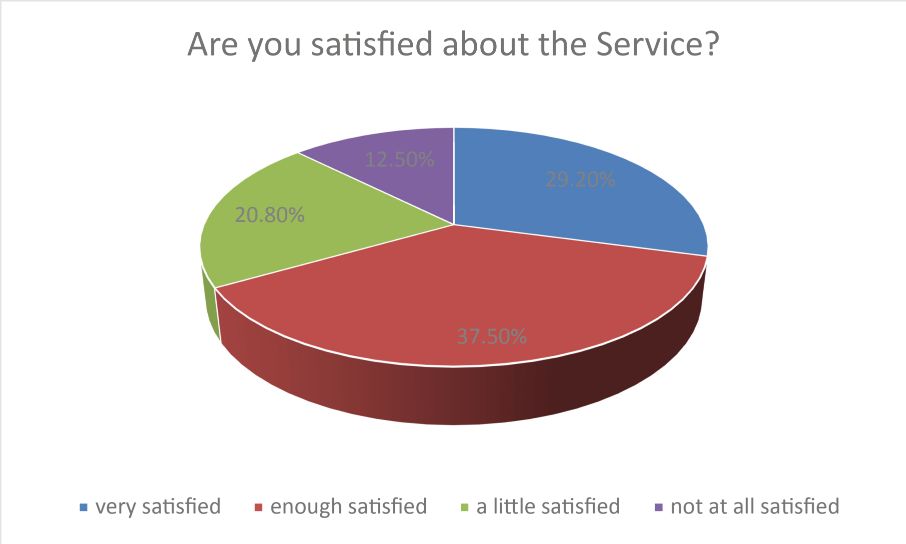

Fig. 8. Degree of satisfaction about the service offered by the University

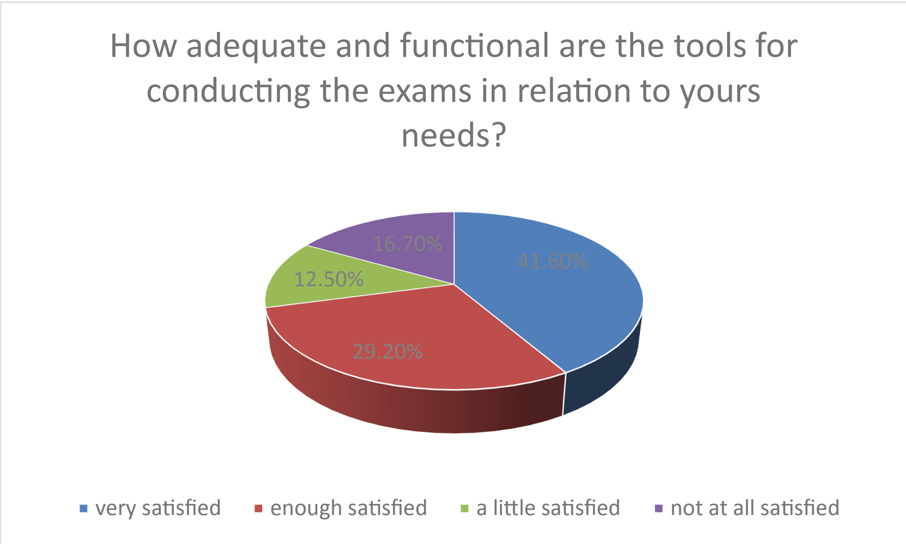

Fig. 9. Evaluation of the usability/availability of the tools for conducting the exams in relation to the needs of the students

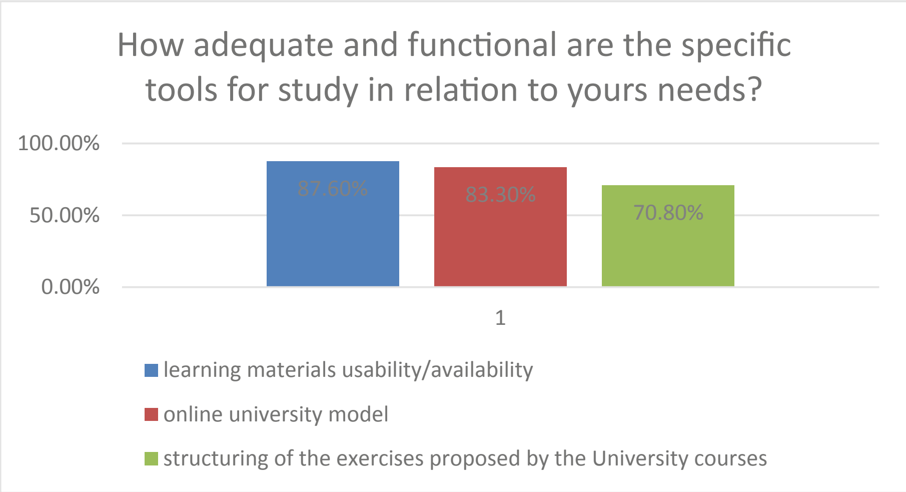

Fig. 10. Evaluation of the usability/availability of the tools for study in relation to the needs of the students

5 Final Remarks

To the best of our knowledge, this paper is the first to report descriptive data about the features of a VLE of an Italian online University, describing services and tools to support students with disabilities and with learning disability. As recently noted [1], many available Italian surveys have been carried out with the participation of students with disabilities only, excluding students with learning difficulties, and thus only offering the perspective of a specific academic part. Our descriptive information about the type of disability of students enrolled at e-Campus University differ from results of a recent national survey that involve 16 Italian universities [9]. The majority of this sample has a physical o motoric disability (58,47%) and only 1,64% has a learning disorder, whereas half of our sample has a learning disorder.

Differently from that, our preliminary data focus on student with learning disability as well. On the one hand, our data highlight the positivity of the services offered from our university; on the other hand, they provide useful suggestions on how such services could be improved. Unlike what was done in previous research [1], teachers were not involved in our survey. It will be interesting in the future to involve them so to better analyse and monitor all the services offered, as well as in training regarding disability as suggested by our students interviewed, and realized in other University [10]. Moreover, we will also investigate the non-academic aspects, such as concerns observed in relations to social inclusion in university life [11] and with peers support [12].

This report highlights possible enhancements to the eCampus VLE functionality to further improve inclusive support, which should not only take into account some "disabilities" (e.g. mobility impairments, sensory o hearing impairment), but all our population of students with special educational needs [13–15].

In a recent publication [16], the main research experiences were collected concerning the inclusion of students with disabilities in the university context, both nationally and internationally level. This volume shows the presence of great attention with regard to inclusiveness and accessibility in higher education, which includes the questioning of different actors. Compared to these, our contribution is an important first step towards monitoring and improving the services offered to students with special educational needs enrolled in an online university. For this reason, it will be important to continue studying in detail the various academic online contexts in Italy, in order to highlight the good practices and identify the barriers that are still hindering inclusion, thus fostering the dialogue between all parties involved at national level.

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Predicting Learning Outcomes in Distance Learning Universities: Perspectives from an Integrated Model

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Abstract. The progressive spread of online academic courses is a result of the flexible and customisable nature of the related learning process, while some studies on students' achievement in distance learning universities have underlined retention as a priority issue for future research. Despite the number of studies that have investigated specific variables related to online learning, there are no systemic reference models that consider specific online environmental variables, IT competence and outcomes together. This paper offers an integrated model to test the contribution of different variables in predicting student performance in online academic courses, building on the literature on the digital learning environment and achievement. The model, based on the initial Biggs' 3P learning model, aims to evaluate technical competency and the ability to self-manage as personal variables; furthermore, it proposes the analysis of a set of perceptions related to course design. Through the proposed model, a student's background, personal variables, perception of the physical learning environment and perception of the course design can be utilized as predictors of student performance. Future research should investigate the applicability of the model in academic distance learning contexts.

Keywords: Digital learning environment · Course design · Technical competency · Student's outcomes

1 Online Learning, Retention and Progression Issues

Recent developments in the education system, the growth in education, the ever-increasing offer structure and the multiplication of universities, have generated a leap in the competitiveness in the entire system, previously limited only to narrow contexts. The quality of the learning environment and services has garnered increasing attention from decision-making centres and boards of directors, from all educational establishments, including distance learning universities.

Online learning is, of course, growing worldwide, thanks to its flexibility, deliverability, freedom and learning independence, though questions on its efficacy and differences from traditional courses have stimulated several studies and pieces of research [1–3].

Distance learning environments are different from traditional ones, especially in terms of social interaction and technological aspects [4–6], and they require particular

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attention to course design to ensure students can achieve their learning objectives and reach high levels of engagement [7, 8].

Some studies on student success in online courses seem to highlight retention and progression as priority issues for future research and practical implications [2, 9–11].

Recently, three categories of explanations for the lower success rates on online courses have been put forward: student characteristics (demographics and prior school background); the student's environment; and course design and interaction [12, 13]. Amongst personal variables, motivation, discipline, technical competency, perceived usefulness, self-efficacy and the ability to self-manage seem to condition online course success [14, 15].

Low progression rates, retention and disengagement issues in online learning require serious consideration and should guide academic policies towards exploring which environmental variables can be managed and modified to better student achievement and outcomes.

Combining insights from a review of the literature, this paper aims to stimulate conceptual discussions about the specific environmental variables of distance learning universities that should be investigated as predictors of study outcomes and to offer a conceivable theoretical perspective.

2 Online Learning Environment and Achievement

Several studies have investigated the role of different factors in predicting student performance on traditional courses: perceptions of the learning environment, personal factors (motivation and self-efficacy) and learning approach affect academic achievement and other learning outcomes [16–19]. In addition to environmental perception and approach to study, personal factors (motivation and self-efficacy) and prior school and academic performance have been shown to have a direct influence on learning outcomes and achievement [18–24].

Despite the impressive amount of studies that have investigated specific variables linked to online learning, there are no systemic reference models that can consider Environmental variables, IT interface, IT competence, Perceptions, and Personal factors together as predictors of student's outcomes.

What seems clear is that there are four relevant sub-themes of design in e-learning and online learning: (1) course structure, security, and variety; (2) content presentation; (3) collaboration and interaction; (4) timely feedback and monitoring by tutors [8]. More specifically, the literature review showed that some elements of the design of online learning courses contribute to effective outcomes: course design around open-ended and real-world problems; group problem-solving; developing a learning community; the tutor's role as a facilitator; course design for guidance and student support [25].

Moreover, independence of learning and freedom of learning are characteristics of an online learning environment that seem to stimulate and enrich student learning; deliverability can be considered an important motivating factor in online learning environments; teacher and tutor enthusiasm and kindness are the most important factors for stimulating motivation on online courses [25–27].

Building on the considerations and references in literature, this paper proposes an integrated model to test the contribution of different and specific variables (course structure, content, tutors, technical competence) in predicting student performance in online academic courses.

The purpose of this perspective paper is to stimulate conceptual discussions about the role of the digital learning environment for academic outcomes in distance learning universities.

3 Biggs' 3P Learning Process Model and Approach to Study

The relationship between actionable factors of the academic environment and experience has become central and has led to a broad range of studies; research which addresses the impact of student perceptions of the learning environment on study outcomes, often framed within Biggs' 3P model [28, 29], which conceptualizes the learning process as an interactive system of three sets of variables: the learning environment and student characteristics (presage), student approach to study (process) and learning outcomes (product).

The model suggests that both personal and situational factors affect how a student adopts specific approaches to study, which in turn influences the types of outcomes achieved [30] (Fig. 1).

According to this theoretical framework, student perceptions of the learning environment, in light of their motivation and expectation, determine how situational factors influence study approach and online learning outcomes (achievement, satisfaction, perceptions of transferable skills development).

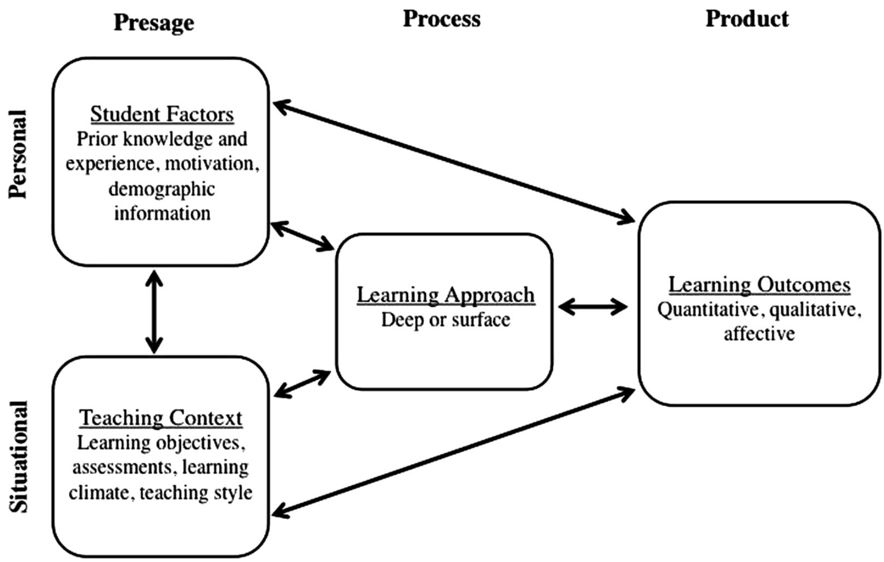

Fig. 1. Biggs' 3P learning process model (1993)

The concept of study approach and approach to learning, developed following research by Marton and Säljö [33], in agreement with the work of other authors [31–36, 41], became the construct of departure for the development of Student Learning Approach (SAL) [28], and a framework for the conceptualization of teaching and learning, definable as constructivist and systemic. From that same cultural context, a so-called phenomenographic approach has developed, the Student Learning Perspective (SLP), which presents several theoretical analogies and a similar structural implant [30] (Table 1).

The study approach can be defined as the set of attitudes and strategies adopted by a student in relation to a specific task, and it is described by a cognitive component, meaning the sense that the student has attributed to the task and the goal to be reached through the task, and a behavioural one, i.e. the study strategy chosen consistent with the goal assigned by the task [37].

The approach to study is considered a critical factor, able to influence academic performance and at the same time an important predictor of student perception of a supportive learning environment, a variable which in turn is capable of modulating academic performance [19].

A further innovative element of the model is the fact that the results of study are categorized into quantitative outcomes (what has been learned), qualitative outcomes (how it is learned) and affective outcomes (what students experience in terms of their study process and level of involvement in university life) expressed in terms of satisfaction and perception of the development of transversal skills.

These outcomes are relatively stable, they are able to influence subsequent educational experiences and can have a backward effect by influencing the process and predictive variables.

Table 1. Features of deep and surface approach [51]

A student who uses the **Deep Approach** to transform knowledge by:	A student who uses the **Surface Approach** to reproduce knowledge by:
Intention – to understand ideas for oneself	Intention – to cope with course requirements
Relating ideas to previous knowledge and experiences	Studying without reflecting on either purpose or strategy
Looking for patterns and underlying principles	Treating the course as unrelated bits of knowledge
Checking evidence and relating it to conclusions	Memorizing facts and procedures routinely
Examining logic and argument cautiously and critically	Finding difficulty in making sense of new ideas presented
Becoming actively interested in the course content	Feeling undue pressure and worry about work

Students interpret the teaching context based on their conceptions, experiences, and motivation, organising their study through meta-learning skills, monitoring, planning, and evaluation. The strategy that the student will adopt (deep or surface) will also be determined, in particular, from perceptions regarding the requirements of the learning environment.

The assumption of the deep-surface metaphor was stimulating and suggestive even if not exempt from critical reflections [40]. Nevertheless, it was undeniably recognised as an "immediate, universal and broad metaphorical power". The use of deep and surface is not far from the target and spirit of university education to represent "critical thought" and "relativistic reasoning ", although this use can be simplistic and reductive limiting the hermeneutical and paradoxical potential. Often the dichotomy has been misused to simply label the student, forgetting that it should represent an answer to the context and demands of a specific task in a specific situation.

The strength of Biggs' 3P learning model lies in focusing attention on a framework of factors that influence the quality of learning, such as the learning and teaching environment, types of teaching and assessment and student perceptions of these [35].

Several studies have explored the applicability of the 3P learning process model to different academic systems and different countries [30], showing that student perceptions of the learning environment play a role in determining the approach to study and, in turn, study outcomes in a wide range of campus models.

As far as we know, no research has examined the applicability of these models in distance learning universities, nor tried to examine the effect of specific environmental factors linked to online learning contexts.

4 Integrating Biggs' 3P Learning Model to Online Courses

According to the literature review [3, 38] online achievement is influenced by: (a) student characteristics (demographics and prior school background); (b) personal characteristics (motivation, technical competence, self-efficacy, and ability for self-management); (c) course design (course structure, security, variety, content presentation); (d) collaboration and interaction with other students; tutor monitoring and feedback [14, 15].

Based on evidence from the literature on the specific and distinctive variables of online learning environments, an integration of Biggs's 3P model of learning (Fig. 1) [29, 34] and Ramsden's model [35] (Fig. 2) is proposed in order to analyse the influence and contribution of different factors (students' prior characteristics, students' personal variables, student perceptions of the learning environment) on the approach to study and academic outcomes in students on online courses (Fig. 3) [39].

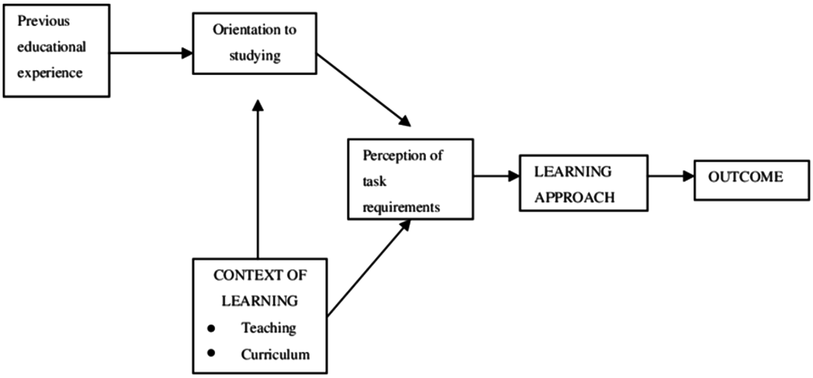

Fig. 2. Ramsden's model of academic learning (2003)

Based on the initial model [29, 34], besides, the model proposes to evaluate, as personal variables, technical competency, and ability to self-manage. Moreover, it proposes to add a set of environmental perceptions related to course design.

Using this model, prior experience variables, personal variables (motivation, and self-efficacy, technical competency, and ability to self-manage), perceptions of the physical learning variables (appropriate workload, appropriate assessment, collegiality, teaching quality) and of the course design (course structure, security, variety, content presentation), approaches to study (deep and surface) together with study process variables (class attendance, autonomy, tutor monitoring) can be used as predictors of students' academic achievement and other learning outcomes in an e-learning context [40].

The proposed integrated model aims to define the framework of the influence on academic outcomes - in terms of performance, perceptions, and satisfaction - of digital learning variables, such as course organisation and design, tutor support, quality of contents, content variety, social climate, etc.

How does perceived technical competency impact on the approach to study and achievement?
How do student perceptions of the learning environment (including those related to the learning platform and the course design) impact on the study process and learning outcomes?
Which technological variables of the course design have the most impact on the approach to study?
Which factors related to course design and structure have the most impact on academic achievement?
What is the role of tutor support in online achievement?
How does students' prior schooling relate to perceived IT competence and perceptions of the course design?

The relationships between the elements expressed by the proposed model allow the identification of areas of intervention to increase the quality of learning, through the modification of content variety, teaching methods, supporting learning interface, assessment methods, course design, and tutor role.

It will certainly be of interest to verify how and if IT competence impacts on study approach, and in, turn, on learning outcomes. Moreover, it will be necessary to investigate the possible effect of student perceptions regarding the course design on approach to study and academic achievement.

Furthermore, it will be necessary to investigate whether the perceptions related to the learning platform should be considered part of the wider category of learning environment factors or should be examined separately.

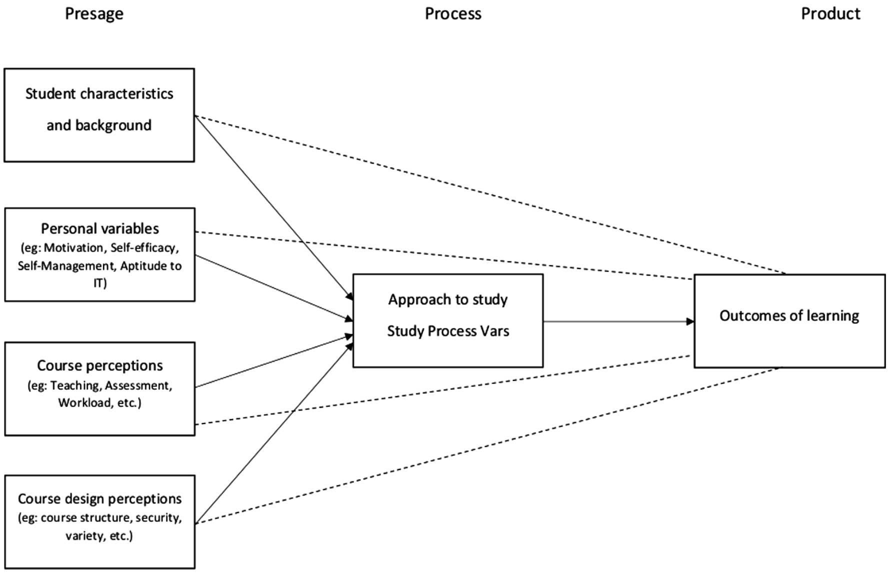

Fig. 3. Adapted 3P model of student e-learning

5 Conclusion

Academic institutions have structured and reworked their policies based on the perceptions, needs, and requirements of their primary clients, paying close attention to course experience, students' professional future and teaching effectiveness to obtain funding, remain competitive in a global market and attract excellent students and researchers [41].

Educational institutions have shown a growing interest in paying attention to how the study environment affects students' perceptions and the value they attribute to it. This attention responds to the desire to improve educational systems, because of their impact in creating positive and supportive environments [35].

The specificities of e-learning academic environment should be explored through theoretical models that can grasp the peculiarities of the learning process in this context and highlight those environmental and study context variables that are controllable and implementable by the universities with the aim to improve the student's outcomes [37].

Literature indicates that achievement in online courses is hampered by student's progression and retention problems, and these difficulties can be strictly related to course design characteristics and IT learning platform.

Consequently, it is fundamental to measure this type of variables together with other environmental perceptions and personological aspects, in order to evaluate, through a systemic model, the contribution and the relationships of the various factors.

Future research should investigate and verify the applicability of the presented theoretical model in distance learning academic contexts, through experimental, correlational or qualitative studies [39].

Academic online courses and degrees provide an opportunity for students to follow specific issues and subjects, offered by an increasing number of universities around the world. Data collected on online courses can allow for an analysis of students' online learning behaviour (study process, study timing, and performance), a better understanding of online learning processes and stronger teaching [42, 43].

Literature-based on learning analytics is trying to contribute to predicting student performance [44–47] to develop a better awareness of the factors that determine effective learning environment and to gain useful insights for teachers to allow them to improve their course materials.

Despite its widespread diffusion, student perceptions related to the learning environment of academic online courses must certainly be explored further and verified, in order to develop academic and institutional strategies aimed at encouraging the best learning outcomes [48–50].

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Online Problem Based Learning for the Professional Development of Educators

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Abstract. The paper presents a blended model developed within a collaborative research project between university researchers and educators in the field of education. The model is based on the problem based learning approach and has been used in a mandatory course to train practitioners who work in the formal, non-formal and informal contexts of the educational system in Italy. We illustrate how they implemented it within Moodle platform and describe results obtained using the Constructivist On-Line Learning Environment Survey. Results show a good level of pertinence among on-line learning activities and professional practices as a good level of critical reflection developed during the activities. Less positive are results for the dimension of interaction in the on-line discussion forum. Despite of good results improvements need to be realized in the developed model, but problem-based learning seems to be confirmed as a good approach to motivate professional attending mandatory training courses.

Keywords: Problem based learning · On line learning · Professional development

1 Introduction

This contribution presents a blended model developed as a result of a collaborative research project between university researchers and practitioners who work in the formal, non-formal and informal contexts of the educational system in Tuscany [1, 2]. The design of the blended model started from the assumption that adults, in this case practitioners who come back to the university to study again, learn only if their experience and practical knowledge are acknowledged and if they have an active role in the learning process. Therefore, the model is proposed for specific professional online learning, but it is adaptable to different typologies of professionals.

1.1 The Context

In the month of December 2017, the law 205 indicates to Italian departments and faculties of education to activate a mandatory intensive course to train professionals that work in the national educational system and that have not a bachelor degree in educational sciences. In 2018 the National Committee of Educational Science Programs and the Committee of Italian Rectors propose to departments and faculties to adopt a

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national common curriculum for the course. The curriculum comprehends subjects as pedagogy and didactic, psychology, philosophy, sociology, anthropology and law.

According to the normative context (see Fig. 1) we started to think how to design a course for adults who have to come back to university. Trying to cope with this challenge we involved representatives of cooperatives and associations in the field of education adopting the model of collaborative research management [3]. The model involves stakeholders as researchers because they are "insiders" of a context. Their collaboration allows intercepting a kind of data that emerge from the experience and that the academic researchers are not able to collect differently. In this frame the co-design of the course represents the opportunity to share knowledge that is close to the professional problems educators experience. Thanks to the collaboration of insiders, we defined four core contents related to educators' professional practice.

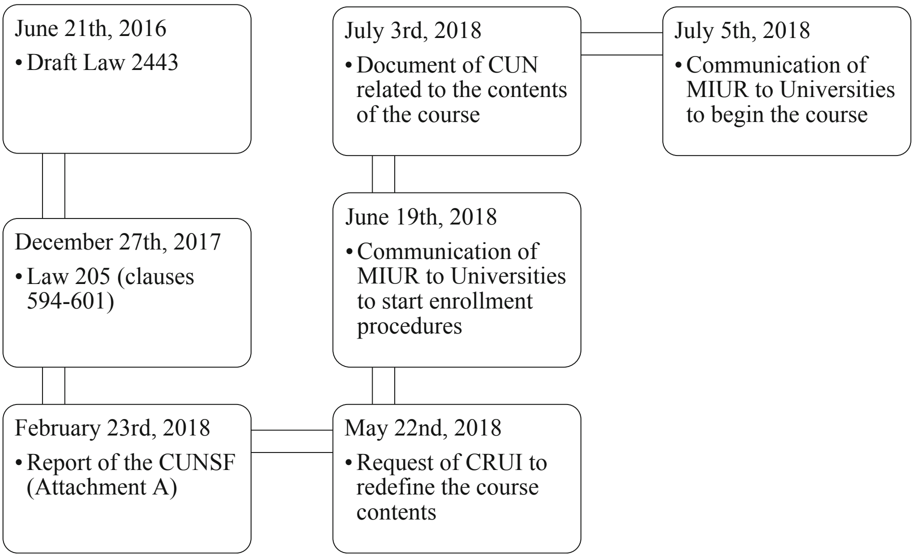

Fig. 1. Institutional and regulatory framework

These four core contents have been implemented in the six modules of the course. The first two modules concern the core content, that is situated theory; the third and fourth modules are related to methodologies of inquiry; the fifth module regards conflicts; and the sixth module the evaluation of educational action [1]. Each module starts with a face-to-face session, involves participants in online activities and finish with a second face-to-face session. Table 1 gives a summary of the structure of the course.

Each module comprehends two related on-line activities that participants have to complete. The online activities use the Problem Based Learning (PBL) as didactic approach. PBL gives principles and guidelines for an educational architecture that encourages critical reflection processes on the knowledge and skills acquired by the

Table 1. The structure of the course

Core contents	First face to face session	On line activities	Second face to face session
Situated theories	December 1st, 2018	From December 2nd to December 14th - The youth centre "Archimede" - Tutor for a day	December 15th, 2018
Situated theories	December 16th, 2018	From December 17th to January 18th - Rehabilitation programs - So…what is the problem?	January 19th, 2019
Methodologies of inquiry	January 20th, 2019	From January 21st to February 15th - I did mine! - Between control and coordination	February 16th, 2019
Methodologies of inquiry	February 17th, 2019	From February 18th to March 15th - The humanitarian educator - A case study	March 16th, 2019
Conflicts among colleagues	March 23rd, 2019	From March 24th to April 12th - Barriers of communication - Roles and responsibilities	April 13th, 2019
Evaluation of educational action	April 14th, 2019	From April 15th to May 10th - The contribute of multimedia technics - A frustrating situation	May 11th, 2019

participants during their work [4]. In the next section we propose an overview of the face to face and on-line models of PBL that compose the theoretical framework of the model proposed in this contribution.

2 Theoretical Frameworks

PBL is a learner-centered approach that allows the application of theories and skills to an authentic problem and the development of a possible solution. Since 1980, when this approach was first proposed in the Mc Master Medical School in Canada [5], different authors described its characteristics [6–10]. Hmelo-Silver [7] describes PBL as an instructional method in which students develop problem-solving skills trying to answer a complex problem. After understanding the problem, they can engage in self-directed learning because they understand what they need to learn in order to solve the problem. Once acquired new knowledge this can be applied to proposed solution strategies.

The characteristics of the Authentic Problem Based Learning (aPBL) [11] inspire the model presented in this paper. For the aPBL learning means managing problems that happen during the work. Authentic problems are chosen on the base of frequency, relevance and importance in a field of application. Problems presented to students have to allow a free inquiry, favoring a practice or developing problem-solving skills. Students apply what they already know with the aims to comprehend and solve problems and during the learning process recognize the information they need. Using a variety of resources from different disciplines, new knowledge related to the problem is acquired through self-directed learning process. Self-directed learning allows developing responsibility in students that are not dependent on the teacher anymore. New knowledge is structured by problems, facilitating the recall and the application in future problems. Students monitor and evaluate their progresses in learning and they also learn to give constructive feedback to the other members of the group. The learning process implies interactive discussion among students to share knowledge, ideas and opinions. Doing so they develop team working, problem solving and interpersonal communication skills.

The PBL model of Delise [12] is similar to the aforementioned model. It has the scope of permitting the learning of core knowledge, to acquire the ability to use knowledge effectively in relation to problematic situations, to improve knowledge and develop strategies to cope with future problems. The model consists of a logic process that allows students to analyze and solve the problem. Students connect themselves with the problem, analyze it, realize a task and evaluate the task. Developing his model, Delisle defines the advantages of the PBL. It allows engagement of students, interdisciplinary learning, possibility for students to choose what to learn, collaborative dimension of learning, and increase of the educational quality.

The third model that composes the theoretical framework is called the Dutch model and was developed during the ‘70 of the 20th century at the University of Limburg, in Maastricht [13]. The model presents seven steps that go from the analysis of a problem to the identification of contents that need to be studied or have to be collected. These seven steps are:

1. clarify terms and concept not immediately understandable;
2. define the problem;
3. analyze the problem;
4. make a systematic list of explanations that are the result of phase three;
5. formulate learning objectives;
6. collect additional information outside the group of students;
7. synthesize and test new acquired information;

As different models of PBL have been developed for face-to-face learning, so several approaches have been designed for PBL on-line learning. PBL online is defined as groups of students that work synchronously or asynchronously to solve or manage a problem [3]. These models have been designed to promote PBL during single modules on-line, blended modules or programs (on-line and face to face) or using content management systems. Different models of PBL online are briefly described in the table below (Table 2).

2.1 The On-Line Problem Based Learning Model for Educators

The online PBL model proposed in this contribution (see Fig. 2) consists of three phases. The first is called "activation". Students can read a scenario that presents a challenge for the reader or asks for the solution of a problem. In this phase students are invited to join a Web forum in which they can use their prior knowledge to discuss the problem and share their understandings.

Table 2. Types of online problem based learning adapted from Savin-Baden, 2007, p. 31.

Type of online PBL	Description
Single module online	This typology is designed as 1-12 week stand-alone modules developed for a specific focus
Single module blended (campus and distance)	This typology provides flexibility and support, but also develops self-direction in inquiry
Blended program	This typology is a full degree program with a focus on students' support during face-to-face seminars
Content management systems (CMS) for PBL online	This typology is a content management system developed to support PBL

Students can compare their thoughts with those of their colleagues in this dedicated virtual space. In the second phase called "appropriation", students engage themselves in a self-directed learning process. They can access a database of selected resources provided by the teacher or they can use the Web and the on-line library database to find new material autonomously. The third phase called "reflection" allows the students to return to the initial problem on the basis of the new information gathered. They have to complete an e-tivity in which they have to propose more structured solutions of the problem. In the same phase they complete a questionnaire that helps them to understand how to transfer what they have learned in their professional context.

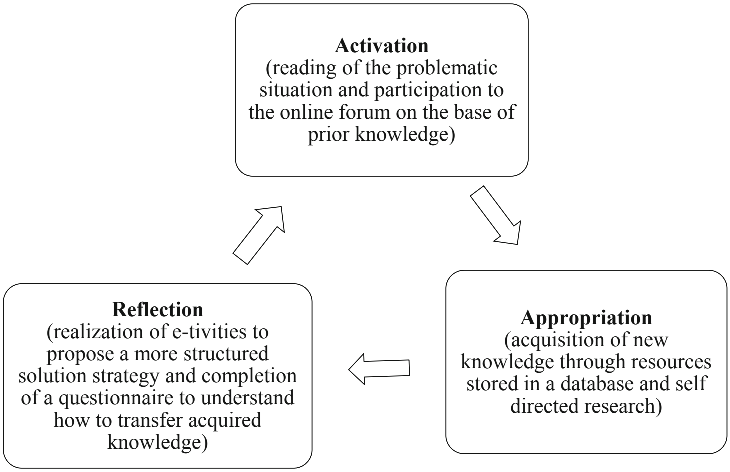

Fig. 2. The on-line problem based learning model used in the course.

In practice we applied this model on Moodle using resources and activities of the platform (Fig. 3). In the activation phase the activity proposes learners a written story using the resource page, then they have the opportunity to share their previous knowledge related to the scenario with other colleagues using a discussion forum. In the forum each participant has to write a brief post and comment at minimum two other participants' posts. We assumed this task as useful to generate interaction. In the appropriation phase it is possible to deliver the resources related to the core content of the module to the participants or to give them the possibility to search academic databases or the Web to find learning resources. In this second case, once found the resources, the participants had to explain the significance of the resource found posting in a second discussion forum. In the reflection phase we propose an e-tivity, a form to complete, that gives learners a structure to propose a possible strategy to challenge the problem and finally a feedback about how applying what they have learned in their work context.

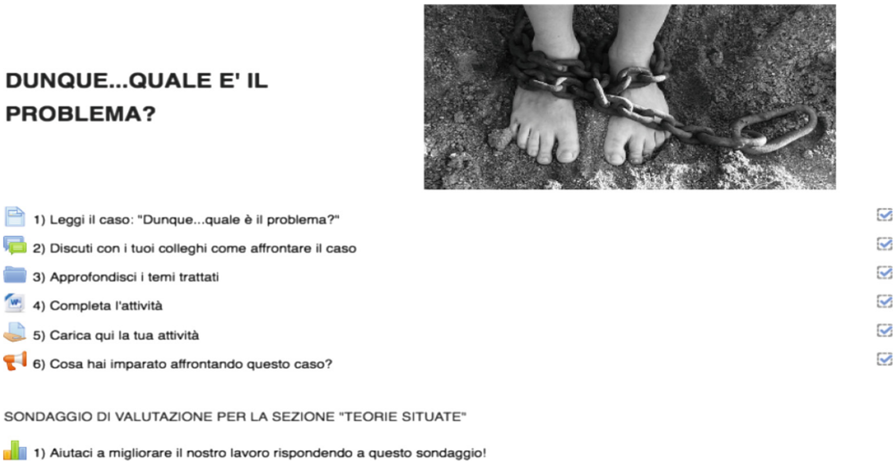

Fig. 3. The implementation of the proposed model on the on-line platform

While we were designing the course, our first objective was the evaluation of the activities based on the PBL model to understand if it was the right approach to facilitate relevant knowledge and reflection on professional practice.

Proposing and applying this model to the course, we tried to answer the following research questions:

(RQ1) Do on-line activities and contents in the course allow the development of professional practice in the perceptions of participants?

(RQ2) Do on-line activities and contents in the course allow critical reflection in the perceptions of participants?

Another research objective was to develop a self directed learning experience making the different activities sequential and automatizing their appearance on the screen. In this direction we tried to realize self-managed discussion forums. As reported in the three models proposed as theoretical framework, group discussions and interactions are fundamental for PBL. For this reason, the third research question can be formulated as follows:

(RQ3) Do on-line activities and contents in the course allow students' interaction in the perceptions of participants?

3 Method

3.1 Participants

Participants on the online platform were 102. They were professionals in education (M = 30%, F = 70%) aged from 27 to 53 and working in Tuscany (Italy). Approximately half of them (55%) had a high school diploma, 37% had a bachelor or a master's degree, and 8% a PhD. They worked in organizations of different sizes: 24% in organizations with less than 30 employees, 30% in organizations with between 30 and 100 employees, 46% in organizations with more than 100 employees. The length of their service varied with a predominance of workers (55%) with a professional experience of less than 10 years, followed by workers (45%) having more than 10 years of service. Their professional roles could be shaped within four main categories: social workers (24%), employees in services addressing people with special needs (27%), nurseries' or schools' educators (25%), employees in services for elderly people (4%). The rest of the participants (19%) worked in other sectors still related to education.

3.2 Instrument

The Constructivist On-Line Learning Environment Survey (COLLES) is designed to assess the extent to which students can take advantage of the interactive possibilities of on-line learning to stimulate students in using dynamic and collaborative learning modalities [13]. It is a popular measure for examining online learning environments along with constructivist categories, which makes it in line with the dominant pedagogical philosophy for online instruction. The COLLES comprises six scales, each of which addresses a key question about the quality of the on-line learning environment. The dimensions of relevance (how relevant is on-line learning to students' professional practices?), reflection (does on-line learning stimulate students' critical reflective thinking?), and interactivity (to what extent do students engage on-line in rich educative dialogue?) are very interesting for this study. The questionnaire collects data on these four dimensions through 12 closed items (four items for each dimension) on a five points scale (hardly ever/almost always).

3.3 Procedure and Data Analysis

The author developed the on line PBL blended model between the months of August and October 2018. The course started in the month of December 2018. In the month of June 2019 participants completed all the six modules of the course. During these six months we administered, using the Moodle platform, 4 questionnaires, one for each core content, to collect data in order to answer research questions. We collected relative frequencies of participants' answers to each item and transformed it in percentages. We analyzed participants' answers by dimension and by item.

4 Results

The following graphs represent the sum of participants' answer (in percentage) to the items that compose a single dimension. Each dimension is compared to the same dimension of the four different core contents. Differently, the tables report the sum of participants' answers (in percentages) to the same item of the four different core contents.

The first dimension of the COLLES questionnaire is the relevance of the on-line learning to participants' professional practice (see Fig. 4). The second dimension is the reflection and is related to on-line learning stimulation of participants' critical reflective thinking (see Fig. 5). Finally, the third dimension is the interactivity and it refers to students' engagement in rich educative dialogue while on-line (see Fig. 6).

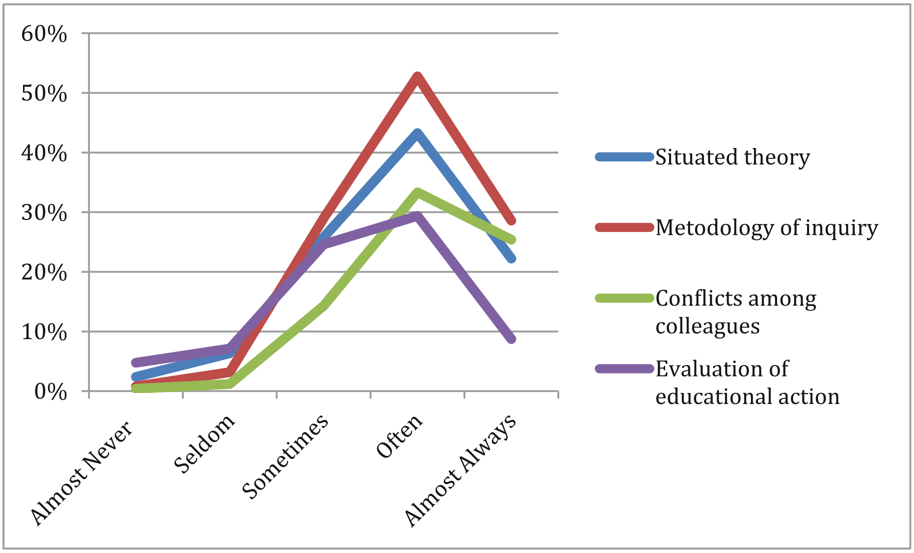

Fig. 4. Participants' answers for the dimension: "relevance"

Table 3. Relevance of the online activities and contents with professional practices

Pertinence	My learning is focused on what is interesting for me	What I am learning is important for my professional practice	I am learning how to improve my professional practice	What I am learning is connected to my professional practice
Almost never	4%	2%	0%	5%
Rarely	8%	4%	5%	6%
Sometimes	30%	14%	15%	29%
Often	44%	48%	50%	45%
Almost ever	14%	32%	30%	15%

In the first dimension, to the item “my learning is focused on what is interesting for me” most of the participants (58%) answered “often” and “almost always”. To the items “what I’m learning is important for my professional practice” 80% of participants answer “often” and “almost always”. To the items “I’m learning how to improve my professional practice” again 80% of participants answered “often” and “almost always”. To the items “what I’m learning is connected to my professional practice” 60% of students answered “often” and “almost always” (Table 3).

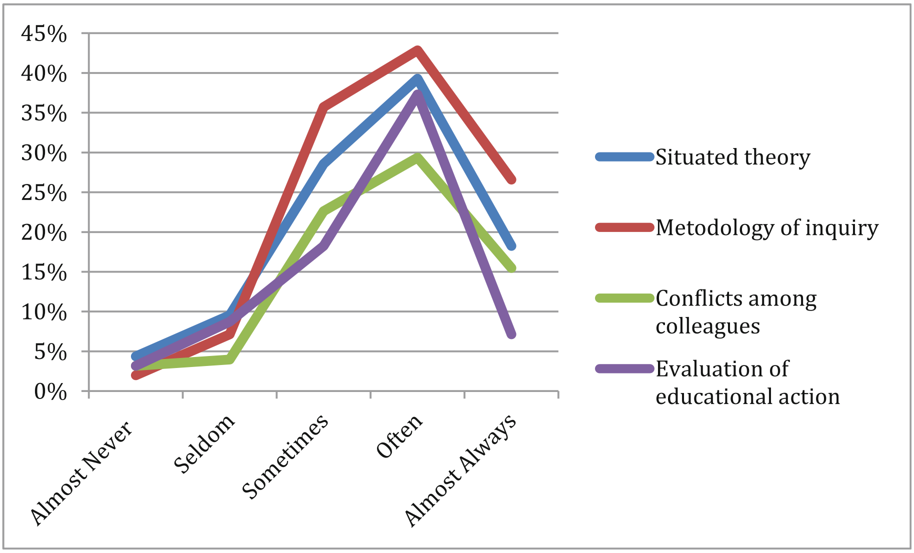

Fig. 5. Participants’ answers for the dimension: “reflection”

Table 4. Critical reflection allowed by the online activities and contents

Critical reflection	I think critically on my learning	I think critically to my ideas	I think critically to other participants’ ideas	I think critically to the ideas of the on-line activities
Almost never	2%	2%	10%	5%
Rarely	7%	4%	19%	11%
Sometimes	29%	20%	24%	25%
Often	42%	50%	32%	45%
Almost ever	20%	24%	15%	14%

The second dimension related to critical reflection has the same positive results. To the item "I think critically on my learning" 62% of participants answered "often" and "almost always". To the item "I think critically to my ideas" 74% of participants answered "often" and "almost always". To the item "I think critically to other participants' ideas" participants' answers are less positive, but 47% answered "often" and "almost always". To the item "I think critically to the ideas of the on-line activities" 59% of participants answered "often" and "almost always" (Table 4).

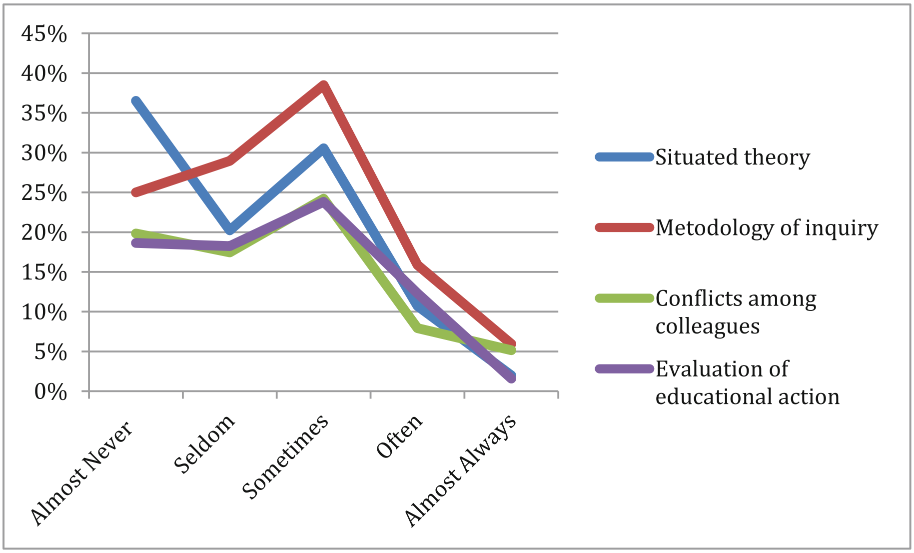

Fig. 6. Participants' answers for the dimension: "interaction"

Table 5. Level of interaction allowed during on-line activities and contents

Interaction	I explain my ideas to other participants	I ask students to explain their ideas	Other participants ask me to explain my ideas	Other students answer to my ideas
Almost never	19%	38%	56%	53%
Rarely	18%	29%	18%	15%
Sometimes	36%	25%	24%	28%
Often	22%	8%	2%	3%
Almost ever	5%	0%	0%	1%

The third dimension is the most problematic and the participants' opinions seem to be clear in the fact that the proposed on-line activities need to be rethought to improve the level of interaction that they allow. To the item "I explain my idea to other participants" 27% of the answers are "often" and "almost always". To the item "I ask students to explain their ideas" 8% of participants answered "often" e nobody answered "almost always". The results on the last two items "other participants ask me to explain my ideas" and "other students answer to my ideas" are not very good as well. In both items less than 5% of participants give positive answers (Table 5).

5 Reflections and Conclusion

The described mandatory intensive course has been developed to offer practitioners a learning path that could be related to the authentic experience of the work contexts. Following this direction PBL has been chosen as didactic approach and it has been applied to a Moodle platform. Participants following the phases of activation, appropriation, and reflection can apply prior knowledge and new learning to solve different problems and develop critical awareness. Results show that the dimensions of "pertinence" and "critical reflection" are allowed by the activities of the model. The results for the interaction dimension are less positive. Our efforts, in this case, were directed through the engagement of the whole group of participants (N = 102) in the discussion after the presentation of the case. Unfortunately, this number is really high and participants could be disoriented in the discussion forum. Moreover, reading all the post could be hard. In the same way the action of moderator is really weak and ineffective due to the huge amount of posts that he or she has to read before participating to the discussion with some consideration or advice. We recognize that allowing interaction in on-line groups requires considerably more effort than face-to-face. Ensuring that groups work effectively together will be the aim to reach for future courses in the next years.

From the literature, for example, several suggestions could be adopted. As cited in Savin-Baden [5] Johnson said that all members have to be engaged in group success and that each of them has to be held accountable for the contribution he or she gives to the common work. A reflection could be done also in the direction to understand which kind of group could fit better for practitioners in the field of education. Also, in this case the literature suggests that groups in the PBL approach for online learning can be tutor guided, reflexive, cooperative, or collaborative. In the future we will try to apply these different types of groups to our blended model and at the same time we will reduce the number of students that discuss together after the presentation of a case.

Information and computer technology in general and Moodle specifically can play different roles in a problem-based learning environment. They can be used to present the problem in a realistic and engaging way, for example through video. They can support research and information organization. They can support communication between learners through electronic means of collaboration and argumentation. Like this contribution, a vast set of field research [15–20] has shown that students respond positively to this approach and benefits are significant:

1. retention of knowledge over time;
2. transfer of knowledge to new problems;
3. integration between "basic" and "applied" disciplines;
4. increase of abilities in information search;

Among these results there is an improvement of “soft skills”, such as abilities of diagnosis, relationship and strategies building. The results concerning the retention of knowledge over time and the transfer of knowledge are particularly significant, taking into account that the two main problems affecting professional training are the decay of learning and the lack of transfer to work of what has been learned. The increase in motivation and interest is also noteworthy, as one of the biggest obstacles to learning is the fact that people often do not attend professional training courses for a personal interest but because, as in the case of the course described, they have been obliged to do so. Concluding, on the base of this experience, we invite universities and companies to transform traditional courses for the training of professionals using a problem-based approach, at least as a pilot experience to evaluate the effectiveness of the method in their organization.

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Empowering Positive Behaviors: A Gamification-Based Approach

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Abstract. Spanish educational laws specify the percentage of a student's grades that correspond to knowledge, skills, and behavior. In recent years, the percentage assigned to attitudes has grown due to the importance that pedagogues and psychologists place on good attitude and coexistence in learning processes. In this regard, this study explores how teachers can evaluate students' attitudes and promote good behaviors in classrooms, as well as improve communication with families. To do that, a gamification approach was implemented in a secondary school in Spain, managing a population of 105 students and an experimental sample of 53 students. The results obtained from comparing the experimental and control groups reveal a deep importance of promoting and recognizing good behavior at school, as well as of letting students and families participate in the process.

Keywords: Behavioral science · Gamification · Learning systems · Semisupervised learning · Adolescence

1 Introduction

Information and communication technologies (ICT) have become the focus of learning processes, and almost every day, new tools appear to ease teaching and administrative work. In fact, Spanish educational departments, assisted by teachers, psychologists, and other specialized staff, have developed technological tools in order to manage the academic data of students in different subjects. Additionally, they try to standardize aspects such as the grading criteria, assessment instruments, and communication tools between teachers and families. That way, when families want to check how their children are progressing at school, they can do it immediately using tools like Educa[1] in the region of Navarra; Racima[2] in La Rioja; or Sigad[3] in Aragón, for example.

[1] https://educa.navarra.es/familias/#/LoginFrame/Login.
[2] https://racima.larioja.org/racima/.
[3] https://servicios.aragon.es/sigad-didactica/.

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Additionally, several educational centers have included e-learning tools on their web pages to allow students and families to access several kinds of didactical resources.

However, although all these actions improve students' performance and ease teachers' labor, we focus here on an aspect that is not so easily managed with these tools: students behavior assessment and how the way in which it is evaluated can influence students' performance and learning experiences.

Moreover, several studies, such as the "State Study on School Coexistence in Obligatory Secondary Education" (from Spanish, Estudio Estatal Sobre la Convivencia Escolar en la Educación Secundaria Obligatoria[4]) [1], the "Validation Study of the Questionnaire on School Maladjustment Problems" [2], or the "Study of Coexistence and Good Practices" (from Spanish Estudio sobre Convivencia y Buenas Prácticas) [3], as well as several institutions, such as the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Spanish Ministry of Education[5], and the National Association of Educational Staff (from Spanish, Asociación Nacional de Profesionales de la Enseñanza – ANPE[6]), have also acknowledged the importance of a positive coexistence and behavior in improving academic performance. However, it is also important to pay attention to the way in which this behavior is assessed and communicated to students and families: rather than punishing bad behaviors, mechanisms to give prizes and recognize good practices should be implemented.

Among several methods to promote motivation, we have chosen gamification. Gamification could be defined as the introduction of techniques, mechanisms, dynamics, and game rules in environments that are otherwise not playful as a way of improving motivation in activities that could be boring [4]. Several authors have stated the benefits of gamification in education, including Ruiz [5]: motivates students and fosters participation among students in activities, promotes camaraderie by stimulating cooperative work and creates atmospheres to ease communication by creating a comfortable environment to absorb new content.

In this paper we study how early-adolescence students improve their behavior and academic results based on an enhancement of their implication in the assessment process by using a gamified strategy. This proposal was evaluated with a group of students' first year of secondary education in Navarra, Spain. In this experiment, students are involved in the design and performance of rewards as well as in the development of the corpus of behaviors that will be awarded and punished.

The rest of the paper is organized as follows: Sect. 2 presents the context where the study took place as well as a review of gamification experiments and the tools used therein; Sect. 3 presents the proposal of a gamification-based approach to improve positive behaviors; Sect. 4 reveals the main results, which are discussed in Sect. 5; and finally, Sect. 6 outlines our main conclusions and further studies.

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[4] Study performed in the frame of the agreement between the Preventive Psychology Unit of the Universidad Complutense de Madrid and the Ministerio de Educación of Spain, in collaboration with regional governments from the State Observatory for the scholar coexistence.

[5] http://www.mecd.gob.es/portada-mecd/.

[6] http://www.anpe.es/wordpress/.

2 Context and Related Work

Adolescence has several features that contribute to slow down the normal development of classes at high school. This transition between childhood and adulthood is characterized by a high importance of social interaction with peers and a high occurrence of chapters of disobedience to parents and bad behavior in class, among others [6].

The focus of this proposal is promoting good behaviors in classrooms by using gamification. Gamification in education is a growing field of research, which, since only 2014, has amassed around 5,000 papers indexed in the most popular scientific databases [7]. A positive correlation between gamification and behavioral changes has been reported in other studies, such as those of Blohm [8], Hamari [9], García [10], Hew [11], Alahaivala [12], Rapp [13] or Schoech [14], for example. Moreover, there are also several studies on the effects of gamification on behavior and motivation [15] as well as how the practice can promote better academic performance [16]. Many of the proposals that we found are related to online instruction, due to its relevance to gamification (Horizon Report 2014, as cited in [17]), and more studies were found conducted at the university level than at the elementary and secondary school levels [7, 9]. Starting with the reviews in these papers and other additional research, we have selected a set of proposals that deal with the gamification of learning at the K-12 level (primary and secondary school, until 12 years old). One of these proposals [18] uses the tool SamEx to develop an experiment at the elementary school level. SamEx is a mobile learning system used in presence that allows students to share pictures, videos, and audio clips, as well as comment on them. Boticki [18] tried to discover the relationship between the use of SamEx and academic performance. The findings revealed that there exists a correlation between participation in a gamified system and academic performance. Concretely, students who participated with self-directed contributions obtained higher marks than the control group. Moreover, the author stated that students' motivation increased only if teachers gave them concrete instructions, facilitated discussion, and summarized learning points.

Regarding motivation, Davis [19] found that students felt empowered when they received badges because this helped them keep track of their progress and, as a general finding, this author supports the idea that gamification motivates students. A point of interest from that study is the fact that students asked for badges to reward soft skills, such as public speaking. Also supporting the affirmation that gamification promotes motivation at the K-12 levels, Su [20] showed how the engagement of elementary school students was improved in a botanical activity with the inclusion of ICT and gamification elements in the activity, combined with the effects of mobile learning in an outdoor activity.

Nevertheless, a lower number of works are found in relation to the usual behavior and coexistence in a normal classroom, which is the goal of this paper. We agree with the study performed by García [10], which also focused on rewarding positive behaviors rather than punishing negative behaviors. In this experiment, the authors tested out ClassDojo[7], a tool to allow teachers to manage their classes on the base of the

[7] https://www.classdojo.com.

behavior grades. By using ClassDojo, the author corrects the poor behavior of misbehaving students. This experience was performed at the elementary school level, and the authors reported that the students were willing to earn many Dojo points because, of course, the Dojo points were tied to real-life prizes, which, in this case, came in the form of extended recess time or small elements of a treasure.

Nevertheless, the most important contribution of this paper relates to the adolescents participation in classroom's behavioral rules in the Spanish educational space. As previously explained, regulations about how behavior is assessed at schools in Spain give regional governments the freedom to establish their own guidelines, which sometimes creates differences between educational centers and a lack of promotion and rewarding of positive behaviors. Additionally, teachers have difficulty keeping track of and recording the attitudes of students to calculate grades for this aspect. There are several tools to manage the academic performance of students in order to ease the communication, management, and administration among schools, students, and families. The most relevant one is Educa[8], a regional tool used in all educational centers. Educa manages the data of about 300,000 users each year and the processes of admission, registration, lesson planning, assessment, assistance, and diagnostic evaluation at kindergarten, elementary, and secondary schools, as well as music and language schools.

For that reason, some local educational centers have included different systems aimed at managing behavior. For example, the system called SGD[9] (teaching management system, translated from Spanish: Sistema de Gestión Docente) has been used to manage academic information as well as communication between schools and families. This system also includes an option to record students' behavior, but the selection is limited to a set of predetermined options, all of them negative.

Summarizing this review, we could conclude that gamification fosters motivation in K-12 students and that this motivation could drive students to improve their academic performance, foster concrete behavior, or both. Additionally, we found a lack of concrete rules to identify and grade behaviors, as well as a need for specific methods to record and grade this aspect, which is particularly important in the early adolescence (secondary school) due to the features of this stage of the students' growth.

3 Gamified Approach to Improve Positive Behaviors in Secondary School Classrooms

The main goal of this study is to check to what extent the introduction of objective assessment of positive and negative behaviors and participation of students in the process of design of those rules contributes to improve the normal development of classes and how this is reflected in students' academic performance.

[8] https://www.educacion.navarra.es/web/pnte/educa.

[9] http://www.tecnausa.com/educacion/gestion_docente.html.

3.1 Methodology

According to González [21], adolescents who participate in decisions at home have a higher index of subjective well-being. In this paper, we interpolate this result to secondary school and allow early adolescents to participate in the process of regulating the coexistence in the classroom. To do that, we had the students actively take part in the process of defining the rewarded and punished behaviors as well as how they are scored. By this participation, the hypothesis is that students would be more engaged with the experience, would be more aware of what is good and bad in this context and would improve their behavior. Consequently, they would improve their learning results.

3.2 Materials and Methods

One of the main difficulties found with secondary school students was piquing their interest in activities performed at school. In order to try to avoid this handicap, we involved the students in the project right from the beginning. In the subject of music, during the third term, a gamified approach to assess and promote positive behaviors was included. This experiment ran over the course of seven teaching weeks, making a total of 21 sessions of 55 min each. The first week (three sessions) was aimed at defining the rules, the badges, and the rest of activities; during the next six weeks, the experiment itself took place.

3.3 Sample

The study was developed in the region of Navarra, Spain. Its population is economically supported by agriculture (wine sector) and by an important industrial factory in the area, which specializes in the processing and transformation of rubber, the manufacturing of components for the automotive industry, the manufacturing of industrial counterweights, and the production of prefabricated materials for construction. The secondary school where the experiment took place was awarded the titles of "Excellent Center" (Certificate of Excellence EFQM and Certificate of Excellence of the Government of Navarra) and of "Erasmus Center" and was also part of the network of centers of the quality system KADINET (Quality in the Public Education). The students who study at this school are classified within a socioeconomic context of middle-low class.

Participating in this experiment were 105 students in their first year of secondary school (55 girls and 50 boys aged 13 years), divided into four groups: A (27 students), B (28 students), C (26 students), and D (24 students). Groups A and C acted as the experimental groups, while groups B and D acted as the control groups.

3.4 Tools

In this experiment, the selected tools were ClassDojo [10] and Edmodo [22]. ClassDojo allows the teacher to effectively register students' behavior while investing a minimum amount of time, to grade those behaviors and to send the information straight away to parents, who are able to access it online at any time. Edmodo is used to quickly and easily assign badges to students who have been awarded for their good behavior. Therefore, the use of both of these tools offers a much higher level of functionality than the traditional tools used at school.

ClassDojo is a web application created in 2011 by Sam Chaudhary and Liam Don in San Francisco, and it is growing at a dizzying pace. It was firstly launched in the United States and is currently used in 60 countries worldwide. ClassDojo can be used with any browser, and there is also a ClassDojo mobile application that works on both iOS and Android. The application is totally free, requiring users only to register the school in which it will be used (if it is not already registered). It is mainly used to monitor students' behavior through grading. The main features of ClassDojo are as follows: instantaneous assignment and grading of behavior; quick and direct communication with parents through easy-to-generate invitations; useful exportable information to enhance the gamification experience, detailed reports, including graphs of students' behavior at the individual or group level in a concrete date range; progress monitoring done in a single click; providing data collection forms.

There are several studies that rank the ClassDojo tool as the most suitable to register and encourage positive student behavior. The positive reinforcement of actions carried out by students is commonly forgotten due to lack of tools to register such actions [10]. However, ClassDojo eases that process and helps teachers to foster student-specific behaviors [23] through real-time feedback via the web and mobile devices, since the constant positive reinforcement helps to build positive behaviors among students.

Additionally, the assignment of badges using gamification techniques can encourage students' motivation and participation [24]. Edmodo, which was already being used with the students in the experimental groups, is an educational social network that enables the creation and assignment of badges. It is a free learning network, used to provide teachers with a simple way to create and manage an online classroom, as well as to allow their students to connect and work with their peers and teachers anywhere, anytime. Balasubramanian et al. [22] demonstrate that the incorporation of Edmodo stimulates student engagement and responsible learning. The main features of this tool are as follows: public forum and private messaging; familiar design and operation; easy creation and management of badges in addition to predefined badges; easily and quickly management of students, classes, and privacy when undertaking any action; contact to other teachers and collaborate with several teachers at the same time in the same school; access limited by easy-to-generate invitations and a restricted and private area that guest users have permanent access to; access to free resources that can be configured to connect to Google Drive for easy access to all documents stored there.

3.5 Experimental Design

The experiment was organized into five phases: (1) student and parent registration in ClassDojo, (2) creation of behavioral rules, (3) design of the gamification process, (4) the experiment, and (5) the evaluation.

In the first phase, the teacher in charge, with the authorization of the manager team, registered the school, created classrooms, and invited students and parents. Once classrooms were created in ClassDojo, students were assigned to these classrooms and each of the student chose a predesigned *monster* for him- or herself. This is an activity that the students loved and that garnered particular attention from them.

After the students were created, invitations were sent or exported to allow both students and parents to access the application, allowing them to monitor at all times the evolution of the data that would be introduced in real time. In this study, paper invitations were distributed, taking advantage of the opportunity to also have direct contact with the family for purposes such as presenting the activity to be carried out, etc. Additionally, the invitations were completed with a brief explanation for parents, letting them know that ClassDojo would be used to manage and to evaluate the attitudes of students and that they would have access to their children's information in a private area. These invitations were also intended to foster families' involvement.

In the second phase, the creation of behavioral rules, students were given an active role in order to encourage engagement in the experiment. Then, in groups, students developed lists of behaviors that they judged as relevant, which would be discussed later, voted (creating a democratic establishment of rules), and established the classroom norms with the greatest possible consensus. Nevertheless, behaviors could be modified, eliminated, or added during the experiment, if needed. In order to develop this norm-setting process, the students had to answer the following questions: (1) what behaviors are positive and deserve a positive score?; (2) what behaviors are negative and deserve a negative score?; and (3) how would you like to be rewarded for positive behaviors? It is worth mentioning that the consequences of conducting negative behaviors were already codified in the Regulation of Internal Regime of the School. This phase aimed to create norms of coexistence and to predetermine which actions and behaviors were positive and which negative as well as what score to grant each of them. Moreover, this task promoted a good working environment in the classroom by encouraging collaborative creation and discussion among the students and the teacher. The final set of behaviors was transferred to ClassDojo as detailed below.

Positive attitudes scored with +1 point were: helping other teammates, correctly answering a question or performing an exercise, showing interest in the subject, participating actively in class activities and participating in the choir of the institute; getting the maximum score on a test were rated with +3.

As negative attitudes, breaking any rule codified within the Internal Regime Rules was scored with −3 points; the rest, with −1: constantly interrupting the class, arriving late to class without a valid excuse, intentionally damaging material or school property, not participating in class activities, coming to class without the required material: −1 point and not performing tasks: −1 point. Negative behaviors can also be classified as running contrary to coexistence. In that case, in addition to discounting the corresponding point allocation in the gamification process, other measures already established in the rules (Decreto Foral 47/2010, of August 23, modified by the Regional Decree 57/2014, of July 2) can be applied, such as the loss of recess time or suspension of the right to participate in complementary or extracurricular activities, for example.

In the third phase, the gamification process and prizes were developed. In a similar way to the process performed to decide the behaviors to be evaluated, the students participated in the design and elaboration of the rewards associated with positive behaviors. Then, the students designed and developed badges and prizes, a fact that received high levels of engagement from the majority of them. A digital badge is not different from traditional ones, such as Scout badges or military awards. However, digital badges can include information to identify and authenticate them, which can render them exportable, independent units of recognition. In this study, they help students visualize their progress and how they are learning.

Thus, in agreement with the students who participated in this experimental pilot, both individual prizes and collective prizes were established. *At the individual level*, the student with the highest score each day would receive a badge. The badge would give students the following privileges for the next class: being able to play the instrument of their choice among those available in the classroom (one of the most popular was the synthesizer), being allowed to leave the classroom for five minutes (to go to the library, café, or any other area supervised by other teachers), and being allowed to postpone the performance of an activity (without negative consequences) if the student does not feel like performing it at that time (although it would have to be finished at home). If a student were to receive three consecutive badges in one week (the highest possible number, since there are three classes per week), he or she would receive the badge called *cup* which gives the student the right to choose the song to be worked on during the week and to receive from the teacher the sheet music of the song that he or she wants. If a student were to receive three "cups" (non-consecutive), he or she would be given a music CD of his or her favorite group. The expenses incurred by this activity were approved in the budget of the music department with the approval of the management team, the faculty members, and the school council. *At the group level*, the group with the highest score every week (evaluation conducted weekly since groups had classes on different days of the week) would be able to choose between (1) going to the computer room to have class there; (2) going out to the playground to have class there; or (3) using the sports pavilion and the equipment available inside for two recesses (the breaks in one single day).

Awards defined were introduced into ClassDojo to be able to register the behaviors. It took very little time because once the information was introduced into one classroom, it could be copied and imported into other classrooms.

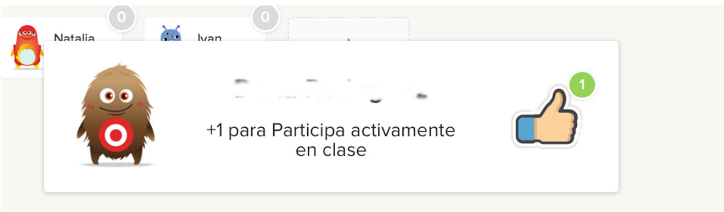

Fig. 1. Assigning a positive behavior to a student: student is actively participating in the class

Phase four is the experiment, conducted for six weeks, when the teacher selected each student and added his or her respective behavior (Fig. 1). One of the advantages of ClassDojo is that the assignment of behaviors is simple and fast (two clicks), not requiring any extra time from the teacher and allowing for quick and immediate feedback for parents. Additionally, students and parents could see their daily results.

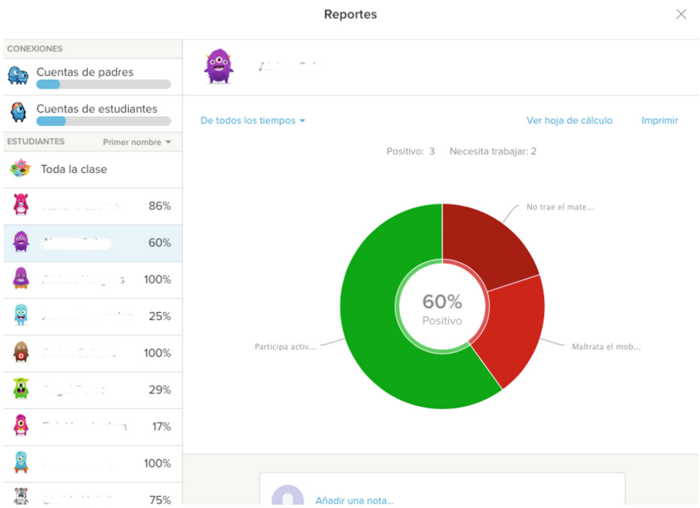

Fig. 2. Example of the behavior registered for a student: 60% positive for active participating; red area: forget materials and mistreat the furniture. (Color figure online)

As a service for teachers, ClassDojo can also display the total score of each class and generate reports focusing on different aspects, such as a students' behavior within a particular time frame or the behavior of a group of students. In addition, ClassDojo also displays the total score of each group. This helps with reporting behavior over several weeks as well as checking how the behavior has changed over the weeks. The teacher can select specific students and time frames, and ClassDojo will automatically generate a file with the respective data, available both in PDF and XLS formats, which can be printed or stored. These reports are enriched with graphs to ease understanding of the data. The example graph in Fig. 2 shows 60% of a student's behavior as positive. Thus, this student would receive 60% as his or her behavioral score.

However, ClassDojo does not allow users to create badges nor to assign them to students. For this purpose, Edmodo was introduced. Once the scores were registered in ClassDojo, Edmodo was used to assign the prizes, since it is an excellent badge manager, where badges can be created, shared, and assigned with total freedom and privacy.

Although predefined badges in Edmodo could be used, involving students in this process was an additionally motivating for them. In this way, the students actively participated in the creation of the badges. Moreover, they proposed designing music-related badges using the color green and to make both digital and physical badges to be able to take them to home. Then, the students were organized into groups to work on the badges, including designing them, naming them, and providing them with features.

Once the badges were created, they were digitized (scanned) and imported into Edmodo to create digital versions. Then, badges were awarded both digitally and physically each day. The digital versions of the badges allowed students and parents to see the badges that had been awarded when checking behavioral progress from home, giving them the opportunity to complain in the case of an error. The *cups* badge only had a digital version.

4 Results

After conducting the experiment over 18 sessions of 55 min with the groups 1A and 1C (the experimental groups), we evaluated the results, comparing the experimental group to the control group as well as to the previous results of the experimental group (when traditional behavior management and evaluation processes were used).

Table 1. Behaviors registered before and during the experiment

	Pre-experiment records				Experiment records			
	Negative		Positive		Negative		Positive	
	Nº	%	Nº	%	Nº	%	Nº	%
Experimental group	109	83,7	21	16,3	118	18,2	533	81,8
Control group	93	82,2	20	17,8	83	80,2	21	19,8

As shown in Table 1, the number of recorded behaviors of the experimental group during the experiment was 651, compared to 104 in the same period for the control group (a difference of 547 records). If we compare the number of recorded behaviors of the experimental group in the pre-experimental phase to those registered in the experimental phase, we see that it goes from 130 (pre-experimental period) to 651 (a difference of 521 records).

It is worth mentioning that this school requires a minimum of two records for each student during each term. If we add up the records for both groups in the pre-experimental period, we obtain 243 records, which just fulfills the school requirements (2.3 records per student).

During the experimental period, which did not consist of a complete term but six weeks, a total of 755 behaviors were recorded (651 in the experimental group), or 7.1 records per student (12.28 per student in the experimental group). Thus, the number of registered behaviors increased by more than 200% (precisely, 208.7%). Moreover, if we observe positive behaviors in the experimental and control groups, we can see that 81.8% of the positive behaviors were registered in the experimental group, while only 19.8% were registered in the control group (a difference of 62%). In addition, comparing the number of positive behaviors registered in the experimental group during the experiment to that of the pre-experimental phase (in which traditional tools were used), the difference is larger yet (65%).

On the other hand, if we compare the negative behaviors registered by the experimental group to those of the control group, we can see that, of the total registered behaviors, the experimental group has significantly fewer negative behaviors (18.2%) than the control group (80.2%). Finally, if we compare the number of negative behaviors of the experimental group to that of the pre-experimental period, we also find a much higher percentage of negative behaviors with respect to positive ones (83.7%) in the pre-experimental phase, which indicates a difference of 65.5%.

In order to establish a frame with which to compare specific negative behaviors that run contrary to coexistence in the school where the experiment was conducted, the Coexistence Commission provided data prior to the experiment, showing that an average of 1.5 behaviors against school rules were committed among the students in the first year. The data in the experimental period show that, in the classrooms where the experiment took place, only one misconduct per student ran contrary to coexistence. In the other classrooms, the number was maintained at 1.5.

In Table 2, results pertaining to failing and passing students are summarized, with the previous view of comparing the experimental and control groups as well as between the experimental group in the pre-experimental period versus the experimental period.

Table 2. Summary of failing and passing students

	Pre-experiment				Experiment			
	Failing		Passing		Failing		Passing	
	Nº	%	Nº	%	Nº	%	Nº	%
Experimental group	13	24,58	40	75,42	8	15,10	45	84,90
Control group	19	36,02	33	63,98	18	33,93	34	66,07

In the first comparison, between the experimental and the control groups, only 8 students failed in the experimental group, versus 18 in the control group. This means that 18.83% more students passed in the experimental group.

On the other hand, if compare the experimental group in the pre-experimental and experimental periods, we can observe that we have only 8 failing students in the experimental period, versus 13 failing students in the pre-experimental period. This shows a growth in passing students of 9.48% in the experimental group against a growth of 2.09% in the control group in the same period. Thus, the percentage of passing students in the experimental group rose from 75.42% to 84.9%, while in the control group, the percentage rose from 63.98% to 66.07%. Table 3 summarizes these comparisons.

Table 3. Summary of differences between failing and passing students

	Passing (pre-experiment)	Passing (experiment)	Growth
Experimental group	75,42%	84,90%	+9,48%
Control group	63,98%	66,07%	+2,09%
Difference	11,14%	18,83%	

As a final activity in the experiment, students and families were provided with a four-open-questions satisfaction questionnaire on Edmodo. This questionnaire was filled out by 72% of the students and families in the experimental group.

The first question pertained to how ClassDojo and Edmodo had fostered student participation, and 85% of participants answered that it had, adding several comments to emphasize certain aspects: “It is very fun to have a monster as my display picture”, “It’s very easy to access information”, and “I can see at any time what my son has done in class” (translated from Spanish).

In the second question, participants were asked how much better the experimental tools of ClassDojo and Edmodo had been in comparison to previous tools. Some of the comments were as follows: “If the Internet is not working, I cannot connect” (the previous tool would not work in this circumstance, either) and “Here there is more information than with [the previous tool]” (translated from Spanish).

In the third question, participants were asked to name what they had liked the most and the least about the experiment. Some of the most relevant positive answers were the following: “What I liked the most was being able to go out on the playground if we won a cup,”, “[I liked] to win badges to have advantages in class”, “[I liked] winning badges for things that were not taken into account before the experiment”, and “[I liked] also being informed about good things that my child does in class”. However, this also was a negative comment: “What I liked the least was that my parents could find out everything I do”.

Finally, in the last question, participants were asked to evaluate their participation in the experiment, rating it from 1 (not satisfied) to 5 (very satisfied). The majority (80%) of participants answered with a 5, while 10% answered with a 4 and the other 10% a 3. We found no ratings of 1 or 2, which suggests that the experiment was satisfying for most of the participants.

5 Discussion

In this paper, we have examined several aspects related to managing the behavior of students at secondary school, mainly in terms of enhancing motivation, improving academic performance, facilitating the recording of behavior, and relating academic performance to the fostering of good behaviors.

Several of these aspects have already been reported in several other studies, as cited in Sect. 2. Authors such as Boticki [18] and Davis [23] have proven how motivation fosters learning results, and García [10] has studied how to change or foster different behaviors.

The results of the experiment showed that it is possible to record all the behaviors carried out by students, both negative and positive. In addition to registering more information about student behavior (an increase of 208.7%), less time was spent making these annotations, a feature requested by teachers. Registering more information also showed that the students behave more positively (65% more) than it can seem when only bad behaviors are recorded. Additionally, using ClassDojo and Edmodo, it was possible to carry out evaluations of students’ attitudes and grade them accordingly, in a wholly objective and individualized way, as well as to assess the attitude of the group in general. By using a methodology that favors student participation and motivation, the climate of the class in general improved and the amount of misconduct decreased considerably (33.3%). During the design of the gamification strategy and prizes, motivation and participation were higher than ever before during any course activity, since all students, without exception, wanted to participate and contribute. Each student's evolution was immediately reported both to the student and to his or her family in real time, creating a feedback system that with traditional tools is impossible and that registers whether the parents have received and read the information on the site. It was possible to contrast the experimental and the control groups and see that the experimental group had significantly better results. If we compare the number of passing students who participated in the experimental pilot with that of the control group, we see a difference of more than 18%.

With regard to behaviors contrary or severely contrary to coexistence between students, it was observed that such behaviors were not eliminated but did drop significantly (33.3%). Nevertheless, it is worth mentioning that these breaches of the rules were accumulated by only two or three students per class.

In addition, it was verified that both students and parents had a very high level of satisfaction regarding the performance of this experiment (80% were highly satisfied).

Finally, communication between parents and the school became more fluent, which helped fulfill one of the requirements parents requested in the school were the experiment was conducted: the establishment of a greater flow of communication about children's behavior in class. The improved communication is a result of the real-time access that parents have to all feeds. When students arrive home, their parents can continue to encourage positive behaviors and leadership behaviors that need to be trained.

6 Conclusions and Further Works

In this study, we presented a proposal to foster good behavior in students of the first year of secondary school. This proposal includes three main elements: fostering good behaviors with a gamification system; involving adolescent students in the rule development and design of the badges; and improving the relationship between a positive environment, motivation, and better academic performance.

Considering previous works in this field, we tried to avoid some of the handicaps found by authors of [18], who highlighted the need of giving concrete instructions in order to increase motivation as well as being aligned with [21], where importance of involving adolescent in the making-decisions process is important to their subjective well-being. We did it by involving students in the design of rewards and punishments, letting them to have precise indications about what the system would assess.

As shown throughout the paper, this study joins findings from several fields and provides promising results in terms of the satisfaction of students, parents, and teachers, as well as evidence of academic improvement. Actually, the number of recorded behaviors, which comprises 20% of a student's final grade, increased by more than 200%, making this evaluation more accurate. Moreover, the growth in the number of passing students was more than 7% higher in the experimental group than in the control group, and the satisfaction of the students and parents was remarkable. These results wide the findings of [25], which were related to primary school.

Our future line of work is related to widening the scope of action of this experiment and trying to implement this system into more subjects and levels in order to detect if generalizing the intervention could provoke a decrease in effectiveness.

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Assessing Attitudes Towards Collaboration of Students in Self-directed Online Groups in Higher Education

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Abstract. This research focused on knowing the attitudes that students have about collaboration when they work in self-directed groups in a virtual learning environment. A survey was fulfilled by 75 students of a master's degree on Education evaluating collaboration within their groups. An EFA was applied to the results and a 5-factor structure was obtained. These factors explain 60.30% of the variance of the questionnaire. The first one, Communication merges conversation, interaction and debate. Secondly, another factor named Trust is highlighted, a belief on the success and well-functioning of the team. The third factor, Cooperation attends to the attitude of sharing and being open to all members. A fourth factor, Cohesion, points to ideas as clearness, efficiency, consensus, roles and goals established. And finally, Coordination factor refers to attitudes to work distribution and acceptance of changes. This structure is aligned with previous literature on groups' dynamics that point to interaction, sharing, clarity and acceptance without conflicts as main elements of successful collaboration.

Keywords: Collaboration · Attitudes · Assessment · Higher Education

1 Introduction

Without any doubt, the educational paradigm has changed due to the profound transformations that technologies, and Internet in particular, have produced. The possibility for students to connect and work together in activities and projects from anywhere in the world is a reality that is observed especially in the field of Higher Education, a context where students have more freedom to work at their own pace. For instance, MOOCS are a good example nowadays.

Collaboration is an active methodology of frequent use in the educational context due to the benefits that brings to students, as it contributes to the development of problem-solving skills [1] and to learning communities [2].

Cooperative and collaborative distance learning has been approached by many different theories and has produced heterogeneous results, giving rise to various controversies. In order to illustrate the main ideas and approaches that generated these debates, Sfard [3] used two metaphors for its explanation. The first metaphor considers

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learning as an "individual acquisition of knowledge" and the second as "participation in a social practice". These metaphors are useful because they present, in a simplified and schematic manner, theoretical and methodological proposals and research results that share similar characteristics and highlight certain attitudes and basic approaches to collaborative learning [4].

In the metaphor of acquisition, learning occurs as a result of the appropriation of the concepts that are reflected in the discussion carried out during a collaborative task in a virtual environment. This incorporation is possible thanks to our ability to connect the new concepts with preexisting conceptual schemes, by giving them meaning through their relationship with other previous knowledge we have [5, 6]. Also the construction of individual knowledge relieved by the explanation to other peers or the need to solve a cognitive conflict in the heart of an interaction, are explanatory mechanisms of knowledge acquisition. According to this conception, knowledge is property of the mind and the individual is the basic unit of knowledge [7].

According to the metaphor of participation as a social practice, collaborative learning implies to participate and develop knowledge jointly, within the framework of an interaction in a community. Different collective processes, such as negotiation, argumentation or community inquiry are involved. This is a vision about learning focused on the process of knowing, rather than on knowledge results. These studies on the processes of interaction and learning are the result of the influence of socio-cultural theories that in the 1990s, led to a shift of the focus that investigated the relationship between learning and technology. From analyzing the effect that technology had on individual learning outcomes, researchers analyzed how to establish links among students to learn collaboratively in small groups and learning communities [8].

In recent years the thematic focus of several researchers on collaborative learning [9, 10] has shifted to the possibilities offered by technological tools, given the number of innovations (social networks, blogs, wikis, PDIs, tablets) that have arrived to the lives of our students, who participate in social activities online every day.

In online collaborative learning situations, the exposition of ideas can stay longer than in the face-to-face groups, since the thoughts, proposals, questions and answers, and their deliberations are written in the forums, in the wikis, in the blogs. The reflection generated by the educational interaction sets in motion a very important cognitive process: the students examine their own approach and compare it with the one contributed by the others and then analyze their own again. This feeds a cycle of cognitive reiteration [11] that allows the student to reflect in a systematic way their thought process and reach new conclusions or re-elaborate ideas that he would not have contemplated.

Despite the profusion of studies on this psycho educational phenomenon, there is still little research about group work as an instructional strategy in online learning environments and how learning is influenced by different elements of the educational situation. The purpose of our research is to extend previous knowledge on students' attitudes towards online collaboration, what they value when they develop a task jointly in a learning situation.

2 Literature Review

Group dynamics have proved to be one of elements that may influence students' attitudes towards collaborative learning, especially in online groups. Students need to share ideas, agree on decisions, solve differences, reach agreements. Many times, teamwork is an essential part of their final evaluation of a course, in particular in Higher Education. This circumstance may cause problems and conflicts [12], some students may not compromise in the activity as much as the rest of the group, what is called "the free rider effect" [13], or students feel they are graded in a way which they consider does not reflect their individual effort [14]. As well, carrying out an activity or a project within a virtual group usually involves more time and more coordination than individual activities [15] as it is difficult to reach consensus. So, many times, students are reluctant and dissatisfied with group work [16].

Researchers have pointed out a set of elements of group dynamics that may facilitate or hinder learning in virtual groups in collaborative situations. Toseland and Rivas [17] consider that these dynamics are formed by several factors: communication, interaction patterns, cohesion, social integration, influence and group culture. In their research on students' attitudes toward collaboration, Ku, Tseng and Akarasriworn [18] point out three relevant factors: group dynamics, acquaintance of the group and teacher support. Grenlee and Karanxha [19] include participation, communication, collaboration, trust and cohesion as main interrelated teamwork factors that define group dynamics.

Open and regular communication is considered the foundation of successful collaboration. In her study on the experiences of learners engaged in computer-supported authentic activities, Bennet [19] found that open communication was a key element for team success and that the teams needed to adapt their communication patterns throughout the project. As such, communication involves negotiation and discussion [19] and expression of personal opinions [20].

Group cohesion is another critical element for successful team dynamics. Cohesion is understood in different ways. Some researchers consider it as the desire to stay in the group [21] and take care of the members of the group [22], while others consider cohesion as the commitment to accomplish a common goal [23]. As well, several researchers [24] distinguish between task cohesion, when members of the group try to success in a common goal and social cohesion, when members feel emotionally attached to the others and try to remain in the group [17].

Trust is usually related to a feeling of psychological safety [25]: when members of a team feel respect among them, concerning their competence and professionalism [26]. Trust is also considered a relevant factor in group performance, as it links team members [27].

These investigations have been carried out in learning groups that have had support and guidance from their instructors. However, increasingly, teachers especially in Higher Education, ask their students to work autonomously and obtain a final result agreed between them. They use this technique as they are not only interested in having their students learn, but also in developing their skills in group work, negotiation and leadership. Hence, it is relevant to investigate on attitudes towards collaboration in self- directed groups as it is essential to ensure basic elements that may allow the group to achieve its main aims successfully and ensure a positive collaborative knowledge construction.

3 Method

3.1 Aims

The first objective of this study is to validate the instrument adapted from previous literature on attitudes towards collaboration in virtual groups. And, secondly, to identify the factors that make up the attitudes of students who work autonomously in virtual learning environments.

3.2 Subjects

Participants were 139 graduate students who were enrolled in an online master's degree on education over an academic year. They were studying at a fully-online university in Spain. 75 of them fulfilled the questionnaire on attitudes towards collaboration, which represents 53.9% of the total number of students. 93.3% were female and 6.7% (5) were male. All of them were graduates in education and 47% of them had previous experience as teachers in schools and high schools. Their mean age was 30.09 years (SD = 5.25 years).

3.3 Study Context

The master degree was focused on developing teachers' competencies to deal with learning disabilities in the classrooms. As part of their final evaluation in the second course of the degree, students had to work autonomously on a project. It involved the design of a pedagogical unit, and students had to decide which technological support could ease students' learning. The instructor's responsibility was to explain the educational material provided to students, communicate the instructions for the group work and the clues for evaluation. He also gave access to the wiki where the students had to work autonomously.

The same instructor was responsible for both groups were participants were studying their degree. The web-based learning management system included an area of educational material, another of evaluation and area of communication where synchronous and asynchronous applications were included. Students could use chats on one hand, and e-mail on forums on the other hand to communicate with their peers and their instructor. As well, students had the wiki for collaborative activities and projects.

During the second week, the instructor assigned students randomly to 10 groups and open them a wiki for their project. Groups were formed by four or five students.

The students worked autonomously during two months. They had to exchange messages, worked together on drafts on the wiki, provide and received feedback on their contributions, agree and discuss the final outcome. During the time of the group work, the instructor did not correct or warn of possible errors or confusions. He just solved doubts and clarified the structure of the report, so that the final responsibility of the outcome was exclusively of the group. As well, the marks of the report corresponded with the mark that each member was going to receive in that subject, in such a way that it was not possible to carry out the work individually.

3.4 Questionnaire

In order to build the survey about attitudes towards collaboration in virtual groups that work autonomously, the Ku et al. [18] students' attitude questionnaire was used in the first place. Secondly, the research developed by Engel and Onrubia [28] on collaborative knowledge construction was used to develop the rest of the items.

In the first case, the items were translated into Spanish and then into English, so that a double translation was made to ensure the equality of the concepts and terms used. In the case of the items derived from Engel and Onrubia (2010) [28] results, it was not necessary, since they were in Spanish.

In Table 1, items can be checked. Numbers 3, 4, 5, 6, 8, 9, 10, 11, 12, 15, 17, 18, 20, 21, 23, 25, 26 were adapted from the Ku et al. survey [18], whereas the rest of the items corresponded to the dimensions described by Engel and Onrubia [28] about the extent of the discussion (items 2, 22, 24), collective contributions (items 1, 7, 13, 16) and general agreement (items 14, 19, 27) of groups.

Table 1. Questionnaire on attitudes towards collaboration

Q1	In my team there was a member who acted as the coordinator of the project
Q2	In my team we could debate many discrepancies
Q3	My team is receiving feedback from each other
Q4	My team members share their professional expertise
Q5	My team members share personal information to know each other better
Q6	My team members share information and professional experiences
Q7	In my team the work was distributed so there was a member responsible for each part of the project
Q8	Getting to know one another in my team allows me to interact with teammates more efficiently
Q9	My team members communicate with each other frequently
Q10	My team members communicate in a courteous tone
Q11	Communicating with team members regularly helps me to understand the project better
Q12	My team members encourage openness with each other
Q13	In my team the project has been distributed among all the members and after we have put the pieces together
Q14	In my team there has been a high consensus about the content of the project and the conclusions
Q15	My team members learn how other members wish to be treated and then act accordingly
Q16	In my team we have developed the project starting from a first draft written by a member
Q17	My team members reply all responses in a timely manner
Q18	I trust each team member can complete his/her work on time

(*continued*)

Table 1. (*continued*)

Q19	In my team we have accepted with little discussion the changes proposed by members
Q20	My team trusts each other and works towards the same goal
Q21	My team develops clear collaborative patterns to increase team learning efficiency
Q22	In my team all members have revised and provided amendments to the whole project
Q23	My team sets clear goals and establishes working norms
Q24	In my team there has been a lot of debate to reach an agreement
Q25	My team has an efficient way to track the edition of documents
Q26	My team members clearly know their roles during the collaboration
Q27	In my team we have reached a consensus quite quickly

The questionnaire used a 5 point Likert scale where 1 was reported as strongly disagreement and 5 as strongly agreement.

3.5 Procedure

The student questionnaire to assess attitudes towards collaboration was distributed at the end of the course as an email attachment where the process to fulfill it was explained. By answering the mail with the survey, students accepted voluntarily to participate in the research. The students completed the survey and send it to their instructor within a week after the communication on the research. The procedure respected the University's ethical code. Personal data was protected.

3.6 Data Analysis

In the first place, descriptive statistics of the distribution of the different items was made. Secondly, and exploratory factor analysis (EFA) was applied to identify the factors that formed the survey and get evidence of internal validity. It was used the maximum likelihood and oblique rotation as factor extraction procedure in order to find out possible relations among factors extracted. Thirdly, it was calculated the reliability of the survey and finally the evidence of convergent validity. SPSS statistical package V.18.0 was used for analysis.

4 Results

The mean scores and standard deviation of 75 attitude questionnaires collected from the participants were tabulated as shown in Table 2. As well, the skewness and kurtosis were obtained. Item 10 (Q10) was eliminated as it presented an inadequate value according to skewness, following West, Finch and Curran (1995) [29] criteria on maximum likelihood procedures.

The three highest rated items on the questionnaire were: "Communicating with team members regularly helps me to understand the project better" (M = 4.44), "In my team all members have revised and provided amendments to the whole project" (M = 4.23) and "My team members communicate with each other frequently" (M = 4.16).

On the opposite, the three lowest rated items were: "In my team there has been a lot of debate to reach an agreement" (M = 2.29), "My team members share personal information to know each other better" (M = 2.47) and "In my team we have developed the project starting from a first draft written by a member" (M = 2.85).

Table 2. Descriptive statistics of the questionnaire on attitudes towards collaboration

Item	Mean	SD	Skewness statistic	Kurtosis statistic
Q1	3.28	1.11	−0.22	−0.52
Q2	3.20	1.21	−0.26	−0.79
Q3	4.05	1.20	−0.98	−0.30
Q4	3.35	1.24	−0.25	−0.92
Q5	2.47	1.38	0.56	−0.94
Q6	3.73	1.17	−0.61	−0.56
Q7	3.25	1.27	−0.45	−0.91
Q8	3.71	1.15	−0.50	−0.79
Q9	4.16	1.07	−1.36	1.43
Q10	4.59	0.81	−2.11	3.83
Q11	4.44	0.81	−1.45	1.56
Q12	4.03	1.04	−1.02	0.55
Q13	3.35	1.36	−0.26	−1.21
Q14	4.13	1.06	−1.12	0.33
Q15	3.59	1.04	−0.50	−0.10
Q16	2.85	1.46	0.07	−1.36
Q17	3.77	1.28	−0.99	0.02
Q18	4.11	1.21	−1.42	1.00
Q19	4.00	1.01	−1.12	0.93
Q20	4.05	1.15	−1.09	0.31
Q21	3.93	1.26	−1.13	0.26
Q22	4.23	1.07	−1.28	0.83
Q23	4.03	1.11	−1.14	0.59
Q24	2.29	1.19	0.53	−0.76
Q25	3.84	1.16	−1.16	0.74
Q26	3.92	1.09	−1.07	0.82
Q27	3.96	1.07	−1.07	0.72

An EFA was applied using the maximum likelihood and oblique rotation as extraction method. A 6 factorial solution was obtained. However, as one of the factors was formed only by item 13 (Q13), and it did not saturate with values greater than $|\pm 0.30|$ in any of the other factors, it was decided to eliminate it. Then, a new EFA was applied and a 5 factor solution was obtained.

In Table 3 it can be observed factorial loads of each item in the 5 factors. These factors explain 60.30% of the variance of the questionnaire. The first one has an eigenvalue of 4.14 and explains 16.56%. The second one has an eigenvalue of 7.28 and explains 29.12%, the third one has an eigenvalue of 1.54 and explains 6.16%, the fourth has an eigenvalue of 1.11 explaining 4.44% of variance, and finally, the fifth factor has an eigenvalue of 1.01 and explains 4.02%.

It was found a very good adjustment for the 5-factor model, $\chi 2$ test [$\chi 2$ (185) = 187.66, p = .432], the ratio $\chi 2/df$ = 1.01, RMSEA = .014 and there were only 50 of 300 statistically significant correlations to 5% in the residual matrix.

Table 3. Factors, items and factorial load

Factor	Items	Load
Communication	Communicating regularly helps me to understand the project better	0.98
	Getting to know one another in my team allows me to interact with teammates more efficiently	0.43
	In my team there has been a lot of debate to reach an agreement	−0.35
Trust	My team members reply all responses in a timely manner	0.81
	I trust each team member can complete his/her work on time	0.69
	My team trusts each other and works towards the same goal	0.60
	In my team all members have revised and provided amendments to the project	0.59
	In my team there was a member who acted as the coordinator of the project	−0.54
	My team members communicate with each other frequently	0.52
	My team is receiving feedback from each other	0.49
Cooperation	My team members share their professional expertise	0.87
	My team members share information and professional experiences	0.75
	My team members share personal information to know each other better	0.68
	My team members encourage openness with each other	0.38
Cohesion	My team members clearly know their roles during the collaboration	0.95
	My team sets clear goals and establishes working norms	0.74
	My team has an efficient way to track the edition of documents	0.63
	In my team there has been a high consensus about the content of the project and the conclusions	0.62
	My team develops clear collaborative patterns to increase team learning efficiency	0.46
	In my team we have reached a consensus quite quickly	0.42
	In my team we could debate discrepancies	0.40
Coordination	In my team we have accepted with little discussion the changes proposed by members	0.63
	In my team we have developed the project starting from a first draft written by a member	0.46
	In my team the work was distributed so there was a member responsible for each part of the project	0.33
	My team members learn how other members wish to be treated and then act accordingly	0.35

In the first factor, Communication, the item with a greater factorial load was: “Communicating regularly helps me to understand the team project better.” In relation to Trust, the item was: “My team members reply all responses in a timely manner”. Cooperation is specially defined by the item: “My team members share information and professional experiences”. In relation to Cohesion, the item with greater load was “My team members clearly know their roles during the collaboration” and in Coordination it was: “In my team we have accepted with little discussion the changes proposed by members”.

5 Discussion and Conclusions

The construction of knowledge in virtual collaborative environments is a relevant issue for teachers and instructional designers since group work using some of the available technologies is common in the field of Higher Education. In addition, as instructors, we tend to assign responsibility for the results to the groups, since we also want them to develop skills and negotiation abilities that they may need in the future. Different theoretical approaches about how we learn when we are in collaborative situations suggest that we acquire knowledge at an individual level by contrasting the information we receive from the group with the information we have according to our previous knowledge. But for this incorporation to take place, different collective processes must take place, as negotiation, argumentation or inquiry. Therefore, successful group dynamics is essential for collaborative learning.

Our results show a validated survey about attitudes of higher education students facing autonomous group work in online learning environments. First a five-factor structure was identified after confirming internal validity and reliability. The first factor, Communication is very much alike the factor described by Grenlee and Karanxa [20] concerning the students’ expression of their points of view. This factor points to interaction and debate, the need to communicate to understand what the project is about. The second factor is Trust, the confidence on the team members, that they will behave accordingly, that they will be successful. Again, is a construct which refers to commitment to group decisions [26], but it is specially highlighted the fact that all members reply in time, which provides a sense of confidence on the group. On the third place, Cooperation is understood as a question of sharing expertise, experiences, personal information. This factor agrees on the study developed by Xu, Du and Fan [30] that sharing professional ideas is very important for effective group work. In the case of Cohesion, it is the fact of clearness about the roles and norms that makes the group work efficiently. And finally, students value how the work is distributed and developed to be successful in the Coordination factor.

Trust on the one hand and Communication on the second hand are the factors that explain more than 45% of the variance and thus, what students value concerning collaboration in self-directed online groups. Time and regularity of communication are felt as very important by students. These elements of group work should be taken in account by instructors when designing collaborative tasks in virtual learning environments in Higher Education.

The study has revealed the attitudes of students when they work in self-directed online groups, especially in situations of carrying out a project jointly and with the use of a wiki. However, we can point out some limitations to this study. In the first place, the sample belongs only to an online university and secondly, the technology used may be influencing the students. However, the questionnaire helps to identify the attitudes of students of virtual groups who work together autonomously to achieve a result in their learning processes.

Possible future research could analyze the reliability of this instrument in other online university contexts and also the independence of these factors of the technology used when evaluating students' attitudes in relation to their teamwork.

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Read, Watch, Do: Developing Digital Competence for University Educators

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Abstract. The paper presents and discusses the pilot experience of the EduHack course as it was developed in Spain by the Universidad Internacional de La Rioja (UNIR) in the first half of 2019. The EduHack course is proposing an active, participative and open approach to university teachers training in the use of digital approaches, that lets teachers experiment with ICT for learning strategies. Following an online learning phase, where participants were exposed to a set of ICT-enhanced teaching strategies and tools, a number of ideas on how to practically implement those strategies were collected among participants. Then, through the organisation of an EduHackathon, a hackathon targeted to university educators, participants had the chance to work in interdisciplinary groups to practically develop those ideas. The pilot experience of the course within UNIR has demonstrated that such an approach can be a valid complement to traditional teachers' training activities in the field of learning innovation and ICT for learning. Participants have actively contributed to all phases of the course, evaluating positively the course approach. Also, the teams formed during the EduHackathon have confirmed their commitment to keep on working on their ideas in the future.

Keywords: Digital teaching · Higher education · Teachers training · E-learning

1 Introduction: How to Train University Educators in Open and Digital Societies

Within Higher Education, the increasing use of Information and Communication Technologies (ICT) and the rising mainstreaming of blended and online teaching practices is challenging educators to be able to meaningfully use ICT within their teaching work. Specifically, new technology-based developments such as social networks and artificial intelligence are fostering collaborative and peer to peer learning, that seems to be a most effective way of learning with respect to traditional lecture-based dynamics [1]. In line with this, the traditional role of educators, as the ones who master the knowledge that needs to be transferred to students, is increasingly being questioned by educational researchers, who appreciate the possibilities offered by open and networked teaching approaches provided by ICT. New forms of active and social

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learning are emerging that challenge the traditional role of teachers [2] towards the one of critical friends, mediators and facilitators [3].

This new role of teachers has strong implications on the way educators perceive themselves and interact with their learners. First, considering that learners today have a much easier and fast access to ideas, resources, and environments that can support their learning interests and choices, contemporary teaching should engage the learner in a social process knowledge co-creation instead of just letting them use the learning material presented by the teacher. Second, contemporary teaching should consider learners as individuals and autonomous agents within the learning process, allowing them to operate independently and learn at their own pace, in their own direction, and using their own connections. Third, contemporary teachers should look at their classroom as a learning network, where each connection between students represents a possibility for learning, using peer-to-peer pedagogies and group assignments over self-study and classroom-based didactic learning ped-agogies. Fourth, they should focus their courses design on the learning process rather than on specific outcomes or competencies, since this will empower learners to think in terms of problems and solutions and will provide the possibility to inspire new perspectives and ideas. Fifth, learners should be encouraged to make learning choices and allowed to make mistakes, since choosing often leads to unexpected and unpredictable results, and while there is risk associated with the unknown, there is even greater reward and goodness.

In summary, contemporary teachers should be able to take full advantage of the possibilities offered by the open web, including social media platforms, through an increased degree of socialization and interactivity, access to open environments, and opportunities for peer-to-peer collaboration [3]. Ultimately what is at stake is the redefinition of both what it means to be an educator in the context of contemporary educational contexts and institutions and of how students can best learn in contemporary networked societies.

Redefining the role of teachers means changing the way educators plan their courses, license their materials, support knowledge creation among students, and evaluate learners' progress, and is therefore an extremely difficult and delicate process. Meaningfully introducing technology in teaching clashes with the fact that most university educators have never been trained to teach [2]. "The use of technology needs to be combined with an understanding of how students learn, how skills are developed, how knowledge is represented through different media and then processed, and how learners use different senses for learning." [2, p. 420]. This process is even more complicated since it has to do with a major cultural shift within the educators' self-perception, related to the need of rethinking and reshaping the roles played by teachers and students within the learning process and the underpinning knowledge production process, working in an open and transparent environment where all traditional implications of learning design, delivery, and assessment are questioned [4].

Against this background, universities are experimenting innovative ways to build competences of educators to modernise their teaching approaches by meaningfully using ICT in line with the emerging open and networked teaching paradigms. The challenge is to build skills and attitudes starting – in many cases – from very low ICT-skilled teachers. In particular, the research accompanying the Opening Up Education Communication of the European Commission found that 50%–80% of students in EU countries never use digital textbooks, exercise software, broadcasts/podcasts, simulations or learning games, that most teachers do not consider themselves as ‘digitally confident’ or able to teach digital skills effectively, and that 70% of teachers would like more training in using ICTs [5].

This paper aims to contribute to the debate on how to build capacity of university educators to meaningfully change their teaching strategies through the use of ICT, by presenting a rather innovative attempt to build university ICT for learning teachers’ capacity designed by an international consortium of universities. Part 2 presents the approach and its innovation potential. Part 3 describes the way the approach has been applied in a real-life setting in the Universidad Internacional de La Rioja in Spain. Part 4 analyses the experience, looking for the acceptance rate of the approach among participants and for possible improvement strategies. Finally, Sect. 5, concludes the paper with a summary of the findings and potential future research directions.

2 The EduHack Approach to Teachers Training on ICT-Enabled Pedagogy

The EduHack.eu initiative, which is put forward by a consortium of universities and research centres from Belgium, Italy, Malta, Spain and the UK with the support of the European Commission, has developed a capacity building course for university educators, based on the idea that to be able to meaningfully teach in an open and networked society, educators need not only to *learn* how to teach with technology, but to *experiment* with it, in an open and collaborative way [6].

The starting point of EduHack is the need for educators to be able to critically use ICT beyond their teaching subject, so as to become examples of digital citizenship for their learners [7]. Many training initiatives are in fact failing in empowering teachers to transfer to students (also by example) the necessary skills that every citizen should master to actively be part of our open and participatory societies. We are talking for example of online identity and personal data management, capacity to legally use open content, ability to engage in intercultural dialogues, critical view on media, capacity to deal with ethical and privacy issues. In order to take these competences into account, EduHack is built on principles of co-creation, collaborative learning and student/learner engagement. In terms of general approach, the EduHack.eu course is drawing on educational paradigms such as networked learning [8], participatory cultures [9], connected learning [10], hybrid pedagogy [11] and Open Education [12].

The Competences at the Core of EduHack

The EduHack.eu learning experience starts with an online course, where learners can browse and select among 19 different activities in four areas: digital resources, teaching and learning, assessment and empowering learners. These four areas represent the core of DigCompEdu [13], a competence framework produced by the European Commission that targets educators at pan-European level with the aim to inspire and national and institutional teachers training initiatives [14].

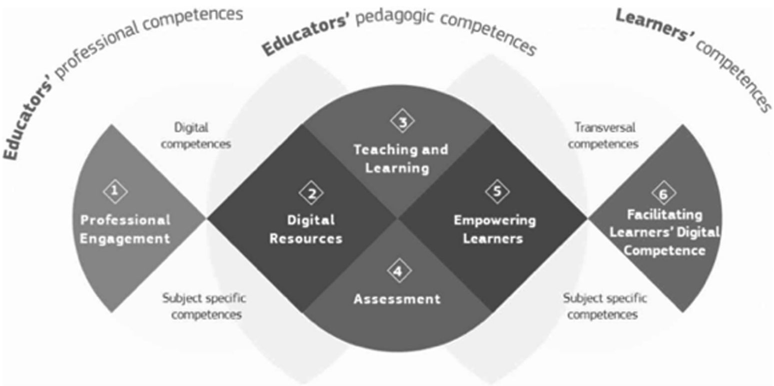

Fig. 1. The DigCompEdu competences framework.

The DigCompEdu structure has been selected as a starting point since it is grounded on a rather holistic understanding of educators' digital literacy. The framework does so by connecting the digital competences that 21st century educators should master (in the centre of Fig. 1) with their professional engagement activities (on the left) and with the impact that teachers can have on their learner's digital literacy (on the right). In other words, the frameworks connects the teacher's professional development path with the needed competences they shall master and with the impact that these competences shall have on their learners.

By taking such an approach, the DigCompEdu framework does indeed suggest a change in the role of teachers, by introducing meta-cognitive and self-development teachers' competences that will be key in contemporary learning settings based on critical thinking and participation [15]. The framework is built around six areas of competence: (1) to work effectively in an ICT-rich professional environment (2) to find, create and share digital resources, (3) to effectively use digital tools for teaching and learning, (4) to enhance learning assessment through ICT, (5) to empower learners and to foster learners-centred strategies through the use of digital tools and (6) to create digital literacy among learners, in terms of active citizenship and media literacy. The EduHack course is based on areas 2 to 5, that focus on practical knowledge, skills and attitudes that educators need to put in place successful ICT teaching strategies.

Online Activities: Read, Watch, Do… and Reflect

Each activity is composed by three components: Read, Watch, Do. The *Read* section corresponds to a short text with hyperlinks that gives an overview of the specific topic, the *Watch* section presents 2–3 videos (selected among existing openly available resources) that go deeper on the issue, and the *Do* part presents a practical task of the duration of around one hour that aims at putting in practice the knowledge acquired in the first two parts, most of the times thanks to the use of a specific online tool (such as Wikipedia, Socrative, Kahoot or Padlet). Also, each activity is providing a set of additional resources for learners who want to dig deeper in that specific theme. Examples of activities, taken from the Digital resources area, are: Search for Open Educational Resources, Modify existing digital content by using wikis, Create digital educational resources, Curate and organise digital resources and Apply open licenses to your resources. In order to complete the activity, learners are then requested to reflect on their learning experience in an open way, so to develop also web publishing and blogging skills. Learners can do that through individual blogging or through a common blogging space that is provided by EduHack called the *Wall*.

The Hands-on Experience of the EduHackathon

Following the online course phase, where participants were exposed to a number of possibilities to meaningfully use ICT in teaching and for developing critical capacities of students, learners are invited to gather in presence for an EduHackaton. This event is a hands-on session where participants work, typically in small interdisciplinary groups, on a set of specific ideas to improve their teaching through digital means, based on and inspired by the activities they have run though the online course. The Eduhackathon can take different shapes and have different characteristics depending on the preferences and context of the organising university: it can last one or more days, it can focus on ICT pedagogies in general or on a specific challenge such as open education or innovative assessment, it can be focussed on newbies or on expert teachers, etc. The only requirement of the event is its hands-on nature: during the Eduhackathon, participants are in fact expected to collaborative plan and possibly produce mock-ups or beta versions of the ideas they have selected, so to demonstrate the feasibility of their ideas and their potential impact on their daily teaching.

The EduHackathon methodology has been borrowed from the world of rapid-prototyping, business-incubation and acceleration of innovation activities. In particular, the methodology is inspired by hackathon events, that are typically focussing on computer programming, where coders meet for a period of time to develop prototype products, which are then implemented by funders. Most famously, Facebook uses this method to develop nearly all its products and features. Also, the following kind of events have inspired the EduHack methodology: business accelerator events, which have eventually led to the creation of several well-known startups such as Dropbox, Game-Jams, where developers meet to collaborative develop online games, and problem-based learning approaches, which challenge students to learn through engagement in a real problem.

The Underlying Course Online Ecosystem

In order to support the Hackathon process and to allow a certain degree of virtuality in moving from the online course to the Hackathon organisation, a platform has been developed, based on a SPLOT system [16], to collect and discuss all the ideas proposed by participants as well as to gather, after the event, the digital artefacts created. Further, all the content produced by learners during the course, both in its online and in its face to face phases, are collected in a specific web environment, called *Hub*, that allow appreciating the connections between what learners have learnt during the online course phase and how they have put this in practice during the hackathon. As illustrated in Fig. 1, the EduHack course ecosystem is composed of tree platforms: the online course platform, the Hub and the Hackathon web space. Those environments are connected through tagging system, so to allow to search for specific material and to highlight connections between teachers that share the same interests, skills, and areas of focus (Fig. 2).

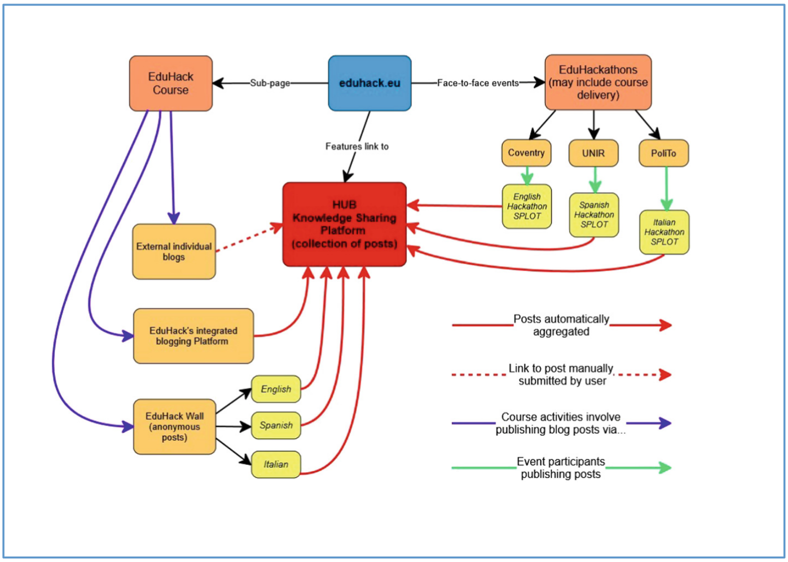

Fig. 2. The EduHack web ecosystem.

3 Description of the Course Pilot

This section will present the first pilot of the EduHack course, that was organised in Spain by the Universidad Internacional de La Rioja (UNIR) in the period April-May 2019. During the period 2019–2020, the project will be organising two more pilot courses in Italy and in the UK, to test the project approach in real-life university settings.

Course Design and Preparation

UNIR is a fully online university, therefore – in line with the flexible approach of EduHack – the online course and especially the EduHackathon were tailored to the characteristics of the institution and especially of the capacity and preferences of perspective participating learners. In the case of UNIR, potential participants are used to teach online, but they do so through the rather uniform approach of the university and are interested in exploring new ways of using ICT tools to enrich their teaching practice. Because of this, the course was designed with the aim to inspire participants to explore potential new tools, to be adapted – during the Hackathon – to the UNIR teaching environment.

During the course design phase, a number of meetings with key stakeholders within the university were organised to plan the course in line with the motivations, the learning styles, and the existing capacity of the target participants. In order to accommodate the preferences of the UNIR teachers. These meetings resulted in two conclusions: the EduHackathon could have been organised attached to the main conference organised every year by UNIR, and at the same time it would have been problematic to have teachers participating for more than one day. Because of these considerations, it was decided to organise a *blended EduHackathon*, where the first typical phase of work of a hackathon (that deals with presenting, selecting and fine-tuning the ideas), was run online, through the organisation of a discussion Webinar and through collaborative work on the EduHackathon online platform.

Following this design phase, the timing and characteristics of the three phases of the course were designed, as shown in Fig. 3. First, four weeks of online course were held, paced by four webinars aiming at keeping the participants motivated and at answering to their doubts and questions. This phase was followed by an online collaborative moment during which the ideas proposed by the participants for the Edu-Hackathon were discussed and teams were created: seven ideas were presented out of which four were selected to be brought forward by learners' teams. Finally, the Edu-Hackathon took place.

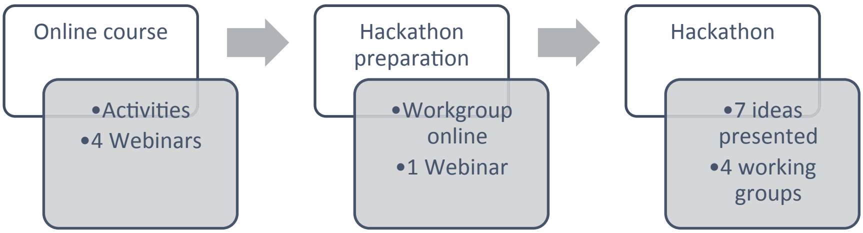

Fig. 3. The EduHack course within UNIR

Recruiting the right participants was key to the course success. This was done through a campaign among the educators community of UNIR, composed of strategic meetings with internal decision makers to motivate them to promote the course among the teaching population of their faculties, complemented by direct mailing to the UNIR faculty members (a total of 3.500 email messages were sent) and by a social media campaign. These activities resulted in a group of 52 registered participants, the majority of them (76%) being from the faculty of education. 8% was from the engineering school, 6% was from the UNIR branch in Ecuador and 10% was from other Spanish universities.

Online Course Phase

During the online course phase, participants were free to select their activities depending on their needs and preference. All the activities were available from day one, even if it was suggested to focus on one area per week. In line with the project approach, in order for an activity to be considered completed, participants had to reflect on the work done with a post on the EduHack online Wall. We registered a total of 165 reflective posts, plus 72 comments for a total of 237 interactions. The great majority of the posts actually reflected the work done within the various activities, providing a number of ideas on how to implement the proposed solutions in the context of the participants' daily work.

Looking at the most-liked activities can help understanding the learning needs of the participants and can help to better targeting the content of the online course for future editions. Even if it is too early to make a judgement on whether some activities should be restructured or improved, it is in fact important to keep track of the learners preferences. In area *Digital resources*, the three most selected activities were *Search for Open Educational Resources* (taken 20 times) followed by *Curate and organize digital resources* (8), by *Modify existing digital content by using Wikis* (7) and by *Create digital educational resources* (6). In the *Teaching* area, the first activity was *Implement ICT-supported collaborative learning* (13) followed by *Design your own eLearning intervention* (7), *Foster knowledge co-creation among students* (6) and *Use games to improve learners engagement* (6). In the *Assessment* area, the two preferred activities have been *Use digital technologies to provide targeted feedback to learners* (14) and *Experiment with different technologies for formative assessment* (12). Finally, all four activities of the *Empowering Learners* area were taken: *Critically evaluate online tools* (11), *Appreciate opportunities and risks of personalization in learning* (10), *Check technical accessibility of platforms and resources* (9) and *Discover the cost of "free" commercial social media platforms* (7). Two main results emerge from the analysis of which activities were actually taken by the learners. First, all the four areas received a rather balanced attention, showing that the course content approach is in line with the areas of need of the UNIR learners. Second, learners privileged the activities that dealt with fostering learners collaboration, engagement and co-creation. As we will see later, this trend was confirmed by the ideas selected for the EduHackathon.

As said before, in order to demonstrate they had taken an activity, participants were requested to publicly reflect on what they had learnt through the *EduHack Wall,* that has therefore operated as a common open portfolio enabling course participants to show their progresses. As visible from Fig. 4, that presents the work done by participants on the Lino.it space prepared for the project for one of the course activities, the course participants were extremely active not only in exploring the proposed activities and tools, but also in reflecting on how these could be applied in their daily work.

Fig. 4. The Lino.it space created for the course with participants posts

During the online course phase, continuous support was provided by the UNIR team, with 105 answered doubts by email, phone, or through face to face meetings.

Additionally four webinars were organised reaching over 100 attendees overall. While the first two webinars aimed at introducing the course content, the third and fourth webinars focussed on how to move from the course to the EduHackathon.

Ideas Collection Phase and EduHackathon
Following the four weeks of the online course, participants were requested to propose embryonic ideas that could be developed during the EduHackathon. A fifth webinar was organised to support the ideas elaboration process, during which a possible structure on how to present a project idea was provided. Seven ideas were proposed by participants and posted in the EduHackathon online space. During this phase some interesting dynamics took place: two ideas were merged following an agreement among the two promoters, one idea spontaneously gathered a team of three promoters, and all participants prioritised two ideas among the available ones. At the end of the process, four ideas, that had in common an interest for gamification and for learners collaborative knowledge production, were selected by the community to be worked out during the EduHackathon.

The EduHackathon took place in Logroño, La Rioja, Spain, on May, 15th, 2019, engaging 26 university teachers from UNIR. As previously mentioned, the objective of Hackathon was to encourage participants to apply the competences they had acquired through the online course with the objective to collaboratively design new digitally-supported learning experiences, experimenting with creative models and approaches to teaching. The four ideas selected during the previous phase were discussed in details during the event in small groups with the support of the organising staff. Each group was able to produce two things: a mock-up version of the tool or resource that the idea was about and a plan to further develop the idea.

As said before, the ideas generation and discussion phase was run online: this allowed focussing, from the very beginning of the EduHackathon, on practical work around the selected ideas. The EduHackathon was structured along two sessions: one aiming at finalising the ideas in details in a sort of *project form*, also identifying what would be needed to make them viable, and one aimed at preparing a mock-up of the idea to give an understanding of how the project and its outcome would look like. Following these two sessions, the groups rapporteurs presented the state of advancement of their work to the overall participants. All four ideas were presented with a view on a possible future exploitation, either within UNIR or as possible national and international projects. The EduHack team at UNIR will follow up with the teams in charge of these ideas in order to support them to make these developments a reality.

At the end of the EduHackathon, a total of 19 course participants, who had completed at least 8 project activities and had actively participated in the event, received a certificate of participation corresponding to 2 European credits (ECTS).

4 Analysis of the Experience

The EduHack course pilot at UNIR was assessed through two methods: teachers structured feedback, received through an online questionnaire, and participant observation by the UNIR project team. Both methods had in common five analysis dimensions: (a) acceptance of the innovative model, (b) barriers to participation, (c) main dynamics during the event, (d) collaboration patterns emerging among participants, (e) future improvements.

Learners' Evaluation

Here we are presenting the results of the participants' evaluation of the online course and of the Hackathon, based on 13 responses received from participants.

As far as the online course is concerned, the most important result for the UNIR organising team is that all participants stated that thanks to the online course they had improved their digital skills and their capacity to use ICT in their teaching, and all but one participants stated that they will apply the knowledge they acquired through the course in their professional life. As detailed in Fig. 5, nine participants rated the course active and collaborative approach as very good, four as good, while no negative response was recorded.

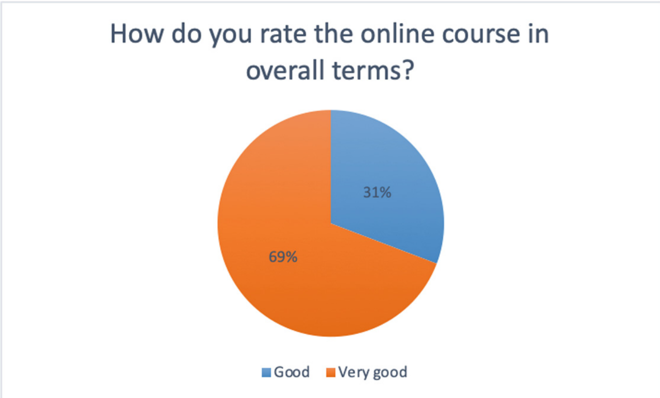

Fig. 5. Participants feedback on the online course

In qualitative terms, participants rated the content quality as well as the *read-watch-do* approach as well-fitting for their needs. Notably, three participants stated that they will use the course materials in the future as a repository of good teaching practices and tools. Also, participants appreciated the possibility to publicly reflect on their learning process and of reading the others' experiences: this confirmed that the reflective approach taken by the course was a valid one. The only negative comment was the lack of time to browse and complete all course activities prior to the EduHackathon, which shows actually a good motivation to explore all the activities of the course.

As far as the EduHackathon is concerned, all participants evaluated the experience positively, with 8 participants stating the EduHackathon approach and the collaborative work during the event was very good and 5 stating it was good. This data is fully confirmed by the UNIR team observation, that noted a very collaborative and creative atmosphere during the event. The feeling was that participants enjoyed a different way to discuss about ICT-supported learning innovation and that they appreciated being *in* *charge* of both deciding which activities to take and of choosing which idea to develop or to participate into (Fig. 6).

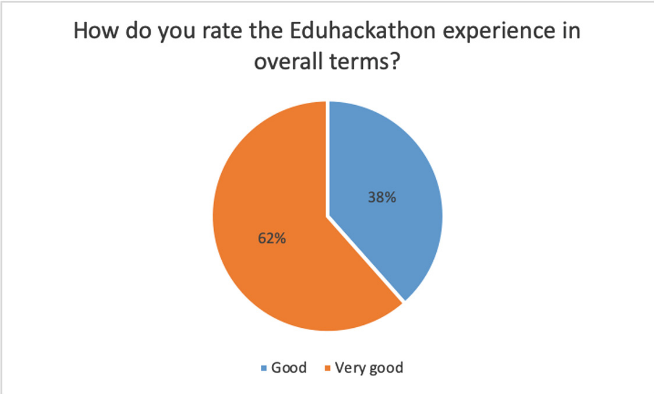

Fig. 6. Participants feedback on the EduHackathon

In qualitative terms, the features that participants liked the most about the EduHackathon were the possibility to get to know and to work with other professors, the interdisciplinarity of the working groups, the time allowed for the preparation process prior to the event and the possibility to further develop the ideas elaborated during the event. Notably, one participant reported that in these times of virtual contacts, taking one day to work hands-on with colleagues on shared problems is a luxury. On the negative side, the main weakness identified by the participants was the short time devoted to the Eduhackathon. This indication, which is somehow contradicting the fact that teachers are normally too busy to take more than one day for an activity such as the EduHackathon, will have to be considered for future editions of the course.

Participant Observation by the UNIR Team

Participant observation [17] has helped the UNIR team in charge of organising the EduHack course to both confirm the participants' feedbacks and to reflect on some important dimensions, that will be considered both by the next pilot courses and by the Guidelines that the project is producing to multiply the course use beyond the consortium can be reported. A first key question has to do with the acceptance of the EduHack innovative model. Participant observation confirmed that the course open and active approach was appreciated by participants. The aim of EduHack was to setup a learning experience that is Active, Open and Collaborative: we can say that the UNIR pilot stressed that such an approach is fitting with the preference of the UNIR participants. In particular, the requirement to reflect on the work done in each activity through an open blogpost did not represent a barrier for participation for learners, on the contrary it was appreciated since it allowed reflecting on strategies to implement the learnt approaches in educators' daily work. It must be noted that the most active participants in the first pilot were rather experienced and ICT-enthusiast teachers, not newcomers to the field of digital education. A second question deals with the quality and purposefulness of the course content. Participants browsed all the proposed activities and did not provide any negative comment about them. Also, the way the content is presented, in the form of a short text plus videos plus one activity, encountered the participants appreciation. Finally, some participants proposed some further activities to be included in the next course iterations, showing a good degree of ownership of the learning experience. A third issue had to do with the complexity of the course web ecosystem, which did work without any major problem, even if some space for improvement exists. All three course environments (the course contents page, the reflection posts Wall and the Edu-Hackathon web environment) were used appropriately and were rather well connected among themselves. Minor possible improvements were reported, connected to the fact that in an open environment such as the one proposed (where for example it is possible to post in an anonymous way) participants are not able to receive alerts when their posts get commented.

5 Conclusions and Future Work

The underlying hypothesis of the EduHack initiative was that by applying an active, participative and open approach to university teachers training in the use of digital approaches, teachers would not just acquire new knowledge, but rather would be able to experiment with practical activities, through an approach that we have codified as "Read, Watch, Do". The research run around the pilot experience of the course within UNIR has demonstrated that such an approach can be a valid complement to traditional teachers' training activities in the field of learning innovation and ICT for learning. In order to develop educators' digital competences, that are able to respond to the need of empowering students for open and participatory societies, we believe in fact that traditional teachers training and innovative hands-on experiences such as EduHack should coexist. "Digital literacy is not a new literacy. This is to say, if digital literacy is simply reading and writing in a digital environment, there is no need for the new terminology. (…) Let us then accept digital literacy as a genre, a format and tool to be found within the domain of standard literacy, rather than a concept standing at odds" [18, p. 535].

Participants active contributions to both the online course and the face to face event, as well as the connection between the course content and the ideas proposed and worked out during the Eduhackathon, are indeed promising results for the mainstream of innovative teacher training approaches. This confirms that educators' digital literacy, being a complex and socio-culturally sensitive issue, should be understood as a set of situated practices and attitudes. Digital literacy is in fact much more than the capacity to use ICT tools, and it should rather be considered as a set of capabilities associated with interacting with peers through digital tools, where the core is about communicating and collaborating with others and making sense of the available information [19]. The positive results and especially the participants' enthusiasm around the EduHack pilot course demonstrate a good readiness degree to engage in capacity building activities aimed not only at marginally improving their daily practices but also at transforming their role within contemporary open and collaborative learning settings.

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Learning Technologies, Data Analytics and Educational Big Data Mining as well as Their Applications

On the Students' Misconceptions in Object-Oriented Language Constructs

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Abstract. Analyze the Object-oriented (OO) source code developed by students provides useful formative tips to instructors. According to this, it is essential to understand the student's real difficulties allowing instructors to shape effective courses. To provide run-time feedback to students and to study and analyze the evolution of their performances offline and over time we designed a framework and developed a tool. It allows to identify students' misconceptions analysing source code and to create personalized student reports automatically. In this paper, we present an empirical study, conducted using our toolchain, that involves 1627 projects extracted from the multi-institution Blackbox dataset. We identified a violation model for Java language constructs based on established results in the computing education community. Afterwards, we grouped such violations in categories and analyzed the relations among them. Our contributions might be helpful in delivering formative feedback and supporting instructors who teach Java and object-oriented programming in general.

Keywords: Object-oriented · Misconceptions · Data analytics

1 Introduction

Since Java-based courses give the first experience in programming to many students, the teaching and knowledge transferring activity is thoroughly critical and arduous [2,10]. For this reason, there is a continuous research of novel teaching strategies allowing to address student questions as soon as possible providing timely feedback [32], and preventing retention. These strategies require a high comprehension of how student perform programming activities a their main difficulties.

Basing on the above considerations, we aim to understand how students use Java and its language constructs by analyzing the most common violations of the Object Oriented paradigm in student source code. Our study is in line with existing literature regarding the comprehension of student mistakes [4] and misconceptions [23] to shape the instructor's teaching strategy. The violations

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are identified from a sample of student source code and organized in categories covering the most relevant language constructs and tipical quality issues.

This paper proposes an empirical study to characterize the violations and to identify their relations. The empirical study addresses the following research questions:

RQ1: *What is the volume of violations of object-oriented language constructs in student source code?*

RQ2: *Are students who make mistakes in one category inclined to make mistakes in other categories as well?*

To perform the empirical study, we developed a static source code analysis framework and a supporting tool—called Student Profiling Tool (SPT)—to detect and report violations in student source code for both students (in real-time) and teachers (allowing offline automatic analyses).

To answer the RQs, we used SPT to analyze a sample of 1627 Java projects extracted from the Blackbox dataset [5]. The results of the analysis highlight interesting correlations among the violations belonging to different categories. We believe that these contributions might be useful to instructors, helping them to drive the development of novel teaching strategies improving the effectiveness of Object Oriented courses.

The rest of the paper is organized as follows. In the next section, we describe related work. In Sect. 3 we introduce the methodology for the creation of the list of violations and design and development of Student Profiling Framework, and Tool. Section 4 deals with the empirical study. Discussion and implications of our findings are in Sect. 5. Finally, Sect. 6 concludes the paper and suggests future work.

2 Related Work

Object-oriented source code errors have been widely investigated in the literature. Some studies are focused on the difficulties faced during the learning process of OOP [18].

In [12], the authors analyse 15,000 code fragments, generated by novice programming students. The logic errors have been classified as algorithmic errors, misinterpretations of the problem, and fundamental misconceptions.

Keuning et al. [17] examine the quality of student code with regards to program flow, functions, clarity of expressions, decomposition, and modularization. They state that novice programmers write source code characterized by significant quality issues and professional static analysis tools (Checkstyle[1], PMD[2], FindBugs[3], Sonar[4]), as currently designed, offer little or no help. Moreover, such tools appear to be troublesome for preparing new teaching strategies since they are considered confusing also for experts as to necessitate the development of an intuitive supporting environment to compare the results of their analyses [6].

[1] http://checkstyle.sourceforge.net.
[2] https://pmd.github.io.
[3] http://findbugs.sourceforge.net.
[4] http://www.sonarqube.org.

Edwards et al. [11], consider the problems detected by several professional tools for analyzing the code of 3,691 students over five semesters.

Sanders and Thomas [25] propose two checklists for grading student programs. The checklists are obtained by considering basic object-oriented programming concepts and typical novice misconceptions as identified in the literature. The evaluation of the checklists is performed in an objects-first CS1 course.

Expresso is an error detection advisory tool [15]. It aims to help teachers to understand the types of frequent errors students make among a list of the typical logic, semantic and syntax errors usually made by novice programmers. Madden and Chambers [20] report a survey about the aspects of the Java language that students perceive to be most difficult. Conversely, in this paper, we present an empirical study to characterize Java language violations. In addition, our study focuses on the analysis of the relationships among categories of language constructs to understand the impact of misconceptions in one category concerning the others. Finally, we exploit a supporting tool that can produce a detailed report on the violations of the source code given as input.

3 Methodology

As we mentioned in the previous section, the literature widely addressed OO concepts and misconceptions of novice programmers. We started from such misconceptions of novice programmers to find how these cause mistakes and violations of language constructs. Similarly to [19,25], we manually inspected a sample of student programs, namely 162 ($\sim$10%) of 1627 Java projects extracted from Blackbox [5]. We then turned to the literature highlighting, for each paper, what kind of misconceptions/errors to expect in student code, (e.g. instance/class conflation, problems with abstractions, issues with inheritance and polymorphism, difficulties with constructors, confusion using attributes and local variables, intricacies with scope). To facilitate our job, we extracted excerpts of code that could have helped us to focus more specifically on language constructs. Once we found good violation candidates, for a given language construct, we implemented a static analysis "recipe" to automatically look for further occurrences in arbitrary student source code.

Finally, after multiple iterations, we reached the list described in the following, and divided into categories.

3.1 Abstraction Violations

This category deals with wrong usage of abstraction. We considered the following violations:

- **Empty NOn-ABstract method in root class (enoab)** In Example 1.1, method `printSmth` is an empty non abstract method (*enoab*) and does not make any sense. This is not, in fact, the case "when classes provide empty implementations that override non-empty implementations." [29]. There is no overriding in the figure since `Enoab` is a root class.

- **Class With Implicit Constructor (cwic)** Ragonis and Ben-Ari [22] consider "teaching constructors a difficult multiple choice" and they found that "the professional style of declaring a constructor to initialize attributes from parameters is to be preferred even though it seems difficult to learn. Other simpler styles caused serious misconceptions.". This means that a class with an implicit constructor (*cwic*), listed among "simpler styles", should be avoided.
- **Class Without Instance Fields (cwif)** It is well-known that students have difficulties in understanding the concepts of object and class [23]. In particular, they have "difficulties in understanding the static aspect of the class definition". A class without instance fields (*cwif*) could be a consequence of such difficulties, like `class Cwif` in Example 1.2. Of course, a class without instance fields containing only a `main` method cannot be considered a violation.
- **Poor Interface usages and definitions (pi)** Among the "good coding practices for Java", Sivilotti et al. [27] advise to "prefer the use of interface types (over class types) for all declared types". In other words, a declared site (e.g. a local declaration) should use an interface (when such an interface is available). This is not the case of `b` in Example 1.3. Another poor use of interfaces is when there is only a single implementation [26].

Example 1.1. Empty NOn-ABstract method in root class

```
public class Enoab {

   public void printSmth(){}
   public int doSmth(){
         int easySum = 2 + 2;
         return easySum;
   }
}
```

Example 1.2. Class Without Instance Fields

```
public class Cwif {

   public void makeStuff(){ //...
   }
   public int makeOtherStuff(){
         return 0;
   }
}
```

Example 1.3. Poor Interfaces

```
public interface Bable { //...
}

// single implementation
public class B implements Bable {
      //...
}
public class B2 implements Bable
      { //...
}

public class A {
   public void doSmth() {
      // declared site should use an
            interface
           B b = new B();
   }
}
```

3.2 Attribute Violations

This category deals with wrong definition or use of fields. We considered the following violations:

- **Field Used as Local Variable (fulv)** Students have issues in understanding the "difference between class fields and local variables inside methods", as stated by Biddle and Tempero [3]. A field written before being read (`fulv` in Example 1.4) is an effect of aforementioned issue. Such field should be indeed a local variable.

- **Missed Constant (mc)** A class field which is only read should be declared as constant—like `mc` in Example 1.5. This is in line with Chen et al. [7] who discovered misconceptions when students "determine which data member is appropriate for declaring as constant". Moreover, Ragonis and Ben-Ari [23] list "difficulties in understanding the static aspect of the class definition".
- **Local variable shadowing a field (lvsf)** The shadowing of a field by the definition of a local variable with the same name is related to the same motivations of *fulv*. This is the case of `shadFloat` in Example 1.6.
- **Public Field Changed by private methods (pfc)** "Difficulties understanding the influence of method execution on the object state" is another problem related to the concepts of object and class [23]. A consequence of aformentioned difficulties is `pfChanger()` in Example 1.7 where a private method changes a public field.
- **Unused Private Field (upf)** This is a well-know warning detected by popular IDEs but the fact that students still commit this violation means that instructors should focus more on this aspect. Reasons of this issue could be the same of *fulv*. Students maybe have still to figure out how to design a class and what should or should not be part of it.

Example 1.4. Field Used as Local Variable

```
public class ClassWithFULV {
  private int fulv = 1;
  public void
        methodUsingFULV(int
        c) {
          fulv = c + 3;
          if(fulv == 4) { //...
          }
  }
}
```

Example 1.5. Missed Constant

```
public class ClassWithMC {
  private String mc = "String";
  public method() {
    if (mc.equals("MISSED")){
          //...
    }
  } //other methods not writing
        on mc
}
```

Example 1.6. Local Variable Shadowing Field

```
public class LVSFClass {
  private float shadFloat = 0.0;

  public float methodF(){
          return shadFloat;
  }
  public void methodS(int d) {
//shadowing instance variable 'shadFloat' with a local variable with the
      same name
          float shadFloat = 0.5;
          float prod = 0.85*shadFloat;
  }
}
```

Example 1.7. Public Field Changed by private methods

```
public class ClassWithPFC {
   public int pfc = 1;
   private void pfChanger(){
            this.pfc = 0;
   }
}
```

Example 1.8. Inheritance to Extend Values

```
public class Bicycle {
   int wheelCount = 2;
   void gearDown(){ //...
   }
}
public class Car extends Bicycle {
   int wheelCount = 4;
}
```

Example 1.9. Constructor Chain

```
public class A {...}

public class B extends A {
   B(){ super(); }
}

public class D extends B {
   D(int n){ super(); }
   D(){ this(3); }
}

public class E extends D {
   E(){ //...
   }
}
```

3.3 Inheritance Violations

This category deals with wrong definitions or uses of inheritance. We considered two well known semantic free misuses of inheritance:

- **Inheritance to Extend Values (iev)** Liberman et al. in [18] report that inheritance can be mistakenly used to "extend values". For instance, some students think that inheritance can be used to change the values of fields, rather than for adding attributes or operations. Students with this kind of misconception can write code that resembles the excerpt shown in Example 1.8. A variable, `wheelCount`, with the same name of the superclass (`Bicycle`) is added into the subclass (`Car`). In fact, there is no overriding but the classes have two different variables named `wheelCount`, one in `Bicycle` and one in `Car`. Moreover, class `Car` has two variables named `wheelCount`—its own and the one inherited from `Bicycle`.
- **Constructor Chaining (cc)** The study in [18] also reports "that many students fail to understand the chain of constructor calls in object creation". A consequence of this failure could be producing the code in Example 1.9. Class `E` does not select which constructor of the superclass to use, and thus the default constructor is chosen—with probably unintended outcomes. Even though the choice of using the default constructor was deliberate, it is always worth giving feedback to students to avoid the proliferation of (bad) long-term habits—as suggested by Ala-Mutka [1].

3.4 Interaction Violations

For what concerns interaction violations, our model considers the following two cases:

– **Unused Private Method (upm)** Method `doC()` in Example 1.10 is a private method which is never called. This is linked with "difficulties with scope", namely with the "private" keyword.
– **Static Invocation Through Instance (siti)** In Example 1.11, method `doSmthStat()` is static and so should be accessed in a static way, but is accessed by means of `this.doSmthStat()`. This is connected with what reported in [24] regarding "understanding `this` as the current object and its usage".

3.5 Polymorphism Violations

Polymorphism is managed, at source code level, with explicit casting. Our model cover the two major mistakes made by novices:

– **Wrong Explicit downCast** Students may think that "all down-casts in an inheritance hierarchy are legal" [18] and this lead to downcasting `R` to `S`—which is wrong, as shown in Example 1.12.
– **Unneeded Explicit Cast** Another issue with polymorphism is using type-casting explicitly especially when is not needed at all [16], like the statement regarding `a` in Example 1.13. This is a bad practice and usually typical of "programmers who have not fully understood the object-oriented paradigm use conditional statements to simulate dynamic dispatch and late binding" [31].

Example 1.10. Unused Private Method

```
public class SomeClass{
  public String doA(){
        System.out.println("do A");
  }
  public int doB(int a){
        System.out.print("do B");
  }
  private void doC(){ //...
  }
}
```

Example 1.11. Static Invocation Through Instance

```
public class G {
  private static void doSmthStat(){
        //...
  }
}
public class ClassWithSITI {
  public wrongCall(String s){
        this.doSmthStat();
  }
}
```

Example 1.12. Wrong Explicit down-Cast

```
public class P extends R {
        //...
}
public class R extends S {
        //...
}
public class S extends Z {
        //...
}
public class Z{
        //...
}

public class M {
  public void doWEC(){
        S s = (S) new R();
  }
}
```

Example 1.13. Unneeded Explicit Cast

```
public class M {

  public void doSmth(){
   S s = (S) new R();
   float f = 2.0;
   int a = (int)f/1;
  }
}
```

Example 1.14. Unused Association

```
public class E { //...
}
public class D {
  private E ua = new E();
  public void uaMethod(){
    System.out.print("2019");
  }
}
```

3.6 Relationship Violations

It is reported that "an extension of the difficulty with writing a program that includes multiple classes is writing a program that includes linked cooperating classes" [33]. Such difficulty could have led to including associations which are never used like association to class `E` in Example 1.14. We call this violation "unused association (ua)".

3.7 Quality Metrics Violations

For what concerns quality of produced source code, SPT evaluates product metrics. The product metrics summarize intrinsic properties of software components (such as the internal complexity or the external coupling). We selected the following metrics from the Chidamber-Kemerer (CK) Object-Oriented (OO) metric suite [8]: WMC (Weighted Method per Class), DIT (Depth of Inheritance Tree), NOC (Number of Children), RFC (Response for a Class), LCOM (Lack of Cohesion in Methods), CE (Efferent Couplings), NPM (Number of Public Methods), LCOM3 (Lack of Cohesion in Methods). In order to compute these metrics, the CKJM tool developed by Spinellis [28] was integrated into SPT as a recipe module.

3.8 Student Profiling Tool

The purpose of the Student Profiling Tool (SPT), is two-fold: (*i*) it allows producing collective reports to be used as feedback to plan or tune new teaching strategies for the entire classroom; (*ii*) it gives information regarding the behaviour of a single student as a personal assessment tool: it provides timely and personalized feedback based on the source code produced and analyzed [32]. The underlying framework used to implement SPT, Student Profiling Framework (SPF), is shown in Fig. 1. SPF is language-agnostic and must be instantiated to be applied. We have chosen to focus on Java adopting Spoon to build a per-project Abstract Syntax Tree (AST) performing source code analysis [21]. Specifically, the Source code analysis repository contains the definitions of the violations (See Sect. 3) which are performed by the static source code analyzer as well as a set of clustering analyses (See Sect. 4.1). The instructor may filter the input code clustering the projects in categories and, thus, the analyses

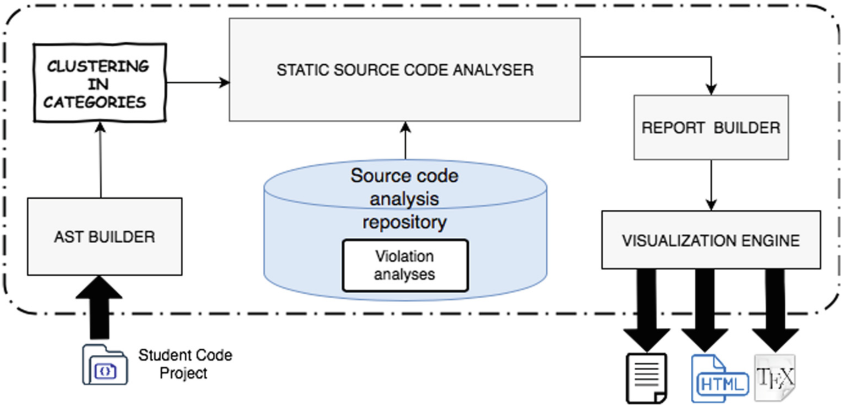

Fig. 1. Student profiling framework

Fig. 2. Distribution of the construct categories among the projects (left) and SPT dashboard (right).

of the language constructs which are not present in a given dataset will not be executed. Possible data-interchange and integration with existing software are available thanks to a custom visualisation engine which supports different types of output (raw text, HTML, LateX). Figure 2, on the right side, shows the results of a regular SPT session (some information are intentionally omitted and sample code is used). The instructor's dashboard gives an instant picture of the class, reporting statistics by category (top part) in a simple bar chart, top five violations (on the right) with matching color to understand the category, and two interactive tables showing the number of violations per student (bottom left) and their breakdown details (bottom right, i.e. "Category|Violation Type|#violations"). Therefore, the table on the left shows the particular situation for that student or student project ("168777" in the figure). By clicking on a particular violation type in the right table, `pi` for example, the instructor can visualize the description along with specific information for each violation ("Class|Related interface|Line" in case of `pi`). Instead, by choosing any row, corresponding Java code (with line numbers, syntax highlighting and injected comment) is presented with a marker on the line when violations occur. SPT also allows to create personalized PDF reports. Students will then receive a report with all their violations explained and suggested further reading. The latter is chosen by the instructor by modifying a configuration file (it includes lecture notes, open source books, specific books with chapter, pages and samples).

4 Empirical Study

The goal of this study, conducted exploiting SPT, is to investigate the volume of violations committed by students with the purpose of understanding which categories of language constructs are directly related. The quality focus is the understanding of object-oriented concepts and its relation to the students' ability to apply them. The perspective is mainly of researchers interested to investigate how, in student projects, miscomprehension of object-oriented language constructs of each category could favor errors on applying the object-oriented constructs of other categories. The perspective is also of teachers interested in improving their CS1 object-first courses by monitoring student performances. From this point of view, SPT allows identifying which constructs of the language are the most problematic within a class at a given time during the course and to study the evolution of the comprehension and ability to apply language constructs over time. The context of the study covers the data extracted from Blackbox [5]. BlackBox collects data from users of the online educational software tool called BlueJ[5]. The data collected is for academic research and addresses the issues related to teaching object-oriented languages. BlackBox has been running for over five years and contains a set of structural information (compiler data, code revisions, error messages) on over 12 million projects, 1.7 billion source history entries, and more than 2 billion events happened within the BlueJ environment.

4.1 The Context: Selection and Clustering

Due to the generous dimension of the dataset, it was necessary to perform a clustering step to obtain a set of projects suitable for the study. A set of ad-hoc scripts allowed to extract such projects by executing the following activities:

- selection of the successful compile events from all the events available in the repository;
- selection of projects with a number of files greater than two—to be able to study relationships, and lower than 15—to filter bigger projects;
- for all the compile events associated with files belonging to selected projects, creation of a CSV file with the following data: (i) identifier of the source code of a JAVA file, (ii) identifier of an event, (iii) successful compilation timestamp, and (iv) identifier of the project to which source code belongs to;
- for each project, using the above information to access index-payload[6] in the repository to extract project source code files used for source static analysis.

[5] https://www.bluej.org/.

[6] "payload files", at time of writing, go from Jun 12th 2013 to Oct 16th 2017; it was not possible to get the completed source code before and after this time interval.

Table 1. Top constructs violations in an excerpt of the dataset with projects pertaining all the categories.

N.	CATEGORY	NAME	#VIOLATIONS
1	Attributes	fulv	3164
2	Attributes	mc	2665
3	Abstraction	pi	2358
4	Attributes	lvsf	504
5	Attributes	pfc	352
6	Inheritance	cc	286
7	Attributes	upf	169

These steps led to a dataset of 1627 projects [9]. The dataset contains source code concerning different language constructs. Thus, there is no assurance a given project can be analyzed for all the considered categories. For this reason, SPT performs project clustering. For each considered project, it executes a static source code analysis to detect the categories of language constructs that are included in that project. The subsequent project analysis finds, for each category identified by the clustering step for that project, the violations described in Sect. 3.

The left side of Fig. 2 shows the results of the clustering. It reports the number of projects (vertical columns) contained in each combination of intersections (pointed lines) of the set of projects associated to each category of language constructs (shown in the horizontal lines on the bottom left). A dark dot in a row means that the corresponding set participates to the intersection. Otherwise, it means that such a set is excluded. For conciseness, Fig. 2 omits empty intersections and shows only the relevant combinations of categories. Looking at the figure, each project can belong to multiple categories and so create an intersection. For each intersection, we can evaluate the number of associated projects, i.e. the ones containing language constructs belonging to that category.

For example, 422 projects contain the *Abstraction* category. An interesting set contains all the six categories of language constructs (Abstraction, Inheritance, Relationship, Attributes, Interactions, and Polymorphism) and is comprised of 394 projects out of the total (1627). This set is essential since it contains a well balanced set of projects (of different sizes) and, for this reason, it is the reference set used as context of the empirical study.

4.2 Top Categories and Violations

The most violated categories, across all the projects in the dataset (1627), are Abstraction (42,17%) and Attributes (38,4%), followed by Relationships. The other categories have a very low rate—less than 6%. The Inheritance is the less infringed construct. Moreover, the dominant ratio of inheritance mistakes has a semantic root whereas in this study we are detecting language construct violations. Our results show that a small fraction of students makes semantic-free errors when applying inheritance. Another interesting perspective is the analysis

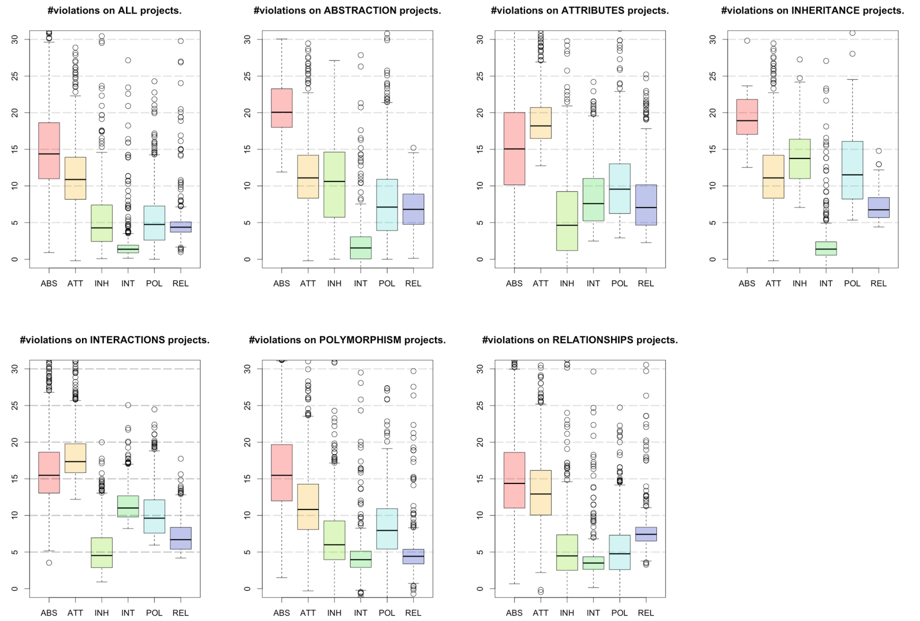

Fig. 3. Boxplots of the violations distributions for the considered categories of language constructs.

of top seven violations reported in Table 1, concerning projects belonging to all the categories.

The most present category is *Attributes*. Students seem to have problems with several aspects of handling attributes related to the kind of declared variables, i.e. most violations are related to instance fields that are defined in place of constants or used as a local variable, suggesting the lack of understanding of the meaning of instance variables. Also shadowing among variables is shown as problematical. Such a violation stands in the fourth place. Even this does not necessarily lead to a bug it suggests a lack in the comprehension of variable scoping rules. Violations of Abstraction are at third place in the top seven, for poor interfaces definitions. It seems students are not able to define interfaces accurately and, even when interfaces are well declared, they often miss the proper usage preferring the definition of variables using concrete types. This leads to worse modularization, increased coupling [30] and the usage of unneeded typecasting [16].

5 Results and Discussion

To address **RQ1**, we consider all the projects extracted from the blackbox dataset belonging to all the categories. We evaluate the distributions of number of violations on these categories using boxplots, as shown in Fig. 3—top-left. For each category, the figure shows the number of violations distribution, the inter-quartile range, and median value. The median number of violations of the projects follows a trend that is similar to the one we have already seen for

Table 2. Comparison of violation count distributions with Mann-Whitney test (✓ for $p-$value < 0.001 - ∅ otherwise) and cliff's delta d (medium and large values are highlighted in blue).

#violations distribution →	ABST	ATTR	INHE	INTE	POLY	RELA
ABST	✓ d=0.60	∅ d=0.03	✓ d=0.55	∅ d=-0.01	✓ d=0.29	✓ d=0.58
ATTR	∅ d=0.04	✓ d=0.80	∅ d=0.04	✓ d=0.95	✓ d=0.54	✓ d=0.58
INHE	✓ d=0.50	∅ d=0.03	✓ d=0.85	∅ d=0.01	✓ d=0.75	✓ d=0.79
INTE	✓ d=0.12	✓ d=0.77	∅ d=0.06	✓ d=0.97	✓ d=0.71	✓ d=0.77
POLY	✓ d=0.11	∅ d=-0.01	✓ d=0.22	✓ d=0.41	✓ d=0.76	∅ d=-0.01
RELA	∅ d=0.01	✓ d=0.25	∅ d=-0.01	✓ d=0.78	∅ d=0.01	✓ d=0.86
Projects of classes ↑						

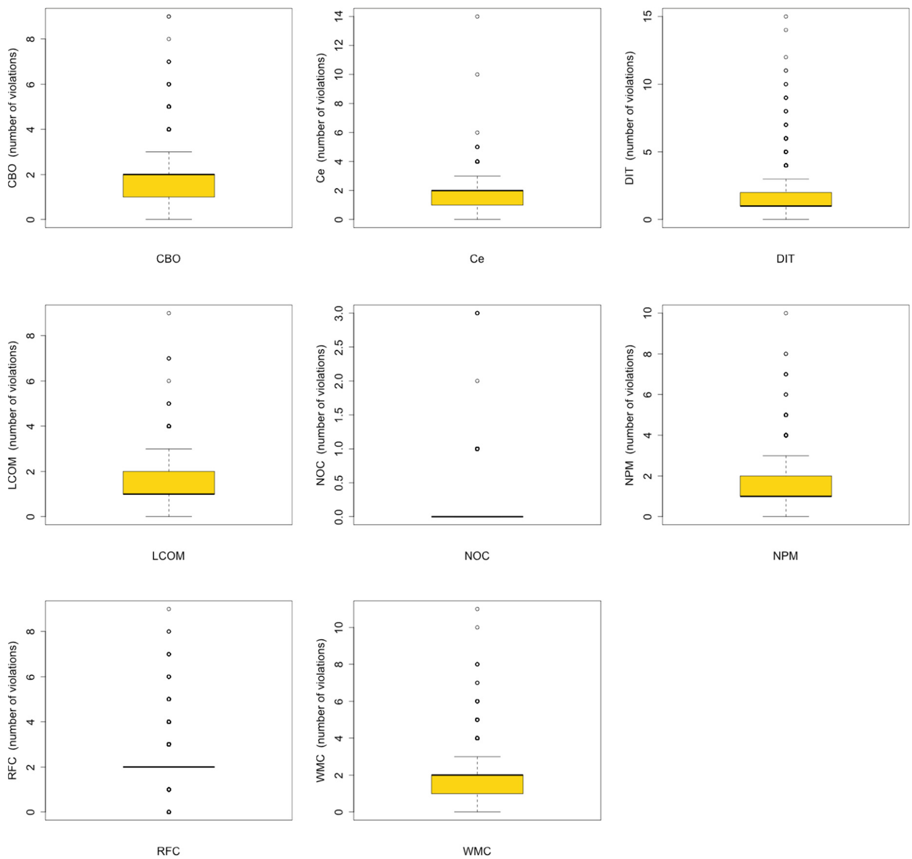

Fig. 4. Boxplots of the violations distributions for the considered CK metrics.

the total violations. In fact, Abstraction (∼15 violations), Attributes (∼13 violations) are the most infringed categories in descending order. The remaining categories (Relationships, Interactions, Inheritance and Polymorphism) have all a median number of violations that is less than five with inheritance being the lowest (with almost three violations per project). The second research question aims at understanding relationships among language constructs that are interrelated and, for this reason, cannot be easily taught or learned in isolation. To address **RQ2**, we consider the projects violating each category in turn and compute the number of violations on the remaining categories. We compare—using boxplots, Mann-Whitney test, and Cliff's delta—the above number of violations with the number of violations distribution evaluated on all the projects already calculated for **RQ1**. We then perform a pairwise comparison applying Mann-Whitney test and correcting p-values using the Holm's correction procedure [14]. This procedure sorts the p-values resulting from n tests in ascending order, multiplying the smallest by n, the next by n − 1, and so on. Finally, in addition to the statistical comparison, we compute the effect size of the difference using Cliff's delta non-parametric effect size measure [13], defined as the probability that a randomly selected member of one sample has a higher response than a randomly selected member of the second sample, minus the reverse probability. Cliff's delta is considered negligible for $|d| < 0.147$, small for $0.148 \leq |d| < 0.33$, medium for $0.33 \leq |d| < 0.474$, and large for $|d| \geq 0.474$. Figure 3 and Table 2 report the results to answer **RQ2**.

The boxplots show the comparison of the number of violation distributions evaluated for projects violating only one category with the one evaluated for all the projects. The table shows the pair-wise comparison using the Mann-Whitney test and Cliff's delta as a measure of the effect size. As Fig. 3 highlights, projects violating the Abstraction category have a significantly higher distribution (with respect to all the projects) of number of violations for *Inheritance*, *Polymorphism*, and *Relationships* language constructs. The effect sizes confirm all the relations (large for *Inheritance* and *Relationships*, and small for *Polymorphism*). The third plot in the first row of Fig. 3 shows that projects violating the *Attributes* category have a significantly higher number of violations, with respect to all the projects in the dataset, for *Interactions* (with a large effect size of d = 0.95) and, with a still large but lower effect size, for *Polymorphism* (d = 0.54) and *Relationships* (d = 0.58). This means that students having misconceptions about attributes and variable handling are more prone to commit errors that are related to object interactions, handling relationships among classes, and applying polymorphism correctly. With regards to projects violating *Inheritance*, results highlight a higher violation count for *Polymorphism* and *Relationships* with a large effect size in both cases.

For what concerning product metrics, boxplots of violations distributions are reported in Fig. 4. As figure shows, violations are mostly related to coupling problems (Ce, CBO and LCOM, NPM). Right behind coupling issues, we found complexity (WMC) and (DIT) with a comparable number of violations.

6 Conclusion and Future Work

We have presented an empirical study concerning 1627 projects of the Blackbox dataset [5]. The focus is on Java language constructs and their use.

We created a list of violations of language constructs, organized into seven categories and supported by existing literature in computer science/software engineering education. Next, we developed a tool, SPT, to do static analysis of Java student code and perform aforementioned empirical study.

The tool [9] can give an instant picture of the trend of a class and their learning process. Overall, students authored many violations with top three belonging to the categories of Abstraction and Attributes. To understand the relations between diverse categories we executed a clustering step (available through SPT). We believe our findings may be beneficial for harmonizing teaching strategies and designing new educational tools. Future work will focus on extending the list of violations, integrating STP into existing IDEs and also providing an interface for students to have new insights.

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CiDAEN: An Online Data Science Course

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Abstract. In the last few years, the platforms for online learning, such as MOOCs, are becoming more and more popular. Particularly, in fields like computer science, students very often choose this way, instead of official programs, to complete their formation. In this context, universities must adapt to changes in order to offer the kind of formation that is demanded nowadays. In this article we present CiDAEN, and online course in data science and cloud applications that is offered from the University of Castilla-La Mancha (Spain). We describe how it has been implemented in a public university through a non-official program. We also share our (successful) experience, describe the methodology, the tools, and the importance of communication channels in maintain the interest of students.

Keywords: On-line course · Data science · Communication · Project based learning

1 Introduction

Data science [2] and cloud computing are nowadays hot (and closely related) topics in computer science. Internet, the popularity of social networks, and Internet of Things, among some other factors, have meant a huge growth in the generation of data. Furthermore, all this has happened at the same time than the improvement in hardware and network systems have brought capability to process them at great scale, or *Big Data*.

In few years, these technologies have became available at cheap cost as pay-for-use services, and enterprises are turning off their on-premises servers and migrating their systems to the *cloud*, saving money in hardware, better dealing with work peaks, etc. This shift has happened short time, and the demand for professionals has also peaked. However, classical programs in computer science education rarely include these topics.

In the last few years, many universities in Spain are offering Masters, and also degrees, in these fields. Despite this growing interest, many small universities

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cannot incorporate related courses to their catalogue of official titles. One of the reasons for that is the cost (in time) of designing and implementing a study program that, finally might not be viable for not reaching the minimum number of students inscribed (due to the number of other programs offered).

Universities in Spain, however, can also offer the so-called "Own programs", i.e, non-official programs that are not subject to the conditions stated by Spanish ANECA[1] (*National Agency for Quality Assessment and Accreditation*). This flexibility can be taken advantage of, since it allows to:

– Design the courses without the need of fitting contents to structures that can become obsolete and require long periods of time and effort to change.
– Out-sourcing professionals from technological enterprises, which provide a different point of view and very appreciated by students.

In this context, from the Faculty of Computer Science Engineering of the University of Castilla-La Mancha (Spain), we offer *CiDAEN: Course in Data Science and High-Scale Application Development on Cloud*[2], an online 30-credit non-official program oriented to undergraduate students and professionals.

In the two editions that have taken place so far, the feedback of students has been extremely good. They like both the program and the activities, and even if they follow the course in their free time, the level of participation and interaction has been fairly high.

The aim of this paper is to share our experience with the course: a description of the program, the way in which it has been implemented, the importance of the tools, and also the importance (in our opinion) of the available communication channels. We will also discuss what we have learnt during these two editions, and the potential problems that can arise as a consequence of the increase in the number of students that we expect.

In order to support our perceptions, we have asked the students to answer a questionnaire. 17 out of 22 have answered it. We used this information to obtain the figures that are shown in this paper.

2 Non-official University Programs

As commented in the introduction, official grades and Masters in the Spanish university system are regulated by the National Agency for Quality Assessment and Accreditation (ANECA). It implies that all the Spanish official university studies must fulfill strict requirements regarding structure, contents, teaching staff, students, evaluation, etc. Although, undoubtedly, this contributes to meet high standards and to control and correct weaknesses in such studies, it also introduces a rigidity and a bureaucracy which strongly conditions their evolution. This rigidity should not be understood as a minor issue as:

[1] http://www.aneca.es/eng.
[2] http://www.cidaen.es/.

- For public universities, it is not easy (and definitively, it is not a fast issue) to incorporate new studies to the official catalogue, since this is subject not only to strategic reasons but also to political ones.
- The design and implementation of a new curriculum takes several months (even years).
- Since the teaching process (face to face and laboratory activities, online classes, asynchronous activities) must be predetermined in the memory accredited by ANECA, it is difficult to adapt the channels to the particular requirements of the students. It should be noticed that, often, the students are working and have restricted schedules to follow the classes. This applies also to the evaluation, which should also be adapted to the students schedules and be, as far as possible, asynchronous.
- Changes in the contents are also subject to the curriculum accredited by ANECA, which makes it problematic to incorporate new topics or discard those which have become non relevant or obsolete.
- The length of the programs is fixed. With a minimum of 180 ECTS (European Credits Transfer System) for Degrees, and 60 ECTS for Masters. Moreover, there is no flexibility in the courses or modules, which must usually fit a number credits regardless of their importance.
- The professors must be accredited by ANECA, which limits the incorporation to the teaching staff of experts from the private world.
- The cost of running accredited grades/master by universities is high.

In this respect, the so called *own programs* (non-official programs) allow to incorporate new offers of formation to the catalogue of studies of Spanish universities in a more flexible way. Furthermore, they normally include renowned specialists from the private world in their teaching staff. As a consequence of this close collaboration between university and private world, the students take contact with companies related with the topics treated in the courses. On the other hand, these courses mean an interesting opportunity for the companies to train their workers in cutting-edge competences.

It should not be assumed that there is not any control or supervision of the non-official programs: they must be approved by the involved departments and schools. Furthermore, these courses should not be viewed as an alternative to official degrees or Masters. They are conceived as a complement in formation, and nowadays the demand mainly comes from students that have finished their official studies and are, often, working in the private world, but want to refresh their knowledge on specific topics or to learn new matters.

Finally, these programs are an alternative to the so-called MOOCs (Massive Open Online Course), and allow universities to retain students that, every time more often, are starting to look for this kind of education.

3 Implementation of the Program

Although there are many programs that specifically focus on data science (statistics, visualization, machine learning, etc.), the arrival of big data and cloud services has also increased the demand of data engineers and data-based application developers. There is also an increasing need of professionals with an intermediate profile. CiDAEN aims to respond to this demand. Table 1 shows an overview of the program.

Table 1. CiDAEN program (initial version)

		Credits
M.1	Introduction to Data Science. Basic Tools	2.5
M.2	Data acquisition, preparation, and storing	2.5
M.3	Exploratory data analysis	1
CS I	Data acquisition, preparation, storing, and exploratory analysis	0.5
M.4	Machine learning foundations	3
CS II	Design of a predictive model	0.5
M.5	Text mining, recommender systems, and network analysis	1.5
CS III	Design of a recommender system	0.5
M.6	Deep learning	2.5
CS IV	Deep-learning based project	0.5
M.7	Data streams, time series, and anomaly detection	2.5
M.8	Big data I: Scalable computing	2.5
CS V	Stream processing with Apache Spark	0.5
M.9	Big Data II: Services on cloud	1.5
M.10	Data-based apps and services	1.5
CS VI	Creation of a data-based service	0.5
Project		6

The program is composed by 10 modules which are divided into 6 blocks. Each one of them concludes with the elaboration of a capstone or small project where students put in practice what they have learnt.

In the first block, students take contact with tools (Module 1), and learn how obtain, store, and arrange data (Module 2), for further analysis (Module 3). The next block (Module 4) introduces the state-of the art machine learning techniques, as well as use cases. Aftwerwards, in the third block (Module 5) the course introduces specific topics related with the commercial environment: Text Mining, Recommender Systems, and Network Analysis. This first part of the course finishes with Module 6, dedicated to Deep Learning an applications.

The next block begins with the study of techniques for analysis of streams, time series and anomalies (Module 7), and introduces scalable computing (Module 8). In particular, students must work during several weeks with Apache Spark. Lastly, the sixth block is dedicated to manage and use services on cloud as basis for the creation of data-based applications.

4 Methodology

From the very beginning, and taking into account both the profile of potential students and the opinion of the staff of the course that works in the private sector, it was clear that the program had to be mainly practical. Thus, Table 2 shows the distribution of the class workload. Due to the nature of the course, lectures are reduced to 60 h (6 ECTS). The rest of the classes consist of seminars, guided work, or sessions to guide the final projects. Next, we describe and the implementation of each of the activities of the course.

Table 2. CiDAEN: distribution of workload (class)

	Class hours
Lectures	60
Practical seminars	120
Capstones and guided work	60
Total (24 credits)	240

4.1 Lectures

Although CiDAEN is an online course, we have not adopted the traditional method of "knowledge pills" [1], with small-edited videos. Instead, we perform live on-line sessions so that students can participate.

After considering some other alternatives, we use Zoom[3] to broadcast and record the classes. This tool is designed for meetings. However, it provides functionalities such as live chat or screen sharing, also from tablets. This last feature is important, as we have noticed that using devices as pencils to make annotations definitely helps both professors and students to keep their attention.

The sessions are recorded so that the students are able to revise them on demand. It becomes essential, since many of the students are working and have difficulties to follow the sessions when they are broadcasted (Fig. 1).

Given that the majority of the students cannot follow the sessions when they are broadcasted, and due to the difficulty to maintain the attention when visualizing long videos (75–90 min), we are considering to reinforce each session with shorter videos that introduce the essential points of each session. In this respect, we asked the students whether they watch the entire videos or skip some parts. Surprisingly, most of them (Fig. 2) watch the whole videos. Nevertheless, we also asked whether they would prefer short videos with the important contents. In this case, although most of them prefer videos as made now, 42% of students show their interest for this option (Fig. 3).

[3] www.zoom.us.

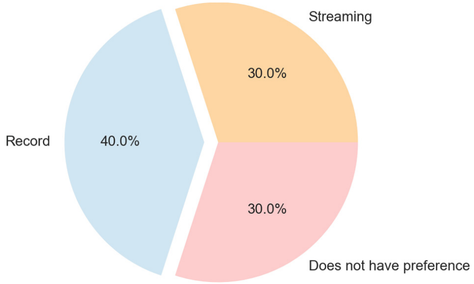


Fig. 1. Answers to the question "When do you see the videos?"

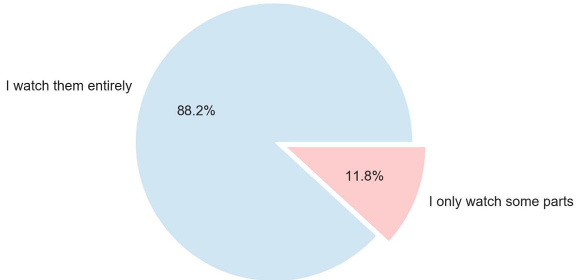


Fig. 2. Answers to the question "Do yo see the entire videos?"

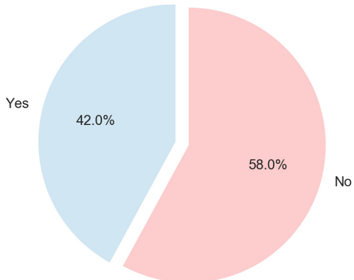


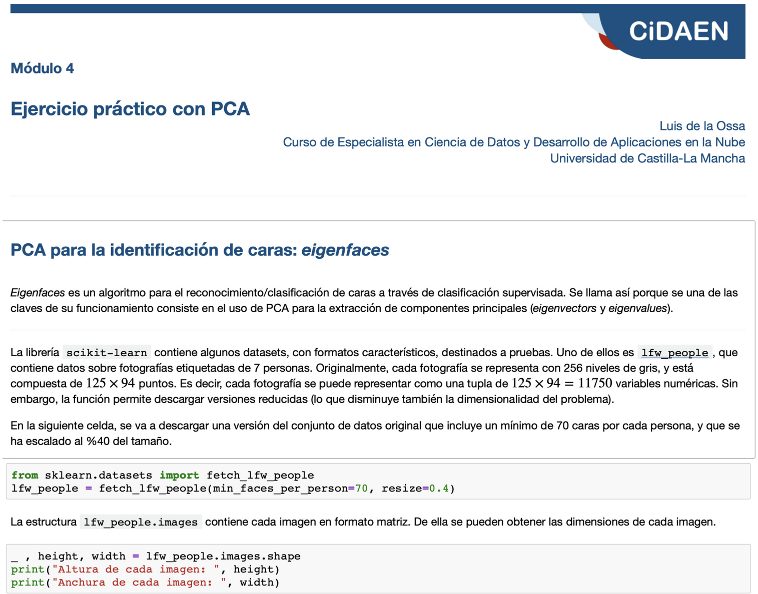
Fig. 3. Answers to the question "Would you prefer short videos with the important contents instead of 90-min videos?"

4.2 Practical Seminars

As mentioned above, practical seminars are one of the kingpins of CiDAEN. We propose small projects and, during a class session, we do live coding and explain the solutions. With this classes, not only we focus in tools and implementation details, but we also introduce new concepts as well.

We mostly use Jupyter notebooks [3] or Google colab[4]. Besides being the state of the art tools in data analysis, notebooks allow to introduce contents and explanations in the form of text, images, etc.

[4] https://colab.research.google.com/.



CiDAEN

Módulo 4

Ejercicio práctico con PCA

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PCA para la identificación de caras: *eigenfaces*

Eigenfaces es un algoritmo para el reconocimiento/clasificación de caras a través de clasificación supervisada. Se llama así porque se una de las claves de su funcionamiento consiste en el uso de PCA para la extracción de componentes principales (*eigenvectors* y *eigenvalues*).

La librería `scikit-learn` contiene algunos datasets, con formatos característicos, destinados a pruebas. Uno de ellos es `lfw_people`, que contiene datos sobre fotografías etiquetadas de 7 personas. Originalmente, cada fotografía se representa con 256 niveles de gris, y está compuesta de 125×94 puntos. Es decir, cada fotografía se puede representar como una tupla de $125 \times 94 = 11750$ variables numéricas. Sin embargo, la función permite descargar versiones reducidas (lo que disminuye también la dimensionalidad del problema).

En la siguiente celda, se va a descargar una versión del conjunto de datos original que incluye un mínimo de 70 caras por cada persona, y que se ha escalado al %40 del tamaño.

```
from sklearn.datasets import fetch_lfw_people
lfw_people = fetch_lfw_people(min_faces_per_person=70, resize=0.4)
```

La estructura `lfw_people.images` contiene cada imagen en formato matriz. De ella se pueden obtener las dimensiones de cada imagen.

```
_ , height, width = lfw_people.images.shape
print("Altura de cada imagen: ", height)
print("Anchura de cada imagen: ", width)
```

Fig. 4. Jupyter notebook used in a seminar.

We provide the students with incomplete notebooks (with some missing code) some days before the class in order to arise their curiosity. Then, in class, we do live coding while explaining the steps. Respect to this, notebooks allow creating, executing and deleting new cells. This gives us the possibility of improvising examples and make tests. This dynamism is clearly one of the keys for the success of the seminars.

Finally, we do not give them the solutions through any channel other than video. Thus, we somehow "force" them to code themselves.

Figure 4 shows one of these notebooks. Under the header, there are some explanations of what the seminar is about, and it is possible to see the first two cells of code.

4.3 Capstones

During the course, we propose 6 capstones or small (but attractive) projects where students must solve a problem from scratch. However, we carefully detail each step, and ask them for specific tasks. Because of that, students really end up completing a sequence of exercises. Due to the workload of the course, we think this is the only way to complete capstones. Therefore, there is a bit of IKEA effect [4], as once terminated the capstones, their feeling is roughly the same as if they had made the whole work. This definitely motivates them. Nevertheless, capstones require a big effort, and students need to ask questions, communicate with their colleagues, and look for information. We have detected one problem, though: biggest capstones produce some impatience, as they do not perceive progress (finished tasks) during weeks.

We use GitHub-Classroom[5] to supervise the work and send feedback. This platform allows each student to create a particular repository from another repository with the starter code, and allows professors to read and write on it. Thus, professors upload corrections with comments when necessary.

4.4 Final Project

As for the final project, students mostly want to focus in problems they have in their jobs. Some other times, we propose them projects. In any case, we supervise the elaboration process, and finally ask them for the code and a description of their job (that can be integrated in the same notebook). Therefore, the result is similar to a capstone, but the workload is bigger, as they must code it from scratch.

4.5 Comparison of the Teaching Methods

One of our main concerns is whether students find all of the teaching methods as useful. Because of that, in the questionnaire we ask them to give a score to what *they think they have learnt* with each type of activity (Fig. 5).

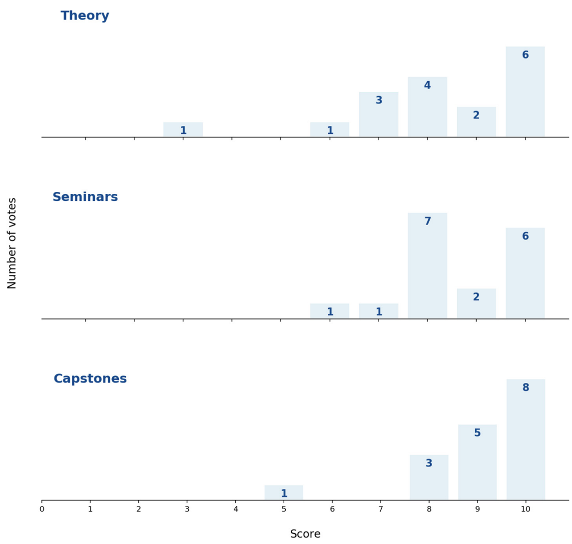

Fig. 5. Satisfaction with teaching methods.

[5] http://classroom.github.com.

As can be seen, for all three methods they have give a score, on average, above 7. This is a great success, and we think it is due, in part, to the profile of the students: professionals that make the course to learn.

As for the comparison among methods, and although differences are not substantial, it is clear that, to their opinion, the effort dedicated to make the capstones is worth, as 13 out of 17 students have evaluated what they have learned with an score equal or greater than 9.

5 Communication

In our opinion, one of the strong points of this course's success is communication. In fact, even if the students barely come to office hours (they can if the want to), the teaching staff is in continuous contact with them.

We use UCLM (University of Castilla-La Mancha) Moodle[6] as base information point for the course, and also as central repository of material. However, this platform has became obsolete as communication channel. As an alternative, we use Slack[7], which is nowadays the reference for communication among work teams. It provides real time channels, and allows to share code, to interact with Zoom, with Google Drive, with Outlook, etc. We use different channels in our site for: the news and organization; supervising each module/capstone; events; and also to communicate with the students personally.

We also asked students to give a score to each one of the communication platforms (Fig. 6). As it can be seen, email is the worst valued, as it is also becoming obsolete for some contexts. However, they seem to consider Slack as a really good communication tool: 14 out of 17 gave it a score of 9 or 10.

The use of Slack is very beneficial in this context. This is due to several reasons. According to our observations:

- In contrast with mail or forums, students have the perception that there is always someone else on the channels (very often the professors) who answers the questions and provides help. This encourages participation and, moreover, helps preventing frustration whenever they get stuck. This feeling of being part of a group is illustrated in Fig. 7. Although answers are not extremely high, all but three students have valuated it with a positive (equal or greater than five) score.
- Almost-Real time communication allows us to make a personalized supervision of the students situation. This is very important, as the workload is high and there is some risk of abandonment. In fact, we have detected that students catch up with the work after contacting and chatting with them. Figure 8 shows the answer to the question "To what extent do you feel attended by the professors?". As it can be seen, in this case the scores given are really high. There is no doubt that this communication has been possible because of Slack.

[6] http://www.moodle.org.

[7] www.slack.com.

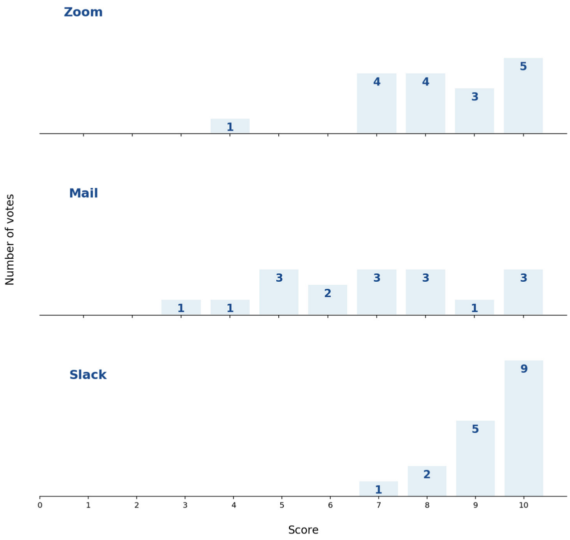

Fig. 6. Satisfaction with the communication methods.

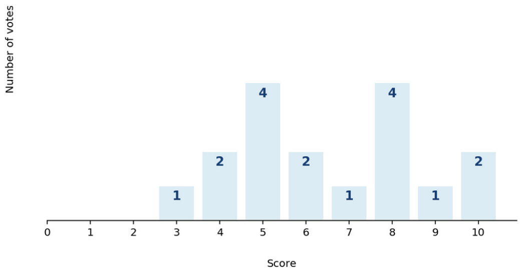

Fig. 7. Answers to the question "To what extent do you feel as part of a group?"

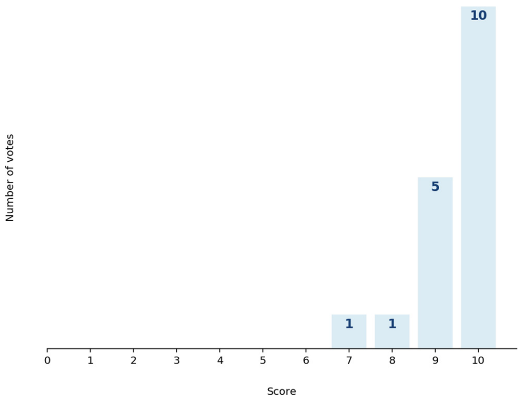

Fig. 8. Answers to the question "To what extent do you feel as attended by the professors?"

6 Discussion

CiDAEN has been totally designed around the students, considering their needs as the main criterion, and focusing on the learning process. We think of CiDAEN as an *alive entity* whose features (contents, teaching methodology, communication channels, etc.) continuously evolves according the changing necessities.

Despite the workload, most students appreciate benefits in the high amount contents and activities of the course. Figure 9 show their overall satisfaction. As can be seen, it is really positive.

One of the key elements of the success of the course has been the design of capstones, as it stimulates work and makes students aware of what the capabilities they are acquiring. We also think that the intense communication has been an another essential element. In this respect, real time communication, and the personalized supervision of projects, definitely encourages students to keep up.

Slack makes possible to establish this communication level. However, it presents a problem: Students tend to talk with the professors personally any time they need to. This might be troublesome, since each person works at a different hours. This also sets a limit in the number of students that can be admitted. Thus, even if we expect an increase in the demand for the next edition, we could not allow more than 30 students to maintain the quality standard.

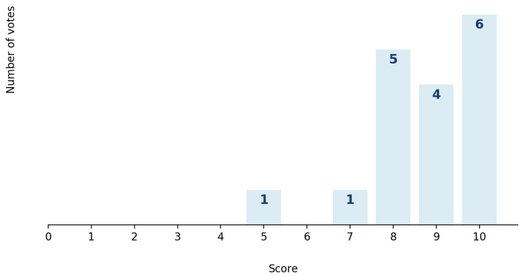

Fig. 9. Overall satisfaction of the students with the course.

Last, there is room for improvement in CiDAEN. Besides some other aspects as, for instance, the order of modules (they need more practice with cloud services), there are two improvements that derive of what has been exposed in this article. First of all, we consider that it is better to split the longest capstones into smallest ones, as this helps students to perceive progress. Secondly, it is definitely necessary to stimulate group communication in Slack to relieve professors. We think this can be done by both establishing communication rules, and participating ourselves in those channels.

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Explainable Artificial Intelligence for Human-Centric Data Analysis in Virtual Learning Environments

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Abstract. The amount of data to analyze in virtual learning environments (VLEs) grows exponentially everyday. The daily interaction of students with VLE platforms represents a digital foot print of the students' engagement with the learning materials and activities. This big and worth source of information needs to be managed and processed to be useful. Educational Data Mining and Learning Analytics are two research branches that have been recently emerged to analyze educational data. Artificial Intelligence techniques are commonly used to extract hidden knowledge from data and to construct models that could be used, for example, to predict students' outcomes. However, in the educational field, where the interaction between humans and AI systems is a main concern, there is a need of developing new Explainable AI (XAI) systems, that are able to communicate, in a human understandable way, the data analysis results. In this paper, we use an XAI tool, called ExpliClas, with the aim of facilitating data analysis in the context of the decision-making processes to be carried out by all the stakeholders involved in the educational process. The Open University Learning Analytics Dataset (OULAD) has been used to predict students' outcome, and both graphical and textual explanations of the predictions have shown the need and the effectiveness of using XAI in the educational field.

Keywords: Educational Data Mining · Data science · Trustworthy AI · Explainable AI · Virtual learning environments

1 Introduction

Distance education history starts almost two centuries ago with postal services [20]. With the advent of the Internet, significant changes have occurred, and the use of on-line distance learning (e-Learning in short) platforms has exponentially grown. These virtual learning environments (VLEs) eliminate the

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physical distance between learners and courses, thus facilitating and favouring the enrollments. In addition to online teaching material, VLEs provide a set of synchronous and asynchronous study assistance tools, such as chat, video lessons, forums, wikis, messaging systems, emails, etc. In these environments, the student learning behaviour can be elicited by observing interaction with the platform: the number of times that the student has visited the main page, the number of messages she has exchanged with the professor, the number of extra resources that have been uploaded, and so on. Accordingly, the observation of the student learning behaviour could be used to suggest adaptive feedback, customized assessment, and more personalized attention [24]. All the stakeholders that are involved in VLEs, such as teachers, tutors, students, and managers, can take advantage from information obtained through educational data analysis.

Educational data mining (EDM) and *Learning Analytics* (LA) are two research branches that are increasingly attracting attention. They use Artificial Intelligence (AI) techniques to collect, process, report and work on educational data, in order to improve the educational process [2]. Indeed, the application of LA to historic VLE activity data allows to predict students' failure or success, and it is commonly used to improve student retention [30].

Several studies have proved the effectiveness of EDM and LA techniques in analyzing educational data [8]. Most related work in the scientific literature is devoted to predict students' performance [1,10,22]. In addition to prediction techniques, visualization techniques are applied to observe the students' performances [11,12,15,23]. In addition, numerical methods can facilitate unveiling unknown hidden learning skills [6]. In addition, learners can be grouped into categories automatically extracted from empirical data [7,21]. There are also advance techniques to manage and analyze big educational data [26–28,31].

Getting effective explanations is becoming more and more important in social sciences [19]. This general trend is confirmed in Education Science. Even though current AI tools have proved to be ready for finding out valuable knowledge in the context of EDM and LA, their effectiveness for decision-making support is still limited by a lack of explanation ability. Thus, in applications such as e-Learning where the interaction between humans and AI systems is a main concern, there is a need of developing new Explainable AI (XAI in short) systems. It is worth noting that this fact is aligned with the XAI scientific challenge launched (in 2016) by the USA Defense Advanced Research Projects Agency (DARPA) which remarked that "even though current AI systems offer many benefits in many applications, their effectiveness is limited by a lack of explanation ability when interacting with humans" [14]. XAI systems are expected to provide users with comprehensible explanations through natural interaction. Moreover, the European Commission emphasizes the importance of boosting innovation and investment in AI technologies as follows "EU must therefore ensure that AI is developed and applied in an appropriate framework which promotes innovation and respects the Union's values and fundamental rights as well as ethical principles such as accountability and transparency"[1]. Hence, XAI systems are expected to be beneficial to society through fairness, transparency and explainability, regarding not only technical but also ethical and legal issues. The interested reader is kindly referred to [13] where an exhaustive review of XAI techniques is presented.

Providing students with explanations in relation with their learning activities is expected to be highly appreciated and to contribute to get better students' satisfaction and qualifications. Moreover, XAI systems may assist teachers and managers when designing courses and contents. In this paper, we describe the use of ExpliClas [4], a web service ready to provide users with multimodal (textual + graphical) explanations, in the context of e-Learning. Namely, we study the utility and effectiveness of explanations automatically generated by ExpliClas when considering the Open University Learning Analytics Dataset (OULAD) [17].

The rest of this manuscript is organized as follows. Section 2 introduces some material and methods. Section 3 presents a use case. Section 4 concludes the paper with some final remarks and points out future work.

2 Preliminaries

2.1 The ExpliClas Web Service

ExpliClas [4] is a XAI tool aimed at facilitating the comprehension of AI systems to both expert and non-expert users. In the core of ExpliClas there are AI, Natural Language (NL) processing and generation techniques, argumentation and Human-Computer Interaction technologies. Fortunately, all these technologies are transparent to the user through a user-friendly interface. Accordingly, users only need to concentrate in reading textual explanations as well as visualizing simple and intuitive graphical model representations.

Currently, ExpliClas generates multimodal (textual + graphical) explanations, at both local and global level, related to Weka classifiers. Local explanations pay attention to how the given AI model is instantiated for single classifications while global explanations look at the AI model itself. Notice that current global explanations are merely descriptive, i.e., they only report information on how good or bad is the classifier but with no indications on how to add/remove/modify a specific rule in order to improve the classification rate. Actually, four Weka classifiers are available [9]:

- Three decision tree classifiers:
  - **J48:** an open source Java implementation of the C4.5 decision tree algorithm [25];

[1] European Commission, Artificial Intelligence for Europe, Brussels, Belgium, "Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions", Tech. Rep., 2018, (SWD(2018) 137 final) https://ec.europa.eu/digital-single-market/en/news/communication-artificial-intelligence-europe.

  - **RepTree:** a fast implementation of C4.5 decision trees using information gain along with backfitting reduced-error pruning;
  - **RandomTree:** C4.5 decision trees that consider K randomly chosen attributes at each node;
- One fuzzy rule-based classifier:
  - **FURIA:** a Fuzzy Unordered Rule Induction Algorithm [16]. FURIA is one of the most outstanding fuzzy rule-based classification methods attending to accuracy. It also produces compact rule bases, i.e., rule bases which are made up of a small number of rules (and antecedents per rule). In addition, its inference mechanism is based on a winner class mechanism with weighted rules in combination with the so-called rule stretching method which is in charge of handling uncovered instances. The interested reader is referred to [16] for further details about FURIA.

    It is worth noting that fuzzy classifiers deal naturally with imprecision and uncertainty [29,32]. In addition, a recent survey in the XAI research field has revealed the importance of fuzzy systems in the quest for XAI systems [3].

ExpliClas is made up of a REST API[2] and a web client[3]. It is released as free software under the GNU General Public License. Interested readers could refer to [4] for more information about ExpliClas.

2.2 The OULAD Dataset

The Open University (OU)[4] is a public distance learning university in the UK. It provides the research community with free open data[5] related to their on-line courses. More precisely, available data are structured in several csv files (courses.csv, assessments.csv, studentInfo.csv, and so on). They contain anonymized information which is taken from the OU database.

In this paper, we have first selected a subset of all the information that is available at the OU database. Then, we have built a dataset ready to be used by ExpliClas. Particularly, data coming from three modules (codes AAA, BBB, CCC) have been considered. Furthermore, we have focused on students' information, useful to predict the students' outcomes, as this is the data analysis goal. Thus, a subset of attributes has been selected, and aggregated attributes have been created to summarize the students' behaviour, as described in Tables 1, 2 and 3.

Only two outcomes (classes) have been considered out of the 4 classes in the original dataset: *Fail* (4219 students) and *Pass* (5959 students). It is worth noting that the *Fail* class has been obtained by merging "Fail" and "Withdrawn" classes in the original dataset. Likewise, the *Pass* class has been obtained by merging the original classes "Pass" and "Distinction". As a result, we have a

[2] ExpliClas API: https://demos.citius.usc.es/ExpliClasAPI/.
[3] ExpliClas Web Client: https://demos.citius.usc.es/ExpliClas/.
[4] Open University (OU) website: http://www.open.ac.uk/.
[5] OU Open Data: https://analyse.kmi.open.ac.uk/open_dataset#data.

Table 1. Description of attributes related to general information.

Attribute name	Description
Code module	Identification code of the module (*AAA, BBB, CCC*) to which the assessment belongs
Code presentation	Identification code of the student presentation (*2014J, 2014B, 2013J, 2013B*): year + session
Gender	Students' gender (*M/F*)
Region	Geographic region, where the student lived while taking the module-presentation (*Scotland, Wales, Ireland, London Region, Yorkshire Region, South Region, South East Region, South West Region, North Region, North Western Region, East Midlands Region, West Midlands Region, East Anglian Region*)
Highest education	Highest student's education level, when enrolled (*A Level or Equivalent, Lower Than A Level, HE Qualification, Post Graduate Qualification, No Formal quals*)
Imd band	Index of Multiple Deprivation band value of the place where the student lived when enrolled. It is an UK government measure to evaluate deprived areas in English local councils. (Values ∈ [0%−100%])
Age band	Students' age band (*0–35, 35–55, higher than 55*)
Disability	Whether the student has declared a disability (*Y/N*)

binary classification dataset which is made up of 10178 samples and 21 attributes grouped in:

- *General information*, such as gender or education level (see Table 1);
- *Student assessments information*, such as average assessment score or the number of previous attempts (see Table 2);
- *Student interactions* with different materials in the platform, such as quiz, glossary, homepage, subpages etc. (see Table 3).

3 Case Study

Data analysis results provided by XAI systems must be comprehensible by both expert and non-expert users in order to become *trustable*. That is, a general user (no matter her expertise on AI) should be able to answer to "why" and "how" questions in the light of outcomes provided by XAI systems.

In order to show the effectiveness of the ExpliClas tool in assisting users to understand results of educational data analysis, we have selected two Weka classifiers (J48 and FURIA) to automatically build XAI models from the dataset described in the previous section. We describe below the classification performance of these models together with the associated explanations.

Table 2. Description of attributes related to assessment of students.

Attribute name	Description
Number of previous attempts	Number times the student has attempted this module (*Numeric*)
Studied credits	Total number of credits that the student is studying (*Numeric*)
Number of assessments	Number of assessments that the student has submitted for the module (*Numeric*)
Average assessments score	Weighted average score that the student has obtained in his assessments for the module. Different assessments could have different weights (*Numeric*)

Table 3. Description of attributes related to VLE interactions.

Attribute name	Description
Resource	Number of interactions with extra material given by the professor (*Numeric*)
Homepage	Number of interactions with the module homepage (*Numeric*)
Forum	Number of student's messages in the module forum (*Numeric*)
Glossary	Number of interactions with an hyper-link dictionary that explains particular words in the module (*Numeric*)
Out content	Number of interactions with extra platform material which was suggested by the professor (*Numeric*)
Subpage	Number of interactions with course subpages that focus on a particular topic (*Numeric*)
Url	Number of interactions with external resources which were liked by the professor (*Numeric*)
Out collaboration	Number of collaborations among students (*Numeric*)
Quiz	Number of interactions with questionnaires regarding the module contents (*Numeric*)

As we already introduced in the previous section, ExpliClas provides users with two different kind of explanations: a *general explanation* that reports the classification results on the whole dataset; and *local explanations* that refer to single cases.

We first uploaded the OULAD dataset to ExpliClas and built a FURIA classifier which achieved 92.56% of classification rate (10-fold cross-validation) with 28 fuzzy rules (16 rules pointing out class = Pass and 12 rules pointing out class = Fail).

The Fig. 1 shows an example of global explanation. The user can select the visualization mode (fuzzy rules and confusion matrices on training and test sets) through the menu in the upper part of the picture. At the bottom, the related

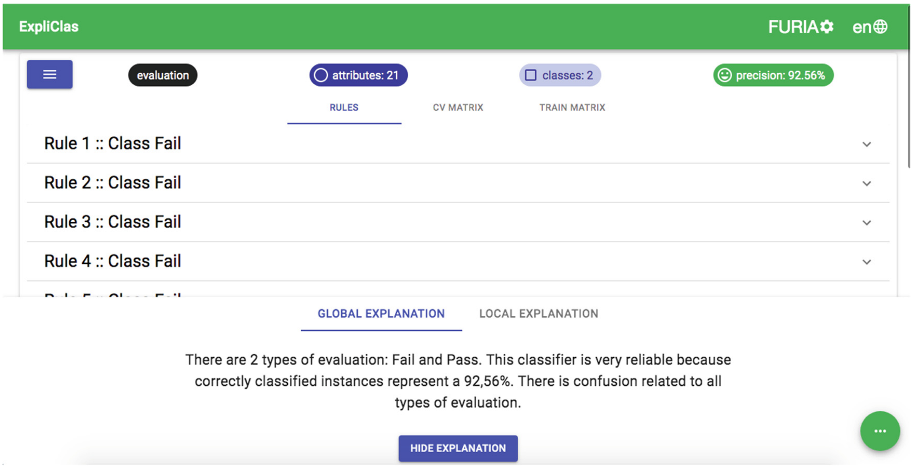


Fig. 1. Example of global explanation obtained with ExpliClas (FURIA classifier).

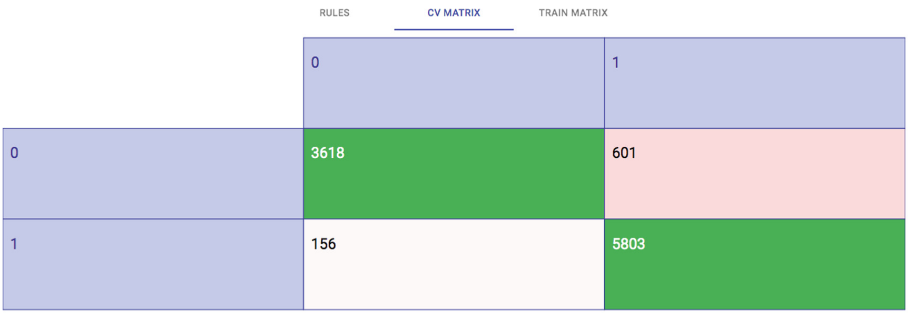
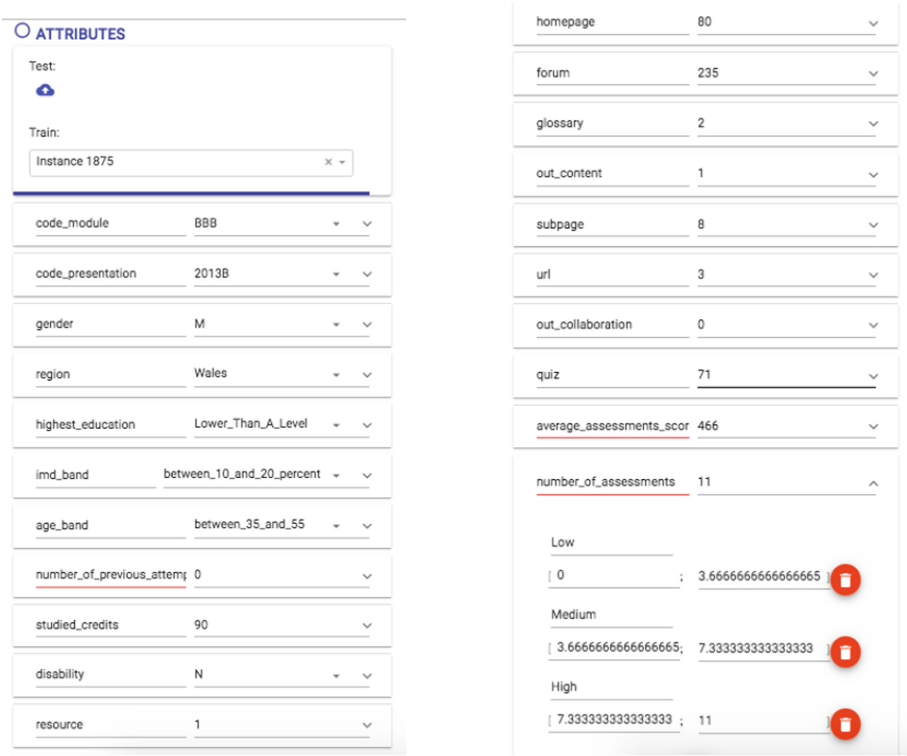


Fig. 2. Confusion matrix of the model obtained by FURIA. On the left the actual class labels, on the top the predicted labels.

explanation in natural language is reported: "*There are 2 types of evaluation: Fail and Pass. This classifier is very reliable because correctly classified instances represent a* 92,56%. *There is confusion related to all types of evaluation.*". This explanation "translate" into natural words (i.e., in a more human understandable form) the content of the confusion matrix that is depicted in the Fig. 2. On the one hand, the class Fail is confused with Pass in 601 out 3618 students who really fail (16.61%). On the other hand, Pass is confused with Fail in 2.69% of students.

In order to illustrate the use of local explanations, we selected one student in the dataset. The Fig. 3 shows the data values associated to all attributes. Moreover, the user can visualize and/or edit the semantic grounding that is behind the explanation model. By default, three linguistic terms are assigned to qualitatively describe each attribute: *Low*, *Medium* and *High*. The Fig. 3(b) shows the definition of these linguistic terms associated to the attribute *number of assessments*. Of course, the user can edit this definition regarding both granularity



(a) (b)

Fig. 3. Example of data values associated to one of the students in the OULAD dataset.

(i.e., the number of terms) and semantics (i.e., linguistic terms along with their numerical values).

Accordingly, local explanations have multi-modal nature in the sense that they combine graphs and text. In the upper part of the Fig. 4 an histogram visualizes the student's outcome (*Pass*) along with the associated activation degree in the interval $[0, 1]$. In the lower part of the figure, the information included in the fired fuzzy rule is verbalized as "*Evaluation is Pass because number of assessments is high, resource is low and forum is medium*". Moreover, the system allows to browse the fuzzy rule base, and to expand the graphical representations of the selected rules. The Fig. 5 shows the fuzzy sets in the winner fired fuzzy rule "IF number of assessments in [9, 10, inf, inf] and forum in [20, 24, inf, inf] and resource in [-inf, -inf, 13, 415] THEN class = Pass (CF = 0.94)". The winner rule is the one with maximum firing degree for the given instance. It is worth noting that the rule firing degree is computed with minimum at t-norm. Then, the output class is computed with maximum as t-conorm, regarding all fired rules which point out as the same output. The certainty factor CF is a weight factor which FURIA computes regarding the relevance of rules in accordance with the training data. In case no rules are fired then FURIA applies the so-called rule stretching mechanism which looks for slight modifications in the rule base with the aim of finding out a new rule on-the-fly able to manage the given instance. The interested reader is kindly referred to [16] for further details about FURIA. Moreover, additional information about how to carefully design fuzzy models (with special attention to how to select the right fuzzy operators) is available at [29,32].

Rules generated by FURIA have local semantics, i.e., the most suitable fuzzy sets are defined independently for each rule. This fact may jeopardize the interpretability of a fuzzy rule-based system that is automatically derived from data like the one described in this section. As described in [5], setting up global semantics a priori is required when looking for interpretable fuzzy systems. Moreover, building interpretable fuzzy systems is a matter of careful design because model interpretability can not be granted only for the fact of using fuzzy sets and systems [29]. However, it is possible to add a linguistic layer to facilitate the interpretability of fuzzy rules even if they lack of global semantics [18]. In ExpliClas, global semantics is set up beforehand (and validated by experts if they are available) for a given dataset (see the Fig. 3). All algorithms (e.g., FURIA or J48) share the same global semantics what makes feasible the comparison among generated explanations. Then, the local semantics determined by fuzzy sets such as those depicted in Fig. 5 can be translated into natural words in the context of the global semantics previously defined. It is worth noting that a similarity measure (see Eq. 1) is used to compare each fuzzy set with all defined linguistic terms and the one with the highest similarity degree is selected.

$$S(A,B) = \frac{A \cap B}{A \cup B} \tag{1}$$

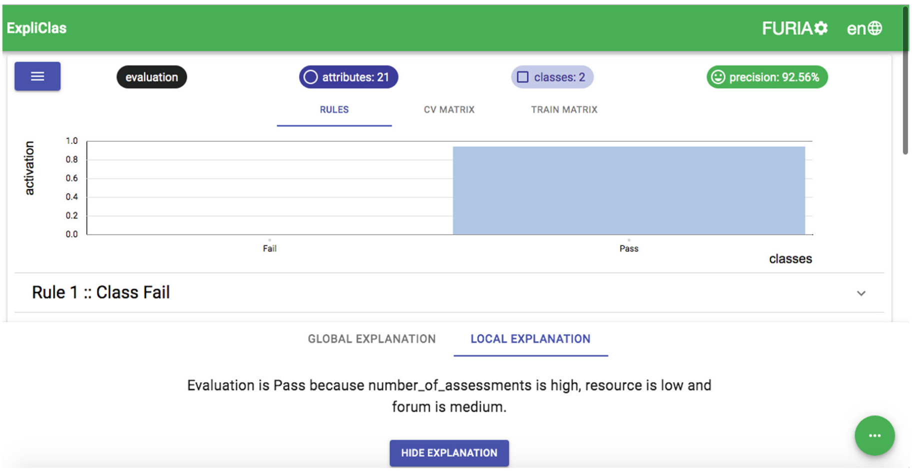


Fig. 4. Example of local explanation (FURIA).

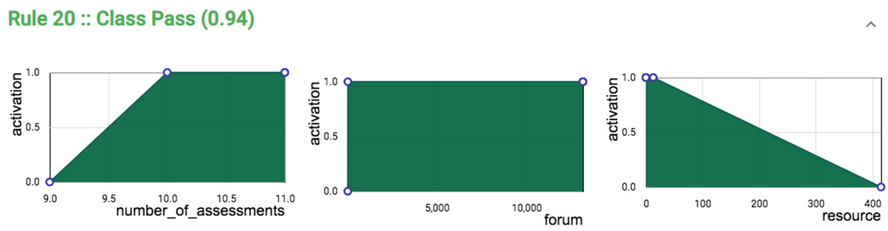


Fig. 5. Example of fired fuzzy rule (FURIA).

Once we have automatically translated the winner fuzzy rule into natural text then it is straightforward to understand the result of the fuzzy inference even if the reader is not an expert in fuzzy logic. The local explanation associated to our illustrative example (see the Fig. 4) suggests that students who perform a high number of assessments along the courses, even if the number of messages exchanges through the forum is medium and the number of visited resources is low, they are more likely to succeed.

As in real context, where more than one expert could be consulted, we used a second classifier to have a different point of view on the student's behaviour, and the factors that could influence her outcome. The Fig. 6 shows the local explanation generated by ExpliClas when data analysis is supported by the J48 classifier instead of the FURIA classifier.

Since J48 builds a binary decision tree instead of a fuzzy rule-based system, in this case the upper part of the picture shows a sketch of the tree where the fired branch is highlighted in green color. This branch of the tree can be interpreted (from the root to the leaf) as an IF-THEN rule. It is worth noting that the same attribute could appear more than once (each time with a different split condition) in the same branch of the tree. As a result, there is an interval of values associated to each attribute similarly to the fuzzy sets defined by FURIA. Once again, there is a lack of global semantics in the classifier model. Fortunately, we can apply the same procedure that we introduced earlier in order to translate the local semantics associated to each branch of tree into the context of global semantics that is used to verbalize (with natural words) the model output. In our illustrative example, the graphical representation in Fig. 6 is interpreted as the following rule (with the same format previously described for FURIA rules): "IF number of assessments in $[4, 9]$ and average assessment score in $[450, 1139]$ THEN class = Pass (CF = 100%)". Of course, ExpliClas verbalizes this rule into a natural text explanation in the lower part of the picture with the aim of becoming understandable by both expert and non-expert users.

It is interesting to notice that on one hand the two classifiers (FURIA and J48) agree on the student's outcome prediction (*Pass*), but on the other hand they identify different attributes as discriminant for the classification task. This could give some insights to teachers, managers, or tutors about how to improve the learning process. For example, if some attributes turned up as not relevant for any case under study, then they could be removed from the OULAD

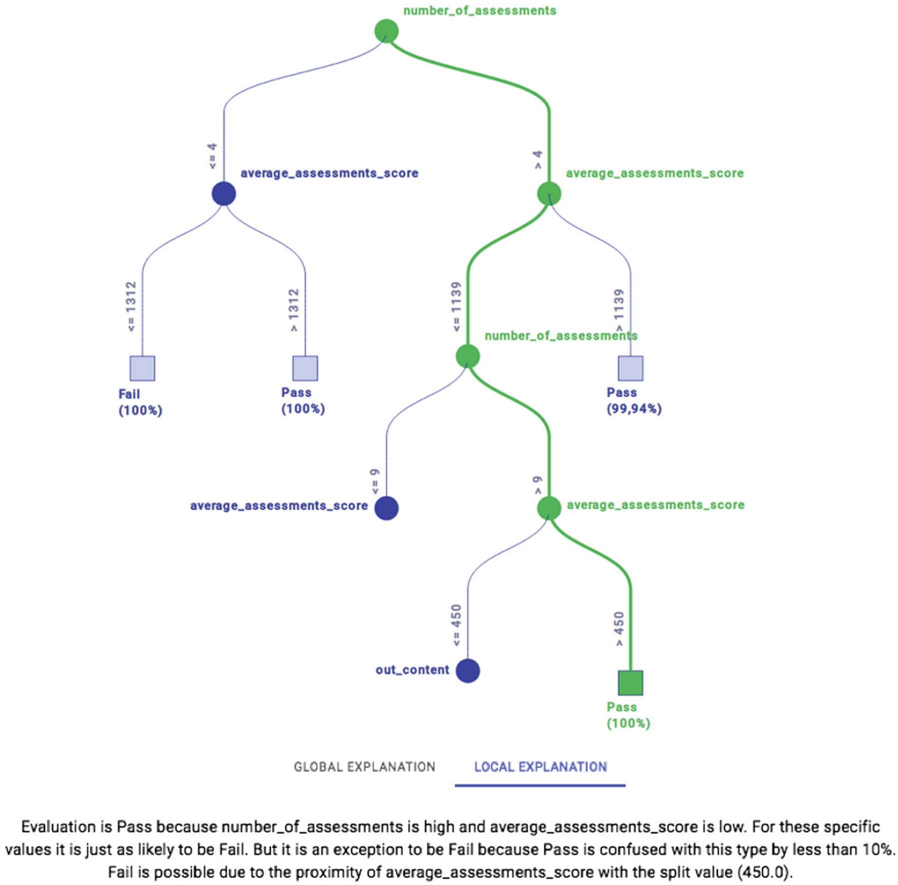


Fig. 6. Example of local explanation (J48). (Color figure online)

dataset. Of course, this means the e-learning program should be revised and updated accordingly to lighten the students' study load and the teachers' work. On the contrary, if some attributes were deemed as essential to pass an examination, then the related tasks should be emphasized and strengthened, perhaps by changing the structure of the educational process.

4 Conclusions and Future Work

We have illustrated the use of the ExpliClas XAI tool in educational data mining context. A classification dataset was built with information extracted from open data provided online by the Open University. ExpliClas provided us with illustrative examples of both global and local explanations related to the given dataset. In addition, ExpliClas automatically generated multimodal explanations which consisted of a mixture of graphs and text. These explanations look like natural, expressive and effective, similar to those expected to be made by humans.

It is worth noting that the rationale behind ExpliClas is completely transparent to the user, which can understand the reasoning that leads to a given output no matter the selected algorithm for classification. The given linguistic layer along with the global semantics that is enforced beforehand makes straightforward the interpretation of results no matter the user background and expertise. Moreover, the knowledge behind the explanation model can be edited and modified if needed to refine the generated explanations, in order to better fit with the user knowledge and intuition.

The case study has shown that the explanations given by ExpliClas are suitable for the stakeholders that are involved in VLEs: teachers, tutors, students, and managers. All these people are domain experts but they are not data analysts, so they need to deeply understand automatic generated results, in order to trust them.

This is a preliminary work to show the need of XAI in the educational field. Several extensions could be explored, but firstly we need to evaluate the user appreciation of the system. As future work, we will set up an online survey to ask human users (including students, teachers and managers) about the goodness of these explanations. Later, we will integrate them in an XAI decision-support tool.

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eLearning Course Design in Higher Education to Maximize Students' Performance

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Abstract. This paper presents an investigation on the impact that e-tivities can have on students' performance. The context of the study is an e-Learnig higher education institution, with 4 years of data collected from various courses on First and Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering; before and after the integration of e-tivity. A cloud service has been developed to get the data about students' performances in terms of examinations participations, rate of success and marks. Two academic years before the introduction of the e-tivities have been compared with the 2 academic years after, for each course under investigation. The results show that the e-tivities provided a slight increase of students' performances in terms of percentage of success. However, the study revealed also a slight decrease of the average mark obtained in the same sessions. The findings suggest that the e-tivities could provide the basic knowledge to pass an exam, but not enough to provide a full comprehension of the subject matter. Further investigation will be done to confirm those findings.

Keywords: e-Learning · e-Tivity · Students' performance · Higher educaton

1 State of the Art

In the last years, one of the most rising applications of network and information technologies is represented by e-learning. E-learning consists of the recent evolution of distance learning since, in a learning situation, the instructors and learners are divided by distance, time or both of them [5]. The main advantage of e-learning methodology is represented by the information and knowledge provision to learners through the use of asynchronous and synchronous learning tools, irrespective of time limits or geographical proximity, offering more "flexible" learning environments [6]. E-learning can be considered as a teaching-learning process sustained by information and communication technologies: the physical lesson of teachers in presence with students is not necessary, but the role of teachers and professors becomes that to make learning flexible (at any

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time and place), interactive, and student-centred [4]. In the last decade, the use of e-learning as a teaching and learning tool is rapidly developing in the educational field, with thousands of courses offered by educational institutions and universities [2,7]. As a consequence, universities are placing rising importance on the improvement of the quality of their educational services [3]. The service quality can be defined as the degree to which an event or experience meets an individual's needs or expectations. The degree of the customers satisfaction determines how much important is the level of service quality [1]. As the education field has transformed itself from a teaching-oriented to a customer-oriented model, an educational institute and university can be considered as providers of products and services to their students, that are their customers [3]. In order to attract students and satisfy their needs, higher education providers have to actively improve services and products quality in order to increase the students' degree of satisfaction. As a matter of fact, with the availability of new technology and the Internet, universities are increasingly finding innovative ways of teaching.

Unlike the model of face-to-face teaching, in which the teacher represents the central figure, in an online teaching model the remote student is the central element, because each student differs from all the others in terms of "where" he enjoys the distance course, of "when" he has the opportunity to use the contents and/or participates in interactive activities, and "how" he is able to regulate his participation and what motivations lead him to attend the course, etc.

2 Introduction

In this framework, the eCampus University, located in Novedrate (Como, Italy), has been undertaking extensive work to improve the teaching material offered by teachers to students since about two years. The proposed e-learning model aims at integrating and combining of different activities based on different learning approaches, proportionally modulating lectures (L-type) to interactive teaching (IT-type). In order to stimulate both the vertical interaction between teacher and student, and the horizontal one between students, the need emerged to diversify the component of teaching lectures supply with interactive online activities not only based on web conferences/webinars but also on others possibility of interaction. In this way, the student's need to complement the self-study with a learning that activates him the most is fulfilled, in order to make him achieve higher educational goals than just knowledge and understanding.

In the L-type education, typical frontal teaching are audio or video recordings and lessons in web-conference (also called "synchronous").

This kind of teaching does not generally create particular organizational problems even if great attention must be paid to the way of developing the e-content and/or to the criteria with which contents freely available on the net, such as articles, videos, resources free educational programs, are used. On the other hand, the interactive teaching includes actions in which some form of interaction-active, stimulated and/or guided by teachers and tutors is envisaged.

As compared to the L-type education, typical IT-type education is characterized by interpersonal interaction of students with teacher or tutor, interpersonal interaction between students, interaction with/through web resources functional to the individual or collaborative development of a task, following indications provided by the teacher or tutor for the development of the related online activity (e-tivity).

The present paper aims at evaluating students' performances of various course on First and Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering, before and after the integration of e-tivity. The reminder of the paper is as follows. Section 1 represents the state of art, in which main works from the literature related to the topic are reported. Section 2 introduces the topic of the paper, while Sect. 3 deals with the description of the methodology adopted in this work. In Sect. 4, experimental results are shown and analyzed. Finally, Sect. 5 concludes the paper.

3 Method

The main goal of this study was to compare student's performance before and after the implementations of e-tivities in teaching materials. The comparison is made on the trend of the average grade obtained by students, percentage of exams passed and not passed.

To allow further analysis and categorization of factors, students were asked to fill out a satisfaction questionnaire. The questionnaire was carefully designed in order to be able to analyze not only student satisfaction, but also student attitude towards e-learning and motivation to complete their study.

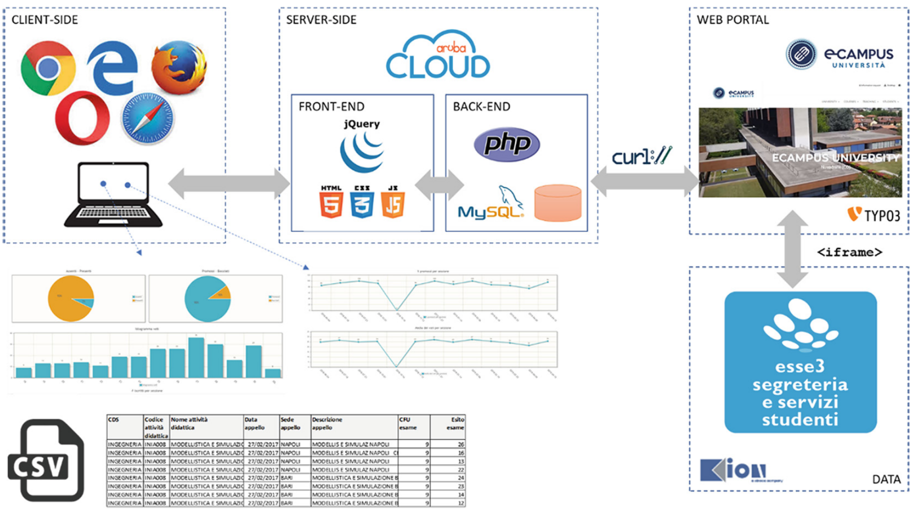

Fig. 1. Data crawling methodology.

Since the analyzed data were available on different systems, the authors developed a cloud service to perform data fusion in an automatic and systematic way (Fig. 1).

In particular, two types of data have been crawled: the exams results and the students questionnaires. The former are stored in a server program called "Esse3 segreteria e servizi studenti" developed and maintained by Kion (a Cineca company); the latter are stored in the eCampus server and exposed by a web-based Typo3 Content Management System.

Table 1. Recap of the data analyzed for Industrial Engineering courses.

First Degrees in Industrial Engineering						
Course name	Course code	Examination under evaluation				
		Academic year 2015/2016	Academic year 2016/2017	Academic year 2017/2018	Academic year 2018/2019	Total
Thermal sciences	INDU011	69	189	172	141	571
Thermal systems and hvac plants	INDU014	16	81	89	34	220
Machine components design and reliability	INDU034	2	8	14	4	28
Master Degrees in Industrial Engineering						
Heat engineering	INDM030	2	6	15	11	34
Machine components and mechanical design	INDM019	16	30	44	16	106
Reliability and safety engineering	INDM013	3	9	30	15	57
Mechanical design	INDM003	9	12	22	13	56

In order to gather these two sources of information a server-side cloud based, web service has been developed using open source languages: PHP+MySQL for the back-end and HTML5+CSS+JS+Jquery for the front-end. The data fusion work-flow can be operated manually (using a browser on the client-side) or automatically (configuring a cron-job on the server- side). The first step is the data collection: a PHP script authenticates on the web page (SAML) version 2. Once authenticated, the script browses among the required web pages and downloads the needed data on the questionnaires from the Typo3 CMS and, using the same SAML2 token, downloads the official exams results from the Esse3 portal. The second step is the data manipulation and data fusion: the gathered data are properly obfuscated and aggregated in order to: (i) be compliant with the GDPR directives and (ii) find the correlations between the exams and questionnaires info.

The last step is the data representation. Using the javascript jqplot library, it is possible to browse the data statistics (e.g. promoted/failed, average score, enrolled, absents, etc.) and perform basic sliding windows analysis to identify and highlight meaningful trends.

Table 2. Recap of the data analyzed for Computer and Automation Engineering courses.

First Degrees in Computer and Automation Engineering						
Course name	Course code	Examination under evaluation				
		Academic year 2015/2016	Academic year 2016/2017	Academic year 2017/2018	Academic year 2018/2019	Total
Thermal sciences	INIA017	29	90	86	56	261
Industrial automation	INIA015	42	85	96	88	311
Master Degrees in Computer and Automation Engineering						
Advanced control systems	INIM020	1	11	22	20	54
Distributed control systems	INIM005	15	39	38	28	120

4 Experimental Evaluation

The data collected are relative to five courses on First cycle Degrees in Industrial Engineering and Computer and Automation Engineering and on six courses for Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering, for a total of 1817 examined students over four years (Tables 1 and 2).

From the analysis of the tables, we can identify a strong imbalance in students distribution between the couple of years under consideration and within exam. This difference is due to presence of different curriculum studiorum. For example for the First cycle degree in Industrial Engineering, we have a Management Engineering and an Energy Engineering curriculum. That means that for some exam the student population it's bigger than the other. For Master degree, instead, the number of examination in account it's lower due to low enrolled students.

The courses has been modified at the end of 2016, for the beginning of Academic year 2017/2018, so the performances will be compared between Academic years 2015/2017 and 2017/2019 biennium. From the analysis, the introduction of the e-tivities generally shows a decline of failed examination.

The courses of First Degree in Industrial Engineering show an increase of passed exam that span from 2% to 5% (Fig. 2). The average mark obtained by the students shift form 24 to 22.5 for INDU011, shift form 23.6 to 23.9 for INDU014 and shift form 26.3 to 21.8 for INDU034.

Fig. 2. Results from the First cycle Degrees in Industrial Engineering analysis.

For two courses of Master Degree in Industrial Engineering, we can register an increase of the passed examination in the range 5%–21%; but also an increase of failed examination for two courses, with reduction of passed exam up to 27% (see Fig. 3). The average mark obtained by the students shift form 26.9 to 25.7 for INDM030, shift form 25.0 to 22.2 for INDM019; shift form 27.7 to 23.7 for INDM013 and shift form 26.5 to 23.5 for INDM003.

Fig. 3. Results from the Master cycle Degrees in Industrial Engineering analysis.

Similar results were observed for the two courses in First Degree in Computer and Automation Engineering, in which the INIA015 course registers a reduction in passed examination value up to 7% and an increase for INIA017 course up to 7% (see Fig. 4). The average mark obtained by the students shift form 25.3 to 23.2 for INIA015 and shift form 24.8 to 22.5 for INIA017.

For Master Degree in Computer and Automation Engineering, both two courses show positive values, with an increase in passed exam up to 8% (see Fig. 5). The average mark obtained by the students shift form 26.5 to 25.6 for INIM020 and shift form 24.5 to 24.1 for INIM005.

At the same, for all courses examined, it is registered a slight reduction in the average grades obtained by students up to 4 grades.

The questionnaire given to the students is based on a 1 to 4 grade scale, where 1 means "Definitely NO" and 4 means "Definitely YES". The questions are as follows:

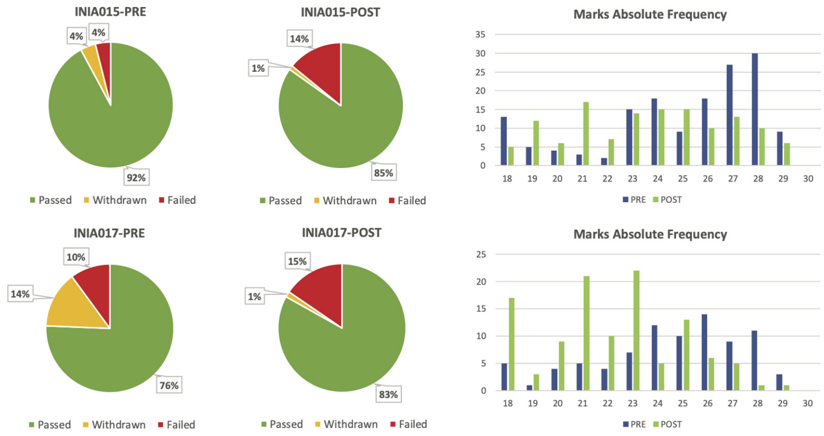

Fig. 4. Results from the First cycle Degrees in Computer and Automation Engineering analysis.

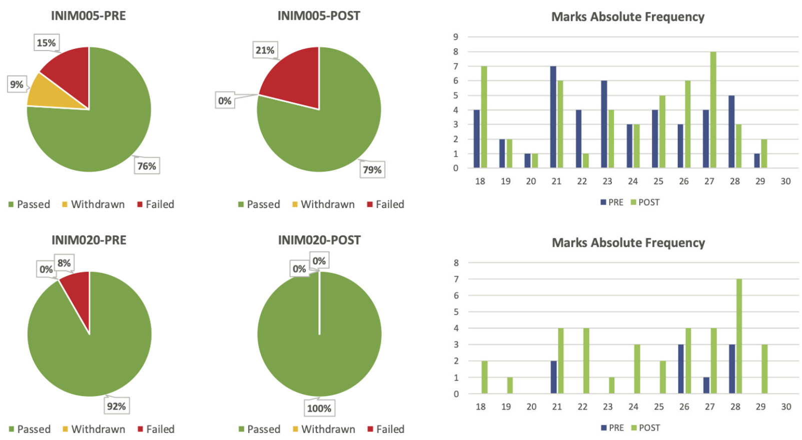

Fig. 5. Results from the Master Degrees in Computer and Automation Engineering analysis.

– D1.1 - Were the preliminary knowledge possessed sufficient for understanding the topics included in the exam program?
– D1.2 - Is the teaching load of the teaching proportionate to the credits awarded?
– D1.3 - Is the teaching material (indicated and available) adequate for the study of the subject?
– D1.4 - Have the examination procedures been clearly defined?
– D1.5 - Are online educational activities (multimedia films, hypertext units ...) easy to access and use?
– D1.6 - Does the teacher stimulate interest in the discipline?
– D1.7 - Does the teacher present the topics clearly?

– D1.8 - Did the educational activities other than the lessons (exercises, workshops, chats, forums etc ...) have been useful for learning the subject?
– D1.9 - Is the teacher actually available for clarifications and explanations?
– D1.10 - Is the tutor available for clarifications and explanations?
– D1.11 - Are you interested in the topics covered in the teaching?

From the analysis of the questionnaires, more than 90% of the students give a score of 3 over 4 for all questions except D1.5 and D1.8. For question D1.5 and D1.8, that relative online educational activities, the score is 2 over 4.

In conclusion, the delivery of blended courses with traditional materials and e-tivities ensures that the students can perform better during examination.

5 Conclusions

The present investigation aimed at evaluating the impact of e-tivities on students' performance. An e-learning higher education institution was taken into account; in particular, data from various courses on First and Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering were collected in four years, i.e. two academic years before and two after the introduction of e-tivities, and analyzed. A proper cloud service was developed in order to get the data about students' performances in terms of examinations participations, rate of success and marks. The main results can be summarized as follows:

– the introduction of the e-tivities led to a slight improve in students' performances, in terms of percentage of success, both in the First and Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering;
– however, a slight decrease of average mark was generally detected after the e-tivities introduction, both in the First and Master cycle Degrees in Industrial Engineering and Computer and Automation Engineering;
– the e-tivities represent a valid tool for providing students with sufficient knowledge to pass an exam;
– the blended courses, characterized both by traditional and e-tivity materials, represents an excellent solution to assure students a full knowledge of the subject matters and to achieve excellent performances.

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A Comparative Assessment of Learning Outcomes in Online vs Traditional Teaching of Engineering Drawing

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Abstract. In recent years, long distance learning has become more and more popular. Web based technologies, that allow the sharing of information in real time, as well as the development of Learning Management Systems, provide the required technological support to implement long distance courses. However, long distance learning is characterized by a completely different relationship between teacher and student, in respect to the traditional teaching approach. It is then important to understand if this difference can affect the students learning outcomes. In this paper the comparison is presented between the summative assessment of two separated groups of students, attending an engineering drawing course, that is part of the curriculum for the bachelor degree in mechanical engineering. One group attended the course in a traditional form, while the second group attended the course in remote. The aim of the study is to verify if significant differences exist between the two groups of students, in terms of learning outcome. The identification of such differences is the premise to develop appropriated teaching strategies, aimed to overcome possible deficiencies related to the teaching approach.

Keywords: Engineering drawing · Online teaching · Learning outcomes

1 Introduction

The interest and the initiatives connected to distance learning are consolidated and widening. They are connected with the possibility to reach students overcoming constraints linked to space and time. Indeed, it provides a strong support to the objectives linked to life-long learning.

One major issue of distance learning is given by the possibility to convey similar contents in respect to traditional courses and with the same efficacy. Such question is particularly important in the engineering field, given the specific nature of many subjects, that require achieving a certain level of abstraction and mastery of specific methods, as well as tools that include machines, software and equipment.

This is the issue tackled in this paper by the authors, which are all involved in teaching activities of design methods and tools. In particular, the authors share a similar

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background and have been involved in courses of Engineering Drawing in the field of industrial engineering in both traditional and online contexts for more than ten years. The main learning objective of an Engineering Drawing course is to provide students with the competence to correctly use the engineering drawing graphical language. The expected learning outcomes include the capacity to be able to correctly interpret and execute the hand drawing of mechanical components and assemblies, in accordance with the standard rules of the mechanical drawing graphical language, as well as the capacity to devise appropriated strategies to interpret and apply dimensions, tolerances and manufacturing annotations.

In order to investigate differences between traditional and online environments, the learning outcomes of two very similar courses in terms of contents and objectives, but provided in different modality, have been compared.

Specifically, data were gathered and analyzed for the engineering drawing courses provided by the Polytechnic University of Marche, in Ancona (Italy) (hereinafter UNIVPM) and the eCampus University (hereinafter eCampus). In both cases the course is mandatory for the bachelor's degree in mechanical engineering and it is held during the first year in eCampus, and during the second year at the UNIVPM.

The paper initially reports a background related to distance learning in particular regarding the engineering drawing subject. Then, the two courses are described in terms of contents, objectives, technological infrastructure and examination modalities. In particular, the paper presents the method and tools being used, within a distance teaching engineering drawing course, to support student learning through a model of use of content and knowledge based on multimedia and interactivity. Finally, in the fourth section, the learning outcomes of the students have been measured by means of summative assessment, aimed to encompass both theoretical and practical competencies. Elements emerging from the comparison with the summative assessment of a traditional course are also reported and discussed.

2 Background and Scope

The debate on the use of methods and tools to support "distance learning" started in the 1960s [1]. The first distance teaching processes were tested by the Open University (Milton Keynes, UK) in 1969. Over the years, the evolution of "remote" teaching has been paralleled to the development of information and communication technologies. While the first "distance" courses were based on technologies such as printing, post and television, nowadays distance learning courses can be used on mobile devices such as laptops, tablets and smartphones even interactively with teachers, databases and forums [1, 2]. In the mid-1980s telematic courses were born thanks to teleconferencing technology. In 1985, the Polytechnic University of New York inaugurated a teleconference system, called Connected Education, with which it begun offering courses entirely channeled via computer [1]. In the 90s and after 2000 the development of distance learning technologies focused on the Internet where image-voice-data can travel in parallel and in real time.

In recent years the scientific debate has increasingly focused on remote teaching methods and systems to make them accessible to students in order to trigger learning phenomena. The challenge of modern distance learning is to make the various formal, non-formal and in-formal learning methods interact in hybrid mode through multimedia content, virtual classes and face-to-face meetings with the teacher for tutoring and seminars. Online universities must also encourage Networked Collaborative Learning activities in order to stimulate the active involvement of students [1, 3]. In fact, in distance courses, unlike the traditional ones, the activities of comparison and group study among the students can be lost. Therefore, group activities such as the realization of projects and term papers can trigger the mechanism of collaboration and comparison between the students to facilitate the synthesis activities during the study.

Regarding the learning of Engineering Drawing, research is mainly focused on the use of e-learning tools in order to improve the preparation of students when they are studying this subject. One of these studies was proposed by Álvarez-Caldas et al. They also pointed out that the preparation of Engineering students can be inadequate for technical subjects such as Engineering Drawing [4]. This study, which was carried out in the context of traditional lectures, confirms that the enhancing of student knowledge by practices and executable exercises is an important teaching issue. In this context, e-learning tools can be used to improve the student knowledge in technical subjects.

Contero et al. confirmed the possibility to improve drawing ability in students using simplified and educational tools. In their study, the spatial ability is improved through 3D modelling and sketching activity. They also pointed out that the spatial ability is an important subject in Engineering Design; however, students can have weaknesses in three-dimensional perception. The spatial ability has been defined by several authors [5]. Sutton and Williams defined spatial ability as the skill to perform the mental rotation of objects understanding how objects appear at different angles in the 3D space [6].

The spatial ability is a necessary competence in Technical Drawing for reading and producing a technical documentation in the context of the engineering profession [4, 7]. The need to improve the teaching activity in Technical Drawing is a common issue both in traditional and distance learning. Several studies show the introduction of additional tools and methods for supporting learning in the context of this subject. Paige and Fu studied educational tools to support teaching and learning about the topic of Geometric Dimensioning and Tolerancing (GD&T) [8]. They focused on this topic because GD&T is a particularly tricky matter to teach due to its complexity and breadth of information. They included CAD modelling to improve the spatial reasoning in students and physical learning tools to conceptualize basic principles of GD&T in 2-D and 3-D.

An example of e-learning tools applied in the context of traditional learning was described in the literature by Villa et al., which proposed online Moodle tests to improve the preparation of students in Technical Drawing [7]. Another example of e-learning tools is represented by the use of Web 3D and haptics technologies, as described in [9]. Even if this reference is not focused on the subject of Technical Drawing, it provides a description of a Web 3D learning approach supported by simulations and haptics. In fact, nowadays, the HTTP protocol can be used for Web pages (HTML language) and Web applications [10]. A special Web application is based on the development of 3D interfaces using the Extensible 3D (X3D) format [9]. The standard X3D allows users to interact with 3D objects over HTTP protocol including simulations and haptics feedback. The research about e-learning tools is related to the improvement of the Information Technology. Generally, e-learning tools are important because they can facilitate the understanding of various concepts and phenomena.

In this context, "eCampus" provides a set of distance courses using several e-learning tools to support the achievement of learning objectives for students involved in University degrees and masters. The eCampus Telematic University offers since 2006 distance university courses in Engineering, Economics, Law, Letters and Psychology. eCampus is structured with a central office at the former IBM center of Novedrate (CO) and many other branches spread over the Italian territory in order to provide a more comprehensive tutoring network, seminars, conferences and exams for students. Some face-to-face activities such as seminars complete the student's learning following the major online teaching and exercise phases based on the e-learning platform. Multimedia collaboration tools allow the synergistic interaction between the students to achieve the educational objectives.

In the next section we outline the course content, the expected learning outcomes and the method and tools used in both the traditional and the long-distance version of the course.

3 The Teaching Context

The two Engineering Drawing courses being analyzed in this study have a similar structure in terms of overall length, i.e. number of lessons and equivalent teaching hours; they share the same learning objectives, and the reference book, suggested to the students for deepening the contents, is the same. Moreover, both courses include the possibility of delivering exercises held before the exam on a voluntary base.

Generally speaking, the learning objective of the engineering drawing course is to provide the students with the skills to correctly use the engineering drawing graphic language. The expected learning outcomes include the capacity to be able to correctly interpret and execute the hand drawing of mechanical components and assemblies, in accordance with the standard rules of the mechanical drawing graphic language, as well as the capacity to make reasoning about appropriated strategies to interpret and apply dimensions, tolerances and manufacturing annotations.

To achieve the above-mentioned learning goal, the teaching approach needs to be supported by both theoretical study and practical exercises: study of standards and notions about the correct application and interpretation of dimensioning, tolerancing and manufacturing annotations, and practical exercises to execute the different views and cross-sections that are required in a mechanical drawing to represent components shape.

The capacity to interpret and execute mechanical drawings, requires the student to develop the cognitive skill to 'read and write' orthographic views (Fig. 1). Reading orthographic views means being able to perceive the tridimensional shape of an object, starting from its bidimensional representation; writing orthographic views means being able to use bidimensional views to represent the tridimensional shape of objects.

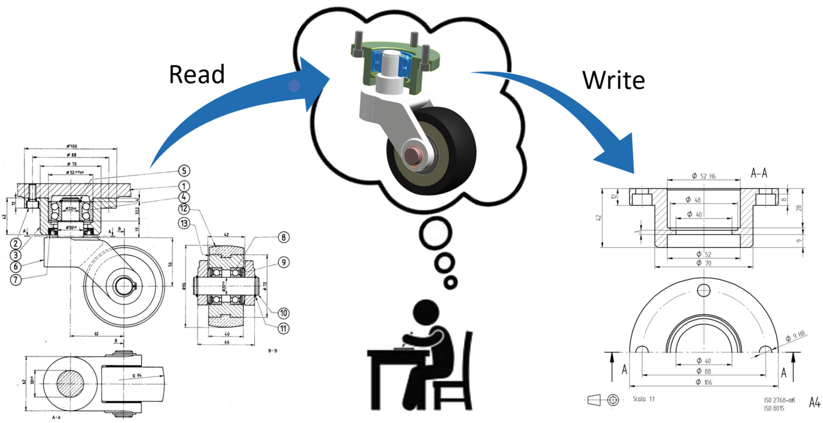

Fig. 1. Model of the ‘read and write’ capacity.

As traditional lectures can benefit from the direct teacher/student interaction, for a continuous supervision of the practical exercises, the design of an online course must include appropriated learning activities and must rely on an appropriated platform, able to support the teacher/student interaction with the possibility of bi-directional sharing of multimedia contents.

3.1 Phases of the Online Teaching

The phases of a university teaching course include design, management, and teaching/learning stages. While in traditional teaching the main efforts concern teaching/learning, in online teaching the phases of management and design of the teaching material are very important [1]. Online educational activities must be designed in order to guarantee the same quality of teaching offered in the traditional classroom. Furthermore, methodologies and design schemes are necessary for the teacher to be able to structure the course in a modular way and with the right balance between the different types of media, such as audio, video, text and data [11]. Furthermore, the modular approach to organizing an educational course offers advantages in modifying and updating the course.

In distance learning the teaching materials must be distributed to the remote user with rules of progressive access to the lessons. The management phase must be supported by IT tools to collect and distribute the contents with a one-to-many relationship. Course management also includes the use of Networked Collaborative Learning tools to promote collaboration activities in virtual classrooms among students and between students and teachers. In this context, the course management tools must also keep track of all the activities carried out within the dedicated IT platforms.

The teaching/learning phase is conveyed by the teacher in both traditional and distance learning. Many examples of distance learning are often based either on textual approaches or on video lessons [12]. However, each of the two models creates “isolated” learning events without feedback from the teacher and other students. Therefore, the phases related to teaching/learning must favor collective learning actions and student-teacher interaction. The teacher can encourage collective learning with methods such as presenting unanswered open questions to stimulate group discussions among students.

3.2 Engineering Drawing in the Virtual Learning Environment

The eCampus university system is based on a Virtual Learning Environment (VLE), which is accessed by teachers, tutors and students to carry out and plan all the daily activities and missions (Fig. 2). Three types of users can access the VLE at different levels. The lecturer can access the platform daily both to verify the presence of messages and communications, and to manage the courses and monitor the study path of his/her students. The interface of the teaching user is therefore different from the others and includes the organizing and managing of online lectures, seminars and receptions using a "virtual office". The tutor user monitors the path of the individual student and interacts with the teachers and the student him/herself for teaching support activities.

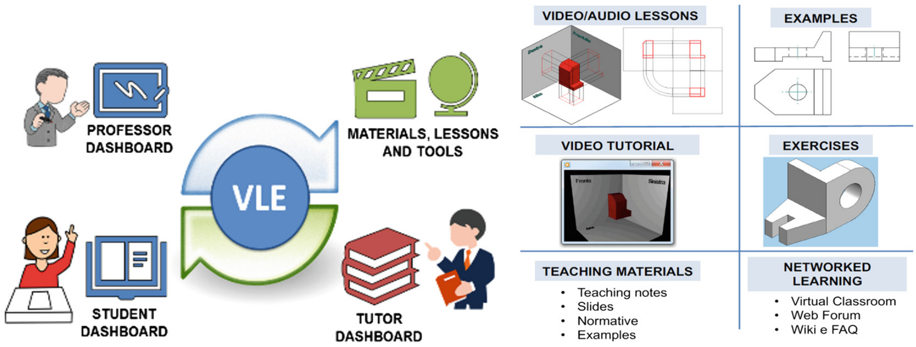

Fig. 2. Architecture of a Virtual Learning Environment (left). Structure of an online lesson of Engineering Drawing (right).

The level called "materials, lessons, and tools" is the virtual container that holds the multimedia materials that can be used by the student. The available "tools" are software applications to create flows like mind maps. Another important tool for the student is the "e-Portfolio" to perform online exercises planned within the interactive teaching. Finally, the VLE platform includes tools for organizing online seminars, i.e. webinars.

The telematic lessons consist of a set of heterogeneous multimedia contents in order to stimulate the student's learning with different types of tools such as laboratory test videos or the description of an industrial case study. The video lesson is an activity inherent to the didactic teaching and is similar to a traditional lecture. In the video lesson the teacher explains the topics through the audio channel alternating images and graphics typical of the presentations. The teacher's audio, which accompanies videos and images, provides explanations and comments typical of the classroom lecture.

Presentations are designed with the right level of synthesis. Simplicity and clarity are the strengths to convey to the student the key concepts to be explored with available text files and documents. The eCampus method involves the creation of a number of short presentations to maintain consistency on the subject and logical flow.

The typical lesson includes a final exercise that the student can perform and send online to the teacher. The exercise can be the solution of a problem, or, more often, the realization of a drawing.

3.3 Organization of the Final Exam

The two analyzed courses share the same finale exam structure. This aspect has allowed a comparison between the students' outcomes. The final exam includes a written test and an oral discussion, whose purpose is to assess the different types of expected learning outcomes. The written test takes place first and lasts 90 min; it includes five open-ended questions and a graphic test. The questions' objective is to verify the basic knowledge acquired by the students about representation rules, dimensioning strategies and tolerance interpretation.

The objective of the graphic test is to establish the level of skills developed by the students about 'reading and writing' mechanical drawings. During the graphic test, the student is asked to make the hand drawing of a mechanical component ('writing' competency), by looking at an assembly drawing ('reading competency').

Questions and graphic tests are evaluated and graded separately, as explained in the next chapter. If the student gets an overall grade good enough to pass the written test, then he/she is admitted to the oral examination. During the oral discussion, that lasts about 20 min, the student must illustrate the choices made during the written test, with particular reference to the discussion about the performed drawing.

The final exam is taken in front of, and is evaluated by, one of the course teachers. The teachers alternate their presence in the exam sessions along the year, in both course sites.

4 Assessment and Comparison of the Learning Outcomes

The learning outcomes of the two Engineering Drawing courses, held at the eCampus and UNIVPM universities, have been measured and compared by means of summative assessment [13].

Data about grades assigned to the students have been collected over a period of four consecutive academic years, from 2012/13 to 2015/16. For both courses, only grades for students that have passed the final exam have been considered. Unfortunately, data about failed tests were not appropriately recorded. The total number of students involved in the study is 593: 224 are from eCampus and 369 are from UNIVPM.

The grading system to perform the summative assessment of the students of the two courses is the following: each student receives a final grade that takes into consideration the written test, the oral examination and the execution of optional on-line exercises, that the students can perform during the course.

As mentioned earlier, the written test includes two parts, that are graded separately, as follows: the answers to the open-ended questions are graded in a range from 0 to 10 (2 points as maximum for each question; half points are allowed); there is no minimum grade to pass the test. The grade for the graphic test ranges from 0 to 20 (half points are not allowed); the minimum grade to pass the graphic test is 8. If the graphic test is failed, the student is not admitted to the oral discussion. To be admitted to the discussion, the sum of the grades of graphic test and of the questions test must be at least 13.

The grade for the oral examination, that includes the number and the results of the optional on-line exercises, that the student may have performed during the course, ranges from −6 to 6 (half points are allowed).

The final grade is the sum of the theory, graphic and oral examination grade, and it ranges between 18 and 30 cum laude (only integer values are allowed).

4.1 Analysis of the Global Summative Assessment

The next charts show the frequencies of the grades (from 18 to 30 cum laude) for the two courses. The vertical line represents the average grade, whose value is 23.71 for the UNIVPM course and 23.11 for the eCampus course (to compute the average grade, the laude has been graded from 1 to 3) (Fig. 3).

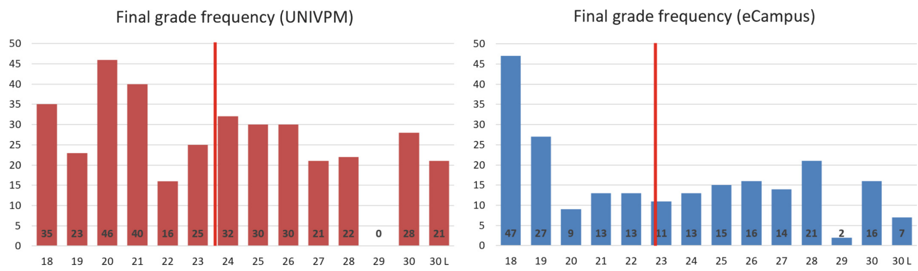

Fig. 3. Absolute frequencies of the grades from UNIVPM and eCampus courses.

The data demonstrates that there is no significant difference between the average grades of the two courses. However, the grades frequencies provide interesting information: first, it is possible to notice the special case of grade 29, that has a very low frequency in eCampus and it has null frequency at UNIVPM. A possible explanation for this situation is that the examiners, when they have to assign the oral grade (that will be added to the grades from the previous tests), will make a compensation in order to award the most brilliant student with an outstanding final grade (30) or to mark the difference by keeping the final grade fairly lower than the maximum value.

Looking at the UNIVPM chart, it can be noticed that both low and high grade have similar frequencies (e.g. 18 has frequency 35 and 30 has frequency 28; 19 has frequency 23 and 30L has frequency 21). On the contrary, the eCampus chart shows that low grades have higher frequencies than high grades (e.g. 18 has frequency 47 as the higher frequency of a high grade is 21 for grade 28).

This seems to demonstrate that, even if the average performance of the students from the two courses is similar, students from eCampus seems to have more difficulty to demonstrate an excellent performance and they have a higher chance to show a low performance.

However, to have a better understanding of the students' performance, the grade frequencies need to be compared by computing the percentage of the frequencies in the two courses, as reported in the next chart (Fig. 4).

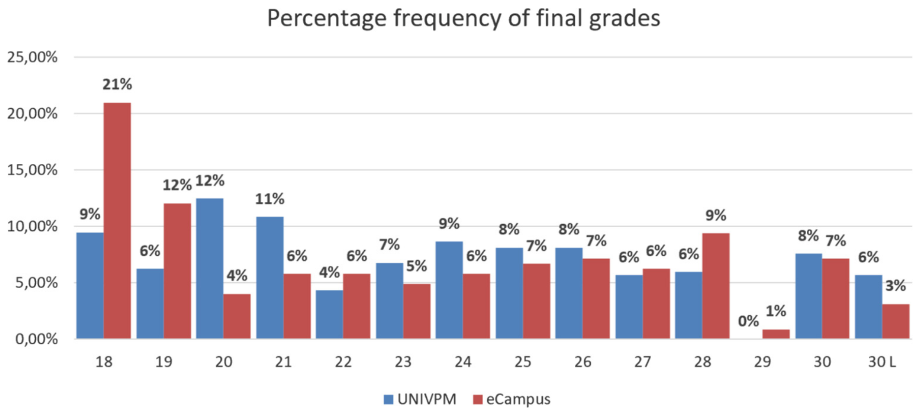

Fig. 4. Compared percentages of the frequencies of the grades

As it can be seen from the chart, the percentage of the frequency for the two lower grades (18 and 19) is more than double for the eCampus students in respect with the UNIVPM ones. This seems to confirm the hypothesis that the eCampus students have a higher chance to have a low performance. However, the percentage for grade 20 and 21, that also are indicators of a low performance, are respectively three times and twice higher at UNIVPM than at eCampus.

We should also notice that, in order to make assumptions and to compare the actual learning outcome of the students attending the two courses, it has to be taken into consideration that, if a wide grading scale is used, the difference of the actual learning outcome between two students that got 1 or 2 points difference in their final evaluation, is hard to be assessed. For this reason, the different grades have been grouped into four assessment categories, as shown in the following Table 1.

Table 1. Grouping of the grading values into assessment categories.

Sufficient	Good	Excellent	Outstanding
18, 19, 20, 21	22, 23, 24, 25	26, 27, 28, 29	30, 30L

The percentages of the frequencies, grouped according to the above-mentioned assessment categories, are reported in the next chart.

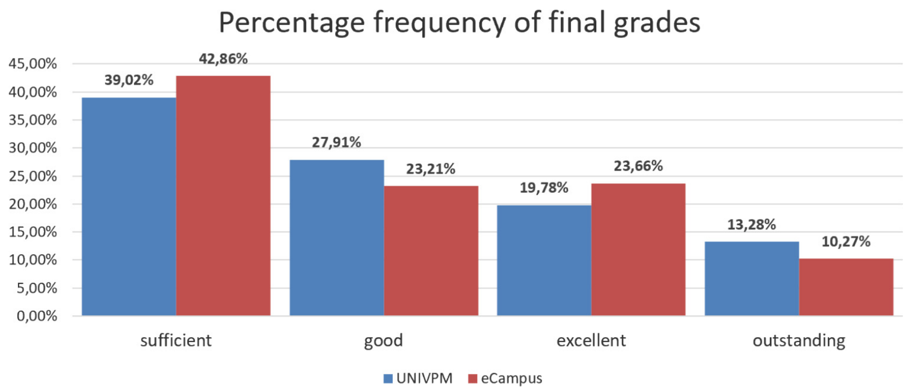

Fig. 5. Percentages of the frequencies of the final grades grouped by assessment categories.

By looking at the grouped percentages of the grades, it can be noticed that still the data shows a greater difficulty of the eCampus students to have outstanding performances in respect to the UNIVPM ones (10.27% vs 13.28%); however, the difference is quite limited (3.01%). By looking at the excellent category, an opposite trend is shown: the eCampus students show better performance than the UNIVPM ones (23.66% vs 19.78%; difference 3.88%). The overall result of the two combined categories, shows that the percentage of the performance above the average is close to 1/3 of the total in both courses (UNIVPM 33.06%; eCampus 33.93%).

On the opposite side of the scale, the eCampus students show a higher percentage of the sufficient performance (42.86% vs 39.02%; difference 3.84%).

Although the analysis of the summative assessment of the final grade can provide general information about the performance of the students of the two courses, to have a better insight about how the different components of the expected learning outcome have been achieved by the students, the global analysis of the summative assessment needs to be split into the more specific analysis of the different parts that make up the exam.

4.2 Analysis of the Split Summative Assessment

As explained earlier in the text, the questions test, the graphic test and the oral examination are graded on the same scale at UNIVPM and eCampus. However, in both cases, the grading scale of the graphic test (from 0 to 20) is different from grading scale of the questions test (from 0 to 10) and the oral examination (from −6 to 6). For this reason, in order to compare the summative assessment of the two tests and the oral examination, the grading scales have been mapped into a uniform grading system, based on the same four categories already introduced to assess the overall performance of the exam. The four categories have been defined as reported in the next table. Please notice that only grades good enough to pass the exam have been considered (Table 2).

Table 2. Grouping of the grading values into assessment categories.

	Sufficient	Good	Excellent	Outstanding
Questions test	≤ 2	$>2, \leq 5$	$>5, \leq 8$	>8
Graphic test	8, 9, 10	11, 12, 13, 14	15, 16, 17, 18	19, 20
Oral examination	≤ -2	$>-2, \leq 2$	$>2, \leq 4$	>4

First, the summative assessment of the questions test has been analyzed. The aim of the questions test is to assess the capacity of the student to correctly apply and interpret drawing standards, with particular reference to geometric product specifications (GPS) standards.

The GPS standards are technical documents, describing the rules to correctly apply and interpret the graphic symbols used in a mechanical drawing to represent information about dimensions, geometrical and dimensional tolerances and surface roughness. The textbook of the course contains explanation of the standards together with examples of application and interpretation.

Besides the learning of the rules, that can be studied on the books, there is no specific cognitive capacity that the students must develop, in order to be able to answer the questions.

The charts in Fig. 6 shows the percentages of the frequencies of the grades of the questions test, grouped by assessment categories.

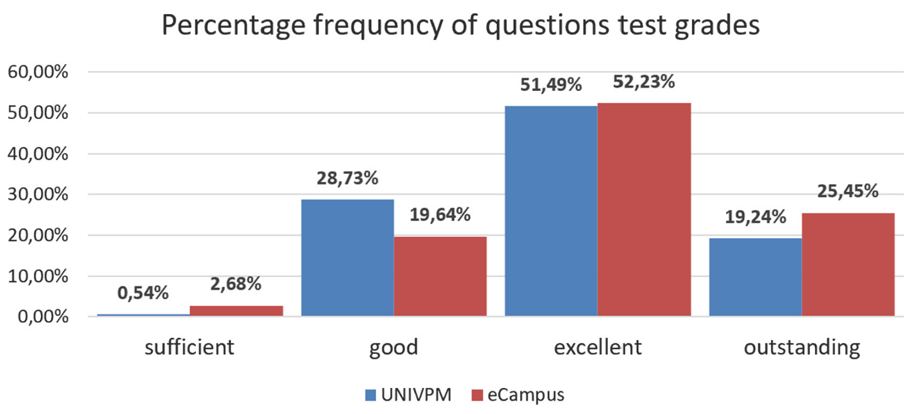

Fig. 6. Percentages of the frequencies of the questions test grades.

The chart shows that the eCampus students have a slightly better performance in the excellent (52.23% vs 51.49%) category and a significant better performance in the outstanding (24.45% vs 19.24%) category. This result seems to demonstrate that the eCampus students did not suffer any limitation during the learning process, in respect to the UNIVPM students. On the contrary, it is possible that the limited opportunity of dealing with a teacher, have pushed the eCampus students to a more accurate study of the subject.

Next, the summative assessment of the graphic test has been considered. The aim of the graphic test is to verify two expected learning outcomes: first, the capacity to 'read' a mechanical drawing, that is, being able to interpret the 3D shapes of a mechanical component, represented in an assembly drawing; second, the capacity to 'write' a mechanical drawing, that is, being able to select and make the hand drawing of the orthographic views required to fully represent the component.

As explained earlier in the text, to acquire the 'reading and writing' skill, the students must learn the graphic representation rules and they must develop the cognitive ability to interpret 3D shapes, represented by means of orthographic views.

The acquisition of such ability is mainly based on experience and it requires the execution of several graphic exercises. In this phase, the supervision of a tutor is crucial to correct the student homework: the tutor can both show correct solutions and make the students aware about common errors and situations that may lead to a wrong representation.

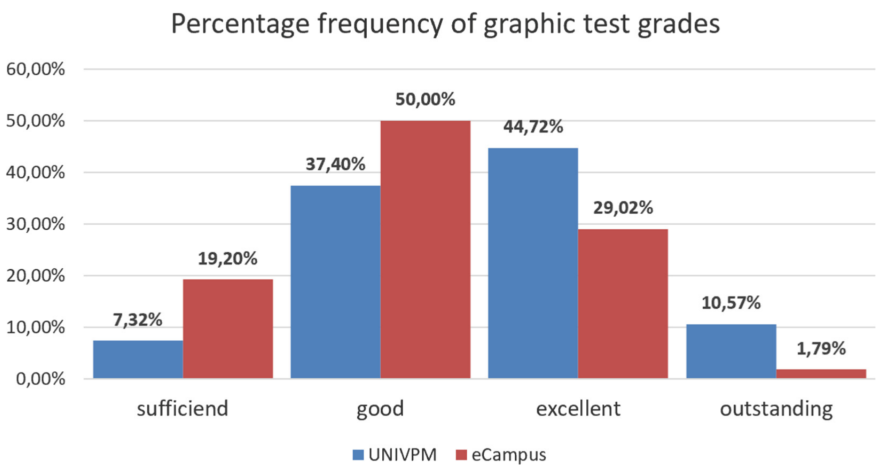

Fig. 7. Percentages of the frequencies of the graphic test grades.

The chart in Fig. 7 shows the percentages of the frequencies of the grades of the graphic test, grouped by assessment categories. It can be noticed that both the excellent and outstanding frequencies of the UNIVPM students are largely higher than those of the eCampus students (44.72% vs 29.02 and 10.57 vs 1.79).

This result seems to demonstrate that the eCampus students have more difficulties than the UNIVPM students in acquiring the competency to correctly apply the 'reading and writing' tasks. The reason for that is probably related to the lower chance that the eCampus students have, to meet a teacher to check the correctness of their graphic homework.

Finally, the summative assessment of the oral examination has been analyzed. As already mentioned, during the oral examination the student is asked to comment the hand drawing that he has produced during the graphic test; in particular, the student must justify the choices that he/she has made.

The chart in Fig. 7 shows the percentages of the frequencies of the grades of the oral examination, grouped by assessment categories. The trend shown in the graphic test chart is magnified in the oral examination chart: the performances of the UNIVPM students are better than the eCampus ones. This result could be expected considering the nature of the oral examination: students that have difficulty in making the drawing also have some difficulty in defending what they have done.

However, it should be noticed that the frequent meetings that the UNIVPM students can have with the teacher, could have help the students in understanding what the teacher expects from them (Fig. 8).

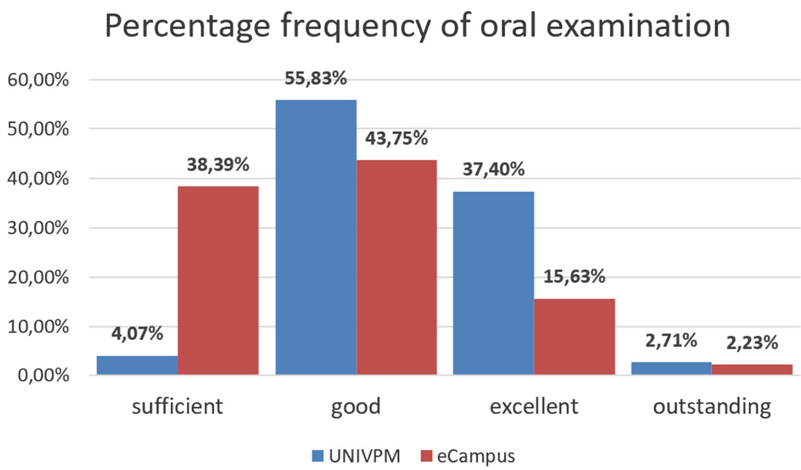

Fig. 8. Percentages of the frequencies of the oral examination grades.

5 Discussion and Conclusions

The paper has presented an assessment of the learning outcomes of an online engineering drawing course compared to a traditional one sharing very similar structure, objectives, contents and examination modalities. The aim of the study is to investigates differences in the final performances in order to understand if specific teaching strategies should be put in place.

The results seem to demonstrate that online students do not suffer significant limitations during the learning process, even if they show slightly lower final scores. Such aspect could be connected to the learning modalities but also to the different groups of students being analyzed. In fact, different characteristics of the two student groups have not been considered. A further development and deepening should include an initial mapping of the specific parameters of the students such as age, background, academic year of the course, and so on.

A second part of the study has shown that online students reach better performances on theoretical parts of the course rather than abstract tasks. This is probably linked to the limited opportunity of dealing with the lecturer. Online students seem to have more difficulties in acquiring the competence to correctly apply the ‘reading and writing’ tasks. Such ability is mainly based on experience and it requires the execution of several graphic exercises under the guide and useful tips provided by the teachers and tutors. Finally, grades from oral exams, seem to show that traditional students, given the greater interaction with colleagues and the teacher, are more aware of what it is expected from them.

In conclusion, the study confirms that online teaching should foster means and tools to make students practice with the teacher and among themselves, as the performances of online students seems to be slightly weaker where more interaction is needed.

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Fostering the Family-School Relationship with a Web-Based Application

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Abstract. This work describes the design of a Web application that allows not only the communication of families with schools but also their immersion in the learning process of their children, so they can contribute in its mediation. To develop this project, an analysis of the needs of teachers in relation to communication with families was needed. To this end, a pilot study has been carried out with 40 teachers of pre-school and primary education and a low-cost information system has been developed. The results obtained reveal that the use of this platform has been useful and effective to enhance the communication process with families and to make them participate in the teaching and learning process of their children.

Keywords: Family-school communication · Pre-school and primary education · Web-application · Low cost system

1 Introduction

In recent years, a huge business market in software systems to support several tasks within the schools has been developed. From this point of view, the so-called e-learning platforms have had a special boom. This concept can be understood as an effort to take advantage of ICT, supported by the widespread expansion of the use of Internet in educational environment. In this way, personalized, meaningful and autonomous learning can be achieved, in which the teacher's role evolves from being a mere transmitter of information to a facilitating agent of knowledge in the educational process [1].

These e-learning platforms, built on most occasions in a generic way without being focused on a specific educational stage, have become almost essential products in the day to day of numerous educational institutions. However, although these tools have several advantages in secondary and higher stages, we here propose to adapt their features to the needs of previous stages: Pre-School and Primary Education.

Most of the e-learning platforms are focused on the learning moment in which students are, with facilities to self-directed learning based on expository, application and collaborative pedagogical methodologies [2]. However, students of early childhood

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education, from zero to five years and primary education, from six to twelve years, do not have the capacity to learn by themselves and it is necessary to wait until the adolescence to find in the students that trained ability to direct their own learning process [3], as well as to have a trained digital competence that enables this type of tools. Then, advantages of e-learning platforms cannot be exploited until students have enough maturity to act autonomously in the field of education.

In pre-school and primary education autonomy is not the means but the end of education [4]. Students require constant interaction with the teacher, who has to create the affective and cognitive conditions for the knowledge reflection to take place [5], so it is difficult to express the advantages of an e-learning platform such as Moodle [6], Edmodo [7] or Educcare [8].

On the other hand, teachers of these early educational stages can see the advantages of automation that ICT could suppose, but limited budgets of the Spanish public schools make not possible to invest in the needed infrastructure to implant these tools [9].

One of the problems in which today's society is immersed in relation to education is the incompatibility of timetables between parents and children, which implies that children have to stay more hours out of home, sometimes at schools, so family communication is relegated to a background. Moreover, the participation of families in schools remains scarce despite the fact that their educational work is of vital importance [10]. In this sense, ICT open a new horizon that, in addition to supposing a medium for information to families, can offer open communication channels to increase their level of involvement. For this reason, it is necessary to bet on policies that favor family life and innovation projects that allow establishing new communication spaces strengthening the links between the family, the school and the community with the aim of helping the student to grow, both academically and personally [11].

Currently, there are several alternatives that allow families to get involved in the education of their children in schools through Web environments such as: parent schools on the Web, learning communities, email, social networks or blogs where you can post news, photos and videos, information about class activities, the grades of results, lack of assistance or even parents can put their own comments. However, this way of interacting is not sufficiently dynamic or proactive in relation to the needs that the students of our current society have.

The problem addressed in this study is one of the key points more reported by professors [12] and researchers [13]: the support tools for the family-school relationship and the tutorial action. In clearer terms, the management of communication between the mediating actors of the educational process in pre-school and primary education is one of the activities that has taken the least advantage of the ICT and that could benefit most from a platform that manages them in a dedicated and integral way. This integral process should be focused on the improvement of the tutorial action in early childhood and primary education assuming reduced costs that allow operation in schools with scarce economic resources.

To summarize these elements, the goal of this paper is helping to solve the problem of managing communications between families and teachers in a comprehensive way through a low-cost Web platform which facilitates the processes of communication. That way, the tutorial action plan of the teachers could be converged through Web browsers or mobile systems, which are present in more than 90% of Spanish homes where there are people between 16 and 74 years, and more than 97% have Internet access [14].

The structure of the paper is as follows. Section 2 shows some of the most relevant ICT applications and Sect. 3 describes the characteristics of the Web-based application proposed, which would be able to be used both by teachers and parents. In Sect. 4 they are verified the completeness and effectiveness of the developed Web platform and Sect. 5 reports the assessment results and its discussion. Finally, Sect. 6 outlines the conclusions of this research and some future work.

2 Related Work

There are many tools in the international market aimed at improving the communicative aspects between the members of the teaching-learning process and, in particular, related to some of the most relevant ICT applications are the following:

2.1 TookApp School

It is a Spanish tool, recommended by [15] that seeks to solve this problem, through an instant messaging platform, which meets the legal regulatory criteria to guarantee privacy and it has the legal validity of a burofax. It offers the possibility of sending unlimited messages via Web platform to teachers, parents and students with read receipt. TokApp School works as a Web or mobile instant messaging application, which only differs from others which are more generic like WhatsApp in that it does not require a telephone number that compromises the privacy of the users, besides it guarantees the veracity and reliability of the communication legally [16].

The free availability of this tool on Google Play does not imply the costless of use. The use of this platform is subject to quotas per user and annual use.

2.2 Remind

It is a Web application supported by a platform that provides a one-way instant messaging service from teachers to families, in order to send announcements, reminders, duties or notifications with receipt confirmation [17].

This application is costless. However, after studying the terms and conditions of use, it can be seen a business model based on Freemium where the user obtains a part of the software for free but is paying in a timely manner (eCommerce Business Model) or recurring (Membership) for features. The free version tested to carry out this work only provides the characteristics of sending messages, announcements and reminders.

2.3 ClassDojo

This application is similar to the previous ones in terms of the deployment of an instant messaging service to be used between teachers, parents and students and the sending of photos, videos and updates among users. As a differentiating element, it is necessary to emphasize the incorporation of a functionality that is considered distinctive, the instantaneous translation in the received messages, depending on the preferences of the parents. This feature provides added functionality to the product, allowing more appropriate integration of students and foreign families. As happened with the tool Remind, the business model of this tool is also Freemium. Though the terms of service, the company undertakes to do not disclose data or information of students [18].

2.4 Educcare

Educcare [8] is a complete academic management platform that provides functionalities for the integral management of the entire center, not only communications, but e-learning, administration, management, teacher management, etc. Specifically, at the point of communication, it only provides very basic communication management functions by publishing PDF documents and sending mass emails to groups of parents and/or students. This platform incurs the problem already explained, to include a wide variety of functionalities in a global platform to manage the entire center, in exchange for a high final cost, which may be unnecessary and economically unattainable for public centers with limited resources.

2.5 Schooltivity

This platform, which has been fully developed in Spain, has been awarded with numerous prizes and recognitions and it is interesting to study it in depth to see its most notable advantages and disadvantages. The functions for which it is intended to are teacher-family bidirectional communication, visualization of the agenda by the parents and upload of didactic material by the teachers for future visualization of the parents. It also develops certain functions related to the school cafeteria, where parents can select some attendance data. Schooltivity can be used via the Web and through a mobile app. Security is one of its main advantages due to the hosting and transmission of encrypted data through the platform "Amazon Web Service", in addition to having a daily backup [19].

Although these tools are used in classrooms with students, it is worth mentioning that no publications have been found on the use of these tools in relation to school-family integration.

3 Designing a Web-Based Application to Foster the Family-School Relationship

A pre-designed survey (Annex I) was conducted based on the desk research and with the aim to focus the attention on the concrete needs of the local population. After this survey, a process of analysis, design and development was performed, obtaining a working tool running over a Raspberry Pi, which acts as Web server with a very low cost. These phases are described in the next sub-sections.

3.1 Pre-application Survey: Current Working and Expectations

The sample for this survey consisted of 40 teachers: 20 of them worked at two public pre-school and primary centers; the other 20, worked at two educational centers with the same features, but being privately-owned but state-funded schools instead of completely public centers. Additionally, all the 4 centers had Internet connection in every classroom.

To develop this survey, we designed a set of questions aimed to detect real needs of teachers in their daily work as well as current tools that they used for them. This survey was distributed by using Google Form (Annex I) and it was divided in four blocks: (1) sample characterization, (2) personal certainties, (3) daily work tools and (4) proper resources in a hypothetical customized platform. In this section, we are mainly interested in blocks 3 and 4.

In the first place, we study data about the tools that teachers used to manage their daily work. This information is summarized in Table 1. Since teachers can use several tools for each of the tasks, options were not mutually exclusive.

Table 1. Tools that teachers used to manage their daily work.

	Discipline	Material[a]	Extracurricular activities	Positive behaviors	Negative behaviors	Intermediate ratings
Orientation time	50%	60%	53.5%	35%	32.5%	0%
Casual interview	0%	7.5%	0%	25%	0%	0%
Group meetings with the master	0%	0%	0%	20%	0%	0%
School diary	0%	17.5%	40%	5%	0%	72.5%
Postal mail	0%	0%	0%	0%	0%	12.5%
Telephone	37.5%	0%	0%	13.5%	45%	0%
Social networks	0%	0%	0%	0%	0%	0%
WhatsApp	7.5%	3.5%	0%	0%	0%	0%
E-mail	5%	15%	0%	3.5%	50%	15%
Subject blog	0%	0%	7.5%	0%	0%	0%

[a]Making reference to material, didactical books, uniform/attire or student's organization

On the other hand, in relation to facilities to be included in a customized platform, the most relevant results we found were that all of the teachers would like to have automatic management of grades, 87.5% of them would like a tool to manage the communication with families and 82.5% would like a calendar manager. The complete set of preferences is included in Fig. 1.

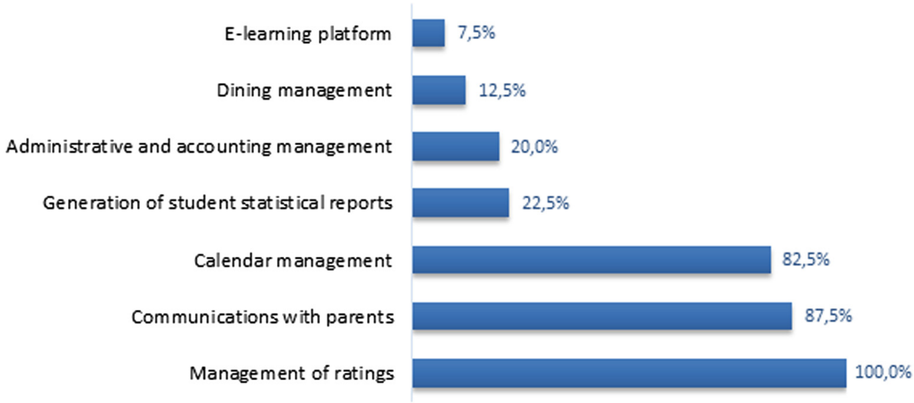


Fig. 1. Appropriate aspects for a school management platform.

As a summary of the findings of this survey, together with different interviews to some of the teachers, we highlight that the majority of them (87.5%) in pre-school and primary school, think that a complete e-learning platform is unnecessary due to students' needs. Moreover, looking at the tools commercially available, they find that administrative and counting management in these tools are too complex. Additionally, almost every teacher uses traditional procedures to contact families, although they think that a platform to ease this task would be useful. With regard to the grades management, the sample is almost half-divided between those who use Excel (or similar) to keep the track and those who use paper-based sheets. However, all of them agree that a tool to manage degrees automatically would be very useful.

Then, we can conclude that the sample of teachers analyzed agree that a platform to manage communication with families, grades and diary school are needed and would be positively received. Moreover, they also agree that e-learning modules are not needed in this educational period (pre-school and primary school).

3.2 Analysis: Joining Desk Research and Survey Results

The life cycle of this project was developed using the methodology Métrica V3 [20], using the framework Scrum, by which criteria and principles of the Manifesto for Agile Software Development [21] have been observed. However, in order to shorten the length of this paper, a summary of this development process is included.

Then, the software developed should be a low-cost information system that provides the functionalities needed to manage communication between teachers and families at pre-school and primary school stages. Additionally, this tool has the goal of fostering a quality education by helping families to be engaged with their children academic processes, despite the narrow margins that work and other responsibilities give them.

System Features

The only limitation we had in this project was the one related to financial costs. For that reason, we needed to reduce costs by using low-cost and freeware devices and languages. Then, the system would be implemented with a LAMP (Linux, Apache, MySQL and PHP) infrastructure, set in an Ubuntu Server 16.04, running over a Raspberry Pi 3 Model B, which is a low-cost Single-Board Computer. This system is able to manage the requests from the average-size of the pre-school or primary school, with about 400 people registered in the platform (families and teachers). As programming languages, we used PHP for the back-end and HTML5, CSS3 and JavaScript for the front-end.

The set of functionalities that the system had to support was:

- Grades management: the teacher needs to create items to be evaluated, to decide what items could be seen by families, to assign a grade for each item, to load grades from an external xls file, and to view grades of students.
- Customized reports: the teacher would be able to select a set of features and to obtain summaries from data stored in the platform. Additionally, families would be also able to generate reports, but only including items that teacher marked as public.
- Attendance control: the teacher would be allowed to register when a student is not attending to classroom and the system would send an alert to families. In addition, the teacher needs to obtain summaries about attendance of each student and mark some of them as "justified" if families send the corresponding document to justify those non-attendances.
- Meetings management: the system would manage the request, book and confirmation of meeting for tutoring. To do that, families would see the agenda and free slots to ask for a meeting, which would be confirmed by the teacher.
- Notifications control: It is required to send notifications from the teacher to the families and vice versa. Moreover, reception of notifications and confirmation of reading would also be managed.
- Users management: registering, deleting, log in and log out of different users with different roles need to be managed.

Data Acquisition, Integrity, Retention, Reporting and Deleting

Data acquisition came from users in the system, in particular, teachers and families, with no incomings from Web services or any other external source. Data would be deleted each year, since this tool is not an official one.

With regard to integrity, due to physical limitations in read-write cycles of the low-cost board, it was necessary to allocate the database in two hard disk units in a mirroring system and a daily policy of local backup.

About reports, the system has to be able to generate statistical reports with high level of abstraction. Additionally, these reports need to be generated both for a concrete student and for a group of them, taking into consideration that, depending on who asked for the information, this summary should include different items (publics, for families and all items, for teachers).

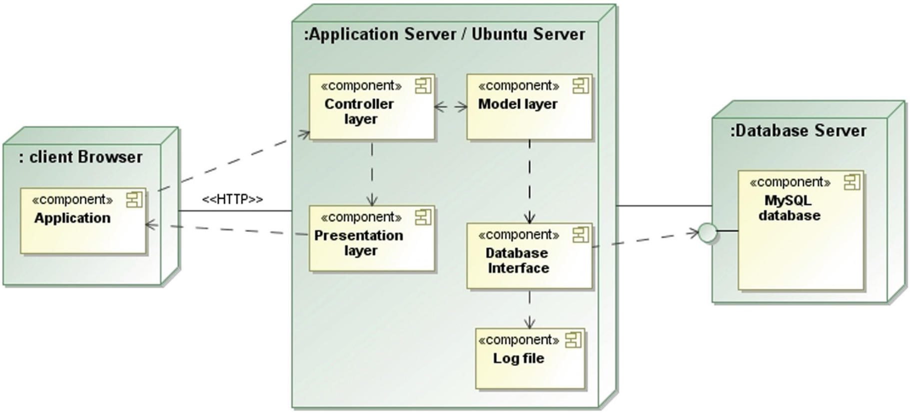
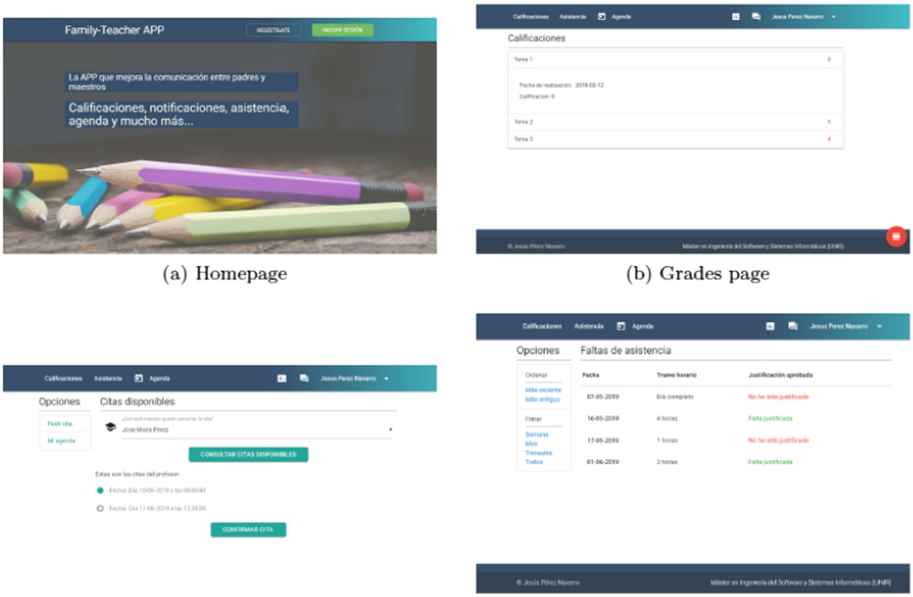


Fig. 2. Model-View-Controller pattern.



(a) Homepage

(b) Grades page

(c) Appointments page

(d) Class attendance page

Fig. 3. User interface.

Design and Development: Including Requirements in a Web-Based Application
To support the requests of teachers, which have been analyzed in the previous section, a Web-based application was developed. To simplify its design and future updates, the Model-View-Controller pattern was used resulting in an abstract structure like the one presented in Fig. 2.

The interface design was developed with UWE [22] (UML-based Web Engineering), an extension of the language UML for Web applications [23]. The entire application has been programmed following a common and intuitive user interface (UI). The UI is structured around 3 user profiles: administrator, teachers and parents. Whatever the profile is, the user accesses to a general view for that profile, where it is displayed a default view with generic data. From there, it is possible to navigate in the different options offered by the application, all with common appearance, using a tab bar. In Fig. 3 there are some images of an overview of the user interface.

4 Assessment

Given the variety of opinions and the number of subjects analyzed to raise this system from its inception, it has been necessary to conclude this software engineering process by carrying out the collection of new information to verify the completeness and effectiveness of the developed Web platform [24, 25].

For this reason, to perform the evaluation of the Web software by end users, the following principles of usability and accessibility were assessed [25]:

- P.1. Visibility of system status: related to the constant feedback users get from the program.
- P.2. Match between system and the real world: in terms of the usage of familiar language.
- P.3. User control and freedom: users should be able to leave an unwanted state by an emergency exit in a clearly way.
- P.4. Consistency and standards: different words or situations cannot mean the same thing.
- P.5. Error prevention: possible errors in the system should be checked and informed to the user rather than emitting error messages.
- P.6. Recognition rather than recall: objects, actions and options should be visible enough to avoid the user having to memorize them.
- P.7. Flexibility and efficiency of use: the use of accelerators make the system being able to cater both inexperienced and experienced users.
- P.8. Aesthetic and minimalist design: the information provided by the system dialogues should be relevant.
- P.9. Help users recognize, diagnose, and recover from errors: errors should be expressed without codes and suggest solutions.
- P.10. Help and documentation: any additional information or help system should be easy to find.

Moreover, there were studied and analysed different methodologies and proven techniques such as:

- Software Usability Measurement Inventory (SUMI): is a rigorously tested and proven method of measuring the software quality from the end user's point of view. It is based on a questionnaire of 50 items to measure the level of satisfaction and perception of the user [26].

SUMI method was the most appropriate to the software implemented. Thus, it was designed a survey to achieve conclusions that verify the acceptance by all the stakeholders of the system, proving that all of the members of the educational community have seen their needs reflected. Other questions were added to SUMI survey related to the evaluation of the relationship and communication improvement between teachers and parents such us:

Q.1. The platform has improved the relation between teacher and parents
Q.2. It has been easy to integrate the way of teaching and working with parents
Q.3. I believe the platform is adequate to reach the purpose raised
Q.4. I would use the platform in the coming years

All these items were assessed with a Likert's scale from 1 to 5, being 1 totally disagree and 5 totally agree.

5 Results and Discussion

From a technical point of view, the stage of testing of the software engineering process has been carried out through scenario testing and user tests. As mentioned above, the survey chosen followed the principles of usability and accessibility [25]. According to these principles, the questionnaire presented in the previous section was given to the same sample of 40 teachers, presented in Sect. 3.1. Results obtained from this survey are collected in the Fig. 4.

As we can see in Fig. 4, questions 2 and 10 were rated with 5 (totally agree) by the 60% and 87.5% of the teachers, respectively, which means that most of them found the program easy to use and intuitive when looking for documentation or asking for help. On the other side, items 5 and 7, were rated with 3 (neither agree nor disagree) by the 72.5% and 82% of the teachers, respectively. Although a better result could be desirable, we deduced that this low score was due to the lack of errors suffered during the test and the homogeneous level of knowledge of the system since all users were inexperienced. Regarding items 1 (state report), 3 (user control and freedom), 6 (recognizing rather that recall) and 8 (relevancy of information provided), most teachers rated them with 4 (80%, 80% and 65%, respectively). Then, we can state than the design is suitable enough to grant the teachers with an efficient and effective user experience, which was one of their demands in the previous study. Finally, in questions 4 and 9, the 80% and 77.5% of teachers, respectively, agree or strongly agree. These questions are related to the meaning of information provided by the system. Here we find a possible contradiction with results in question 5. However, once the process of testing was analyzed, we deduced that users did not judge some situations as errors, but they did with situations where they mistake some data and the system asked them for the correct ones.

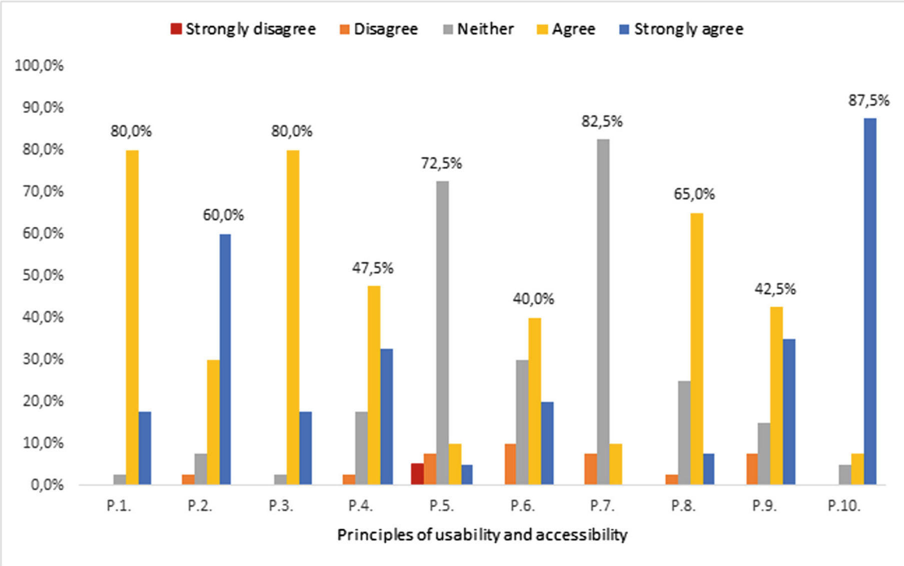


Fig. 4. Results of software assessment survey.

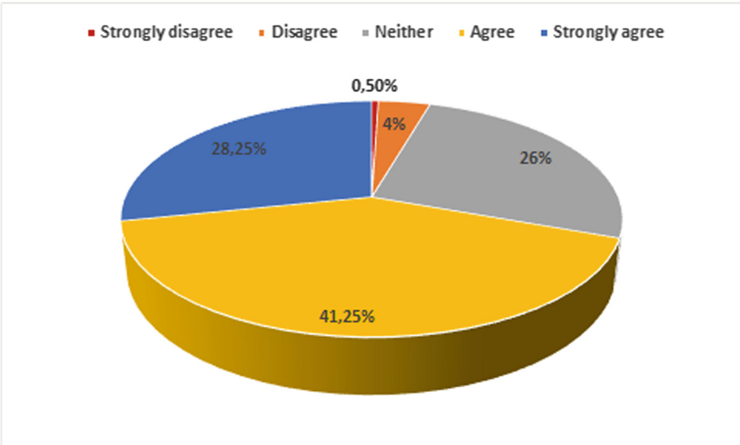


Fig. 5. Global results of software assessment survey.

Additionally, as SUMI questionnaire states that the greater the scoring is, the better the system will be, we can perform an overall assessment of the results by considering how often each of the ratings has been selected. These results are shown in Fig. 5. In these results, we see that 41.25% of teachers rated the system with an overall assessment of 4 on the Likert scale (agree) and 28.25% with 5 (totally agree), which makes a 69.5% of them reporting their satisfaction with the solution provided.

Moreover, additional statistical results related to the evaluation of the relationship and communication improvement between teachers and parents have been carrying out. Figure 6 summarizes the findings.

In this case, we find that all questions are rated with high score, which reveals that the system developed in this work, further than being technically sounding, solves the problem of relation with families, since most of them agree that it improves the relationship with parents (95%) and its integration in the daily work would be done without significant effort (97.5%). Moreover, 90% of the teachers believe that the platform has been adequate to reach the purpose raised and they would use the application in the coming years (75%).

Finally, in Fig. 7, we can see how the system is judged from an overall standpoint. Again, if we summarize ratings 4 and 5 (agree and strongly agree), we find that 89.4% of teachers report that the developed application really improves the relationship between parents and families. Furthermore, taking into consideration that the effort needed to implement this solution has been positively rated, we could conclude, as expected, that this application eases the involvement of parents in the educational process of students in the pre-school and the primary school.

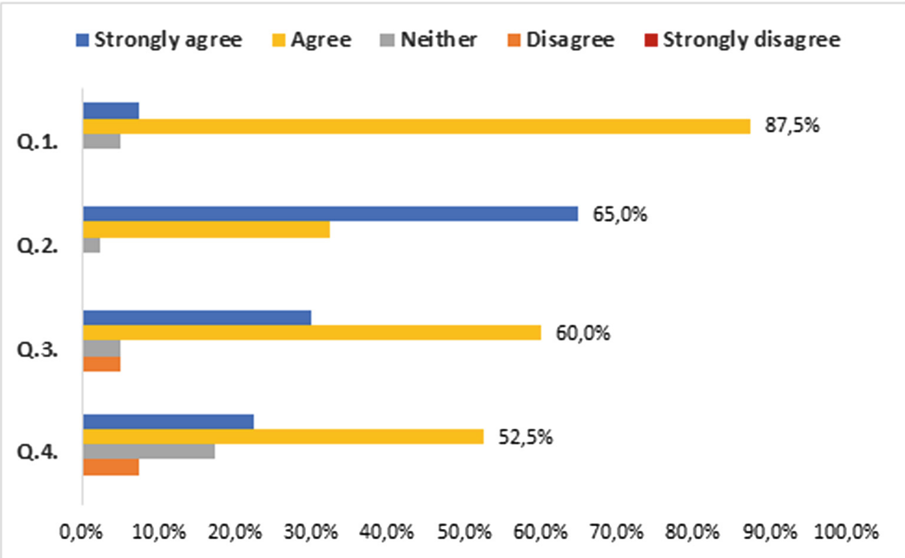


Fig. 6. Global results of software assessment survey.

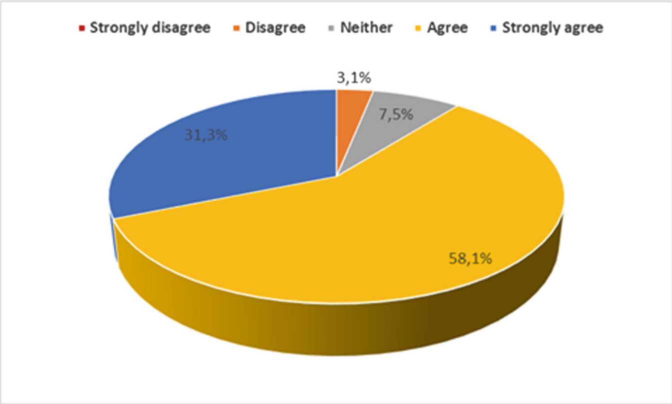


Fig. 7. Results of evaluation of the relationship and communication improvement between teachers and parents.

6 Conclusions and Further Works

In this paper, we have presented the gap between the needs found in the pre-school and primary school and the facilities provided by most of the e-learning platforms, which are mainly focused on an autonomous work. However, pre-school and the primary school teachers claim for applications where the autonomy is not the means but the end.

Trying to fill this gap, in this paper we have presented a process where a sample of 40 early childhood and primary teachers have been asked about the needs they found in their daily work with students and parents. From this previous work, we found that these teachers used a variety of tools, many times private tools (their mobile phones, or private e-mail accounts, for example), to keep the contact with parents. This contact is intended to report advances or problems of students, who can better progress with a tight relation between teachers and families. Then, the proposal of an integral solution to maintain this contact, also bidirectional, was warmly received.

Based on the findings on this survey and following a process of design based on current life cycle of software, the application was developed. This application was provided to the same sample of teachers, who after a period to test the tool, rated it by an adaptation of the standard survey SUMI.

Based on these user acceptance tests, we can conclude that the development of this Web platform for the management of communications in family-school relations is a useful, effective and error free facility for teachers, which enhances the communication in the teaching-learning process. No difficulties of use or understanding have been found in terms of working with it and its design and usability was also positively rated.

Although it has been possible to automate the most demanding communicative processes, other administrative aspects such as records management or registrations can be improved. In order to exploit the platform in real educational environments, it would be appropriate to adapt the aspects required by the legislation of the country of operation, as well as to implement the necessary physical and logical security measures.

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Annex I – Pre-application Survey

1. Your center is: (a) private, (b) state-subsided, (c) private school with public funds.
2. Has your center Internet connection in all the classrooms? (a) yes, (b) no.
3. Do you think that using an on-line platform (like Edmodo, Moodle) could be fruitful in pre-school and primary school? (a) yes, (b) no, (c) Maybe, I don't know these platforms.
4. How much involved are your students' parents? (Rated from 0 to 10, being 0 inexistent and 10 total involvement).
5. Do you find a cause-effect relationship between parents' involvement and students' academic results? (a) yes, (b) no.
6. To communicate with parents about issues related to discipline, what means do you use more frequently? (a) the tutorial timetable, (b) group meeting with the tutor, (c) occasional meetings with the tutor, (d) notes in students' school diary, (e) postal mail, (f) telephone, (g) social networks (twitter, Facebook), (h) whatsApp, (i) e-mail.
7. To communicate with parents about issues related to material, didactical books, uniform/attire or student's organization, what means do you use more frequently? (a) the tutorial timetable, (b) group meeting with the tutor, (c) occasional meetings with the tutor, (d) notes in students' school diary, (e) postal mail, (f) telephone, (g) social networks (twitter, Facebook), (h) whatsApp, (i) e-mail, (j) subject blog.
8. To communicate with parents about issues related to extracurricular activities, what means do you use more frequently? (a) the tutorial timetable, (b) group meeting with the tutor, (c) occasional meetings with the tutor (d) notes in students' school diary, (e) postal mail, (f) telephone, (g) social networks (twitter, Facebook), (h) whatsApp, (i) e-mail, (j) subject blog.
9. To communicate with parents about issues related to students positive behaviors or actions, what means do you use more frequently? (a) the tutorial timetable, (b) group meeting with the tutor, (c) occasional meetings with the tutor, (d) notes in students' school diary, (e) postal mail, (f) telephone, (g) social networks (twitter, Facebook), (h) whatsApp, (i) e-mail, (j) subject blog.
10. To communicate with parents about issues related to students negative behaviors or actions, what means do you use more frequently? (a) the tutorial timetable, (b) group meeting with the tutor, (c) occasional meetings with the tutor, (d) notes in students' schools diary, (e) postal mail, (f) telephone, (g) social networks (twitter, Facebook), (h) whatsApp, (i) e-mail, (j) subject blog.
11. Indicate the tool you use to manage grades: (a) Excel, (b) paper-based sheet, (c) internal e-learning platform, (d) other.

12. To communicate with parents about student's intermediate grades, what means do you use? (a) paper-based report, (b) notes in the student's school diary, (c) e-mail, (d) whatsapp, (e) telephone.
13. If your center were going to be gifted with a customized platform, what issue would do you prefer to be managed? (a) administrative and counting management, (b) school canteen, (c) parents communication, (d) grades management, (e) automatic generation of students statistical reports, (f) school diary management, (g) e-learning platform.

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A Novel Keyword Ontology Generator Method Tested on "Digital Transformation in Higher Education" Topic

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Abstract. The practice of using ontology to understand a field of study through the analysis of keywords was not found to have been documented, and a five-step method is therefore presented to generate ontologies of keywords: data selection and extraction, data unification strategy, keyword processing, weight and connection standardisation and final representation. Using the proposed method, an experimental evaluation was undertaken using as the field of study the digital transformation in universities and university institutions, generating a knowledge graph that enables the clear visualisation of the various connections among different topics in a chosen field of study. Finally, the effectiveness and the observed limitations are discussed while stressing that each researcher should perform a thorough analysis of those relationships, enabling to obtain useful information for teaching and learning processes, especially in higher education environments.

Keywords: Ontologies · Metadata · Digital transformation · Higher education

1 Introduction

The transition from a traditional investigation pattern to a mainly digital workflow [1] presupposes a problem associated with the impossibility of processing large volumes of data and the consequent loss of information that finally produces a deficient general map of the area of investigation [2] because a holistic view of scientific activities in the field of study cannot be generated, nor is it possible to track the changing nature of the subject, complicating the understanding of the evolution of the science over time [3].

Thus, beyond identifying the general aspects of the field of study to be analysed, this study seeks to encourage intelligent searches that would enable a vision of the more significant aspects of a subject [4]. To that effect, keywords, which identify in few words the fields of knowledge with which each document may be associated, are among the most relevant and standard metadata in academic publications [5].

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Given the above, it is interesting to note that, although the content in publications is not standard, keywords are standard metadata [6]. Keywords provide a general concept of the field of study being consulted, which in turn may be understood as a logical theory offering a partial and explicit explanation of a conceptual system, according to the definitions of ontology laid out in Fig. 1 [7].

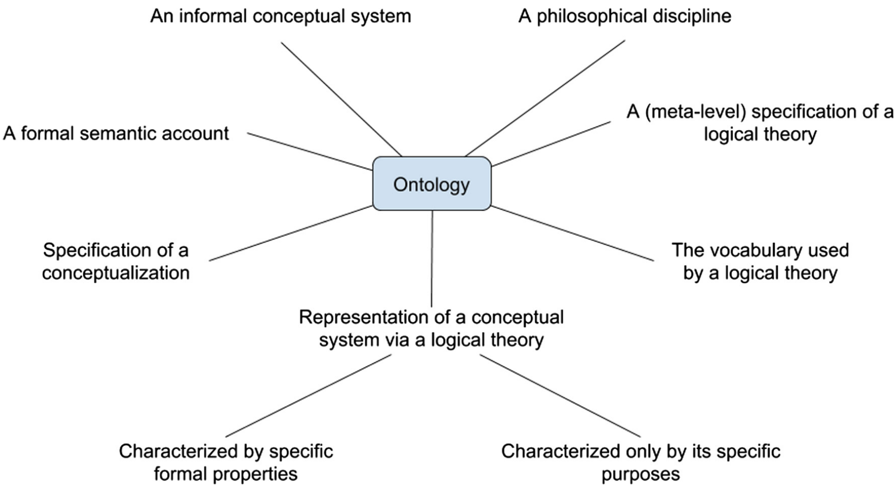

Fig. 1. Ontology definitions. Source [7]

The ontology will help to discover, about any topic, which things are fundamental and can be learnt, helping to support a good thinking [8]. This is especially useful in education environments where the learning and teaching dynamics for a given topic can developed from knowing the essence of that topic.

2 Background

The way researchers access and read about their field of interest has undergone a revolutionary change [9]. The underlying causes are found in the incremental improvements of meta search engines and the evolution of technology, given that the electronic format has transformed how scientific information is consumed [10]; as a result, the dissemination of scientific content is instantaneous and overabundant [3].

Researchers certainly face huge challenges when managing the knowledge and information circulating through electronic channels [11] and increasingly resort to retrieval algorithms, search capabilities and user interfaces in information management systems and a set of highly sophisticated digital analytical tools that allow them to perform interactive searches that produce precise results [1].

In recent years, the retrieval of information has become more complicated with the increase of the use of data extraction, support for decisions and business analysis applications [12]. Consequently, researchers have focused on visual database interfaces

[13] and interactive consultation generating graphs [14, 15], with an emphasis on providing interactive interfaces in natural language to support the creation of questions.

The role of ontology is critical to knowledge-based software applications [16] because they facilitate automatic semantic interpretation and interoperability of the information from diverse sources [17]. Many industries have developed ontologies to efficiently manage knowledge [18]; one reason is that ontologies involve diverse collaborative studies by multiple professionals and stakeholders seeking to improve the exchange of information and the reuse of structured information to perfect the capability of the various computer systems [19].

In the context of higher education institution, the ontology-based knowledge networks have been used to support the design and development of study materials for teaching [20]. Citing another example, they have been used to represent disciplines related to computing. This is due to the different names of the higher education programs, which makes difficult to understand the goals and content of those programs [21].

Although the benefits of ontology have been confirmed, its development requires considerable effort from knowledge engineers [22], and therefore few prior studies have analysed the body of ontology research leveraging aspects, such as keyword co-occurrence, evolution and analysis of conglomerates [16].

3 Keyword Ontology Generator Method

The proposed process for generating keyword ontologies has been simplified into five activities which lead to an ontology representation on the basis of the chosen field of study while overcoming the aforementioned difficulties.

This method is expected to provide a graph that would help the researcher understand their chosen field of study; being a general conceptualisation, however, it would not explicitly provide the meaning of existing relationships between two concepts, although it will provide visualisation of the connections among the field of study's sub-themes, facilitating their understanding and exploration.

3.1 Data Selection and Extraction

The keywords of the various publications within a field of study are the main input of this method, so the first step is to delimit the area of interest through advanced searches in the selected databases. Databases of academic information, such as SCOPUS or WoS, allow queries on their indexed documents through search equations that enable the delimitation of the field of study in question [23].

The documents produced in the different searches will represent the knowledge in that field of study; thus, their keywords will be considered those that summarise the entire field of study. Once the results have been obtained, it is the researcher's challenge to correctly analyse the metadata contained in each of the documents produced by the search [24].

Due to this, its relevant a correct construction of the search equation. Since it is a selection, which is subjective to the research, it might bias the definition of the system to be represented through the ontology. It is recommended to define the purpose of each search to be performed and, in case of requiring queries to multiple databases, to cover such purpose in every one of them.

Each group of publications to be analysed must be stored in a standard format, BibTeX. Therefore, once the results of the search are obtained, they must be exported to said format, standardising the file contents with the '.bib'file extension so the documents can be systematically analysed regardless of their originating databases.

3.2 Data Unification Strategy

Metadata fields differ according to the database that generates the BibTeX file; four common ones among scientific publications, however, are 'title', 'author', 'summary' and 'keywords'. Consequently, the title field is identified as the only value in the metadata obtained that can represent the publication's singularity; that is to say, it will represent a document's uniqueness or conversely its repeated appearance in the search results.

Duplication of documents must be avoided, as it would affect the ensuing representation; in other words, counting an article several times would endow the words describing it with greater relevance than they actually have. Therefore, a representation of a field of study must take into consideration only unique documents.

The proposed strategy is to homogenise the titles so that publications with identical titles may be identified despite slight variations, such as punctuation or capitalisation; the text should therefore be changed to a set standard, such as all lowercase letters, eliminating any non-alphanumeric characters such as spaces, colons or dashes.

The results will allow us to identify any repetitive records among them, thus indicating their relevance with respect to their visibility; in other words, we can analyse how the publications with multiple identical results have more relevance in the chosen field of study and are more likely to be found.

3.3 Processing Keywords

Keywords are terms chosen by the authors without any bias or outside intervention, and there is no list of predefined words from which to choose; this allows each author to use his or her own vocabulary [25]. Ontology demands a formal characterisation of keywords, so the data obtained must be processed. We chose to use natural language processing as a means to handle keywords. The goal is to eliminate each of the keywords called stop words (the, of, in etc.) as these do not reflect content *per se,* and then stripping suffixes and derivations.

This latter step is achieved by using a process to determine each word's lemma, i.e., reducing a word to its root so that each keyword is cut down in order to obtain the most basic form of each word. This will allow the identification of different words that share a same root. This process, represented in Fig. 2, will allow transforming the keyword "culture of digital" in its roots "culture" and "digit", just for presenting an example.

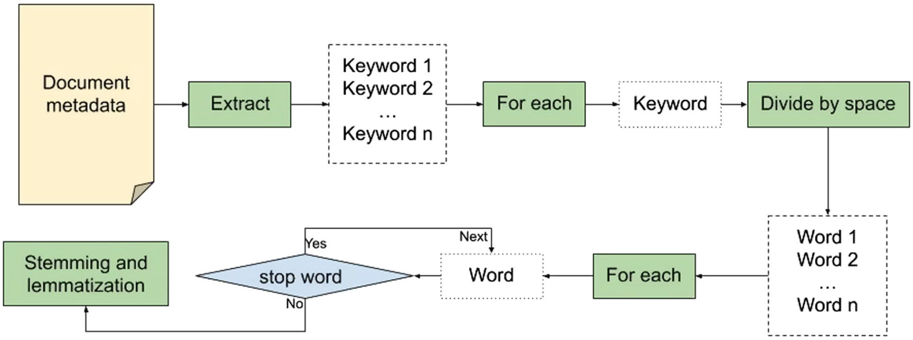

Fig. 2. Processing keywords

3.4 Standardising Weight and Connections

Processing keywords might result in a root being used in various keywords in one single document, in which case its weight should be one, as it represents only one publication. This keyword standardisation process will not only help to correctly determine the weight of each root word but also enable the identification of new connections.

Keywords themselves establish a correlation among different terms used within one document, i.e., when an author uses three different keywords to describe his or her work, they are explicitly stating that those three words are related to one other. When the keywords used contain more than one word, however, it can be surmised that, for example, three keywords comprise five different roots, indicating that the five words are related to each other. This process allows us to make connections that would be less visible had the keywords not been processed.

In sum, it can be stated that a term's weight is determined by the number of documents that use it and that the repeated use of the same pair of terms in different documents will establish the weight of their connection. The first thing that is achieved by performing a count of the appearance of the term, enabling to observe the dimension of each use of the root word. The second thing is achieved by the creation of a keywords auto-correlation matrix, using the Pearson's r measure.

3.5 Final Representation

Considering the term's weight and the connection's weight, it will possible generate a graph describing the conceptual system of the chosen field of study, where the nodes will be the different roots obtained from processing the keywords and whose connections will have been established by the authors themselves when describing their research with their chosen keywords.

The graph can be easier to read by replacing the keywords with others that represent the derivative: for example, 'digital' instead of 'digit', which would group 'digitalization' and 'digitization', among other keywords. In addition to this, it is recommended to select the stronger connections and the most used terms in order to be plotted.

4 Experimental Evaluation

To test and verify the performance of the proposed method, we chose to generate an ontology of keywords in the field of study 'Digital Transformation in Universities and University Institutions'. This field was chosen to generate the intended selection not based on any strategic considerations or due to any theoretical or hypothetical intent contributing to better understanding of how a graph representing keyword ontology in a field is generated, but instead rooted simply in the authors' interest in the subject.

Due to this, it is worth to indicate that the current evaluation scenario should not be considered a heterogeneous sample representing every knowledge field, which makes impossible to observe and describe the behavior of the proposed method in every possible scenario. Despite this, a clear implementation of the method is presented.

4.1 Data Selection and Extraction

Having chosen the field of study, we proceeded to search for related documents on the EBSCOhost Research Databases (EBSCO), SCOPUS and WoS databases, where search equations were used according to the syntax permitted by each database, as seen in Table 1. These equations identified the publications indexed in the databases pertaining to the chosen field of study.

Table 1. Construction of the search strategies

Purpose	SCOPUS strategy	EBSCO strategy	WoS strategy
Seek a line of argument on the importance of digital transformation on the development of industry and culture; meanwhile, the search strategy considers various ways of understanding and interpreting the social component from the cultural sphere	TITLE ("digital transformation" AND (organi?ation* OR cultur* OR chang*))	TI (digital transformation) AND TI (higher education or college or university or post secondary or postsecondary)	TI = ("digital transformation") AND TI = (organi?ation* OR cultur* OR chang*) OR (TI = (digital transformation) AND TI = (organization OR organisation))
Identify some categories and topics that could explain the new relationship between digital transformation and higher education	TITLE ("digital transformation" AND (universit* OR "Higher education" OR "adult education" OR "Tertiary education"))	TI (digital transformation) AND TI (organization or organisation)	TI = (digital transformation) AND TI = (higher education OR college OR university OR post secondary OR postsecondary)
Consider the role of digital disruption from the integration and articulation of education of the learners	TITLE (("digital disruption") AND (education OR learn*))	TI digital disruption AND TI (higher education or college or university)	TI = (digital disruption) AND TI = (education)

(*continued*)

Table 1. (*continued*)

Purpose	SCOPUS strategy	EBSCO strategy	WoS strategy
Explore in the document summaries how the emergence of technology has been perceived in higher education	ABS ("digital transformation" W/4 ("Higher education" OR universit* OR learn*))	AB digital transformation AND AB (higher education or college or university)	TS = ("digital transformation") AND TS = ("higher education" OR college OR university OR "Tertiary education")
Acknowledge the influence of the emergence of the digital world on the performance of procedure innovation in universities	ABS (Digitization* AND ("Higher education" OR "adult education" OR "Tertiary education"))	AB (digitization or digitisation or digitalization or digitalisation) AND AB higher education	TS = (Digitization*) AND TS = ("Higher education" OR "adult education" OR "Tertiary education")
Understand through the literature how digital technology has evolved in higher learning organisations and institutions	ABS ("digital transformation" W/3 (organi?ation* OR compan*))	AB digital technology AND AB higher education	TS = ("digital technology") AND TS = ("higher education")
Understand how human and social practices are articulated with the technological changes and coexisting gaps in that world of transformation and new ways of learning	ABS (("digital disruption") AND (education OR learn*))	AB digital transformation AND AB change culture OR AB (digital transformation or digital economy) AND AB social change	TS = ("digital transformation" OR "digital economy") AND TS = ("social change" OR "Cultural change" OR "Organizational change")
Analyse keywords used in this field and its most influential terms; determine the size and evolution of the literature on this subject	KEY (("digital transformation") AND ("Higher education" OR HEI* OR universit*)) OR KEY (("digital transformation") AND (cultur*))		ALL = ("Digital transformation" OR "digital society" OR digitization) AND ALL = (Higher Education) AND ALL = (Culture)

Source: prepared by the authors

At the time of this study a combination of 229, 247 and 164 publications were obtained from the EBSCO, SCOPUS and WoS databases, respectively. Each of the databases provides a tool for exporting the results, thereby facilitating the creation and download of a file with a '.bib' extension for each group of results, i.e., a BibTeX file was exported from each database containing the full compilation of the literature coinciding with the search criteria as well as a standard format with the metadata of each including the keywords of each publication.

4.2 Data Unification Strategy

In order for an iterative comparison to be made of the records in the document title field from the three databases, the regular expression '[^a-zA-Z0-9] + ' was used for the extraction of only alphanumeric characters, the result was followed by a lowercase capitalisation so that a value was generated representing the document title and its identifying uniqueness.

Using the aforementioned procedure brought to light the existing overlap in the results from each database, i.e., duplicate articles were identified in the records exported from EBSCO, in the same manner six records were found in the WoS database with identical titles and, finally, SCOPUS produced two duplicate articles. It should be noted that in order to perform the analysis proposed in the method, the records shown in Table 2 were considered together.

Table 2. Overlapping titles in records exported per database

Title	Type of publication	Occurrences	Database
CenturyLink launches Managed Security Services 2.0 to help Asia Pacific organizations protect against cyber risks and achieve secure digital transformation	Misc.	2	EBSCO
Books in the Digital Age: The Transformation of Academic and Higher Education Publishing in Britain and the United States	Article	6	WoS
JSTOR: Past, present, and future	Article and book	2	SCOPUS
Change culture, compete on costs & deliver: A success story on adapting a worldwide international oil company organization to a challenging low oil price environment	Article presented at conference	2	SCOPUS

Source: prepared by the authors

Continuing with the data unification analysis of the different database search results, we were able to confirm a lack of homogeneity among some of the titles. An example of this is given by the article whose title under EBSCO shows each word capitalised, except for prepositions and conjunctions, as follows: 'How Does the Digital Transformation Affect Organizations? Key Themes of Change in Work Design and Leadership.' For WoS, however, the title has no final period, and for SCOPUS the capitalisation is different: 'How does the digital transformation affect organizations? Key themes of change in work design and leadership'.

The number of records obtained was thus reduced from 640 to 632, with the breakdown being 228, 159 and 245 among the EBSCO, WoS and SCOPUS, respectively.

4.3 Processing Keywords

The 632 consolidated publications define the general framework of the field of study and consequently constitute the source used to generate the ontology of keywords that will represent the subject 'Digital Transformation in Universities and University Institutions'.

Self-correlation of the keywords without the proposed method results in a graph that does not characterise the chosen system, as shown in Fig. 3: the keywords 'digital transformation', 'digital world' and 'digital innovation' are presented as different elements, preventing a view of the true dimension of the digital aspect of the field. Conversely, 'organizational cultures' is a keyword that does not add to the term 'culture', which is treated as a different keyword when the influence of culture should be the result of combining both keywords, and, similarly, the terms 'organizational transformation' and 'organizational change' which are not connected to each other, are also considered independently although they reflect a similar purpose.

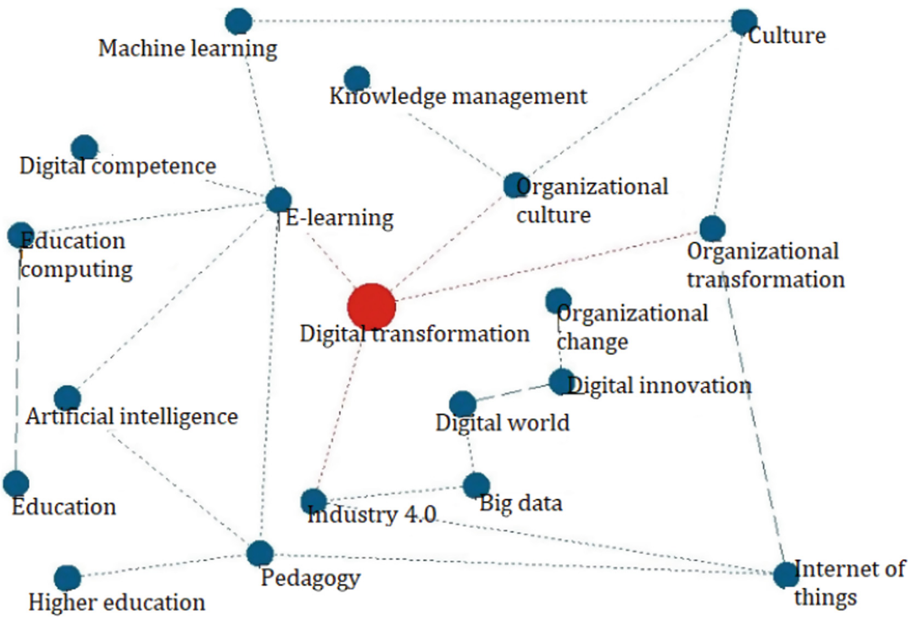

Fig. 3. Knowledge graph without the proposed method. Source: prepared by the authors

By applying Porter's stemming algorithm [26], for example, using Python NLTK to eliminate *stop words*, and make the steaming and lemmatisation process, will be enough to get a formal characterization of the keywords that will be used to build the ontology.

4.4 Standardising Weight and Connections

Automated standardisation of the keywords that have already been processed is done by storing the derived keywords from each document in a set type object, which allows each root word to be stored only once. In this way words that could affect the weight and connections are eliminated from each document.

4.5 Final Representation

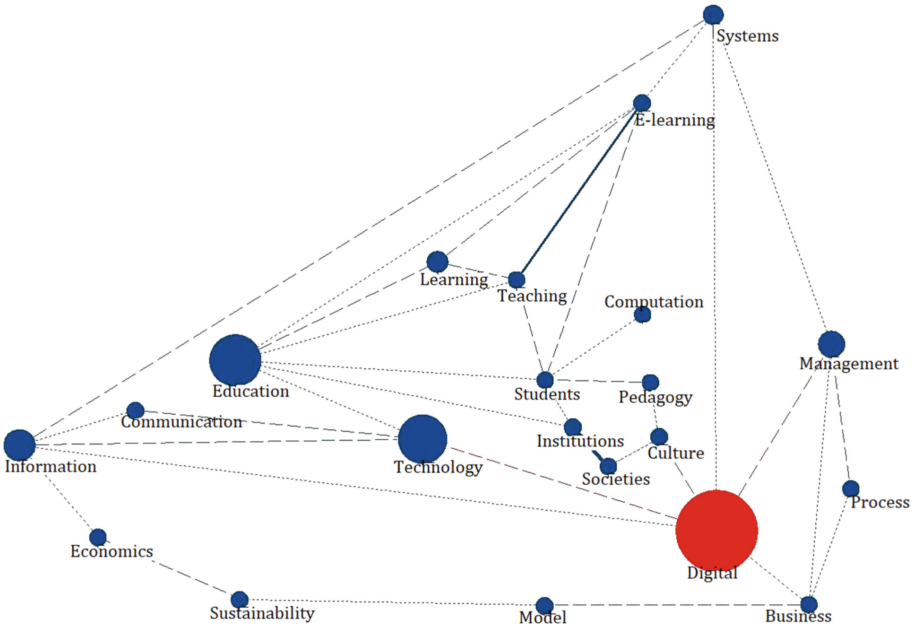

Fig. 4. Knowledge graph applying the proposed method. Source: prepared by the authors

The application of the method to the chosen field of study generated the graph shown in Fig. 4, where we see the relevance and connection of six terms found to be linked to 'digital': 'technology', 'information', 'management', 'business', 'culture' and 'systems'. In addition, one can see the real size of 'education' in the field of study, which is not evident without this method. Finally, the formal characterisation of the keywords allows greater simplicity in understanding the system, which is the purpose of this ontology.

5 Discussion

The overabundance of information that characterises the current era makes any subject search an act requiring thoroughness and prudence, where the objective moves beyond a search for information and must focus primarily on learning to define the key elements that enable the location of trustworthy sources that provide responses about the research subject.

This study sought to generate a method that would add to the act of searching intelligently for academic information and therefore visualise the most significant aspects of a topic or, in other words, transform the data into actionable information [27], understanding that by using concepts, attributes, taxonomies, functional relations, restrictions, axioms and instances, the learning process of any field of study can be accelerated. This proves that an appropriate ontological information system constitutes one of the most efficient and powerful tools to assemble and analyse knowledge [12].

Therefore, regardless of how advanced the technology used to recover information is, one must keep in mind that the data are not related to their environment in themselves; so, the process of analysing and giving meaning to that data is especially relevant [27]. In that sense, the method developed here was able to involve the different stages of the search, among which we identified: data retrieval, pre-processing of results, extraction of unique records, standardisation, mapping and visualisation. At the end of this process, the researcher must interpret and obtain conclusions from the graph generated by the keywords.

The result interpretation enables the support to higher education activities, not only by the generation of support material or the definition of a course as mentioned in the antecedents, but also identifying updates of a topic, searching interactively subtopics, achieving concept abstractions, analysing the relevance of each term or focusing on the learning and teaching of the topics with stronger connections.

6 Conclusions and Future Work

The exercise undertaken as a case study to test the proposed method proved that the graph generated by the keywords used by the documents' authors did not reflect the same clarity obtained after being processed to generate the ontology of keywords. The terms used, being the roots of keywords, permitted the observation of greater proximity to a standardisation process, which enabled the interpretation of the ontology graph and a clearer understanding of the selected study subject.

We observed the great potential that the proposed method has for the higher education, not only due to the facts expressed in the antecedents, but also due to the possibilities mentioned in the discussion. In addition, we identified virtues and difficulties of the proposed method in order to make easier the use of ontologies in every discipline, observing as a future work the generation of dynamic graphs that allow understanding the time evolution.

Although this input allows the identification and visualisation of possible connections among different topics within a chosen field of study, it does not allow clear reasoning of the connection among the terms; for example, representing the relationship between a fruit and a disease will not determine whether the relationship is due to the former causing or curing the latter. It is critical for each researcher to analyse the relationships carefully when seeking information in the articles that contain the keywords in which they are interested.

The validity of this method is affected with regard to keywords that should not be derived to their root terms, like names of countries ('United States of America' or 'United Kingdom') or companies ('General Motors' or 'Royal Dutch Shell'), for example, because during the derivation and standardisation process they would be considered in the ontology individually when what they represent should not be separated. Therefore, a future study would include an analysis of keywords that considers the context in which they are used.

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The 4Ts Game to Develop Teachers' Competences for the Design of Collaborative Learning

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Abstract. This work describes a serious game aimed at supporting teachers in the development of competences in the conceptualization phase of Learning Design. The game builds on the 4Ts model, which addresses four main dimensions of collaborative learning activities: the **task** learners will carry out, the **team** structure of working groups, the **time** schedule and the **technology** adopted. Participants play the game by laying down cards on a board; cards represent instances of the above-mentioned dimensions, while the board structures their aggregation and allocation in time. Scaffolding is available to novice designers, who can start the design from an existing pattern by using **technique** cards. The application that implements the game performs various consistency checks on the status of the board; provides on-demand feedback; supports multiple sessions both locally and at a distance; allows for further reuse and deployment of the designed activity. The article displays various examples of the application usage, highlights the system architecture, and describes some possible directions of evolution for this game.

Keywords: Serious games · Learning design · Teacher training

1 Learning Design

Collaboration is a key aspect of learning: learners engaged in collaborative activities are involved in a process of co-construction of knowledge based on meaning negotiation, sharing and reinforcement. Online Collaborative Learning, in particular, is believed to hold the promise to implement socio-constructivist learning processes based on active learning, collaborative knowledge building, reflection triggered by multiple perspectives. However, effective design of collaborative learning activities is not an easy task, especially for teachers and instructors who are not familiar with Learning Design (LD). In this context, a variety of tools, both conceptual and technological, has been proposed in literature [1–5]; these tools provide support to some specific design tasks, ranging from the planning of student activities to their delivery of learning resources and instructions.

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Unfortunately, very few tools support the creative process of conceptualizing collaborative tasks, although many teachers and designers, even experienced ones, face significant problems when addressing this task. The reason for this lack of support can be found in the level of creativity required by the conceptualization process, and in its intrinsic complexity, thus making it hard to reduce the design activity to a sequence of predetermined steps. Consequently, existing LD tools seldom have a significant impact on teachers' practice and therefore encounter limited adoption [6–8].

For these reasons, [9] proposed a collaborative board game aimed at supporting the design of game-based learning scenarios. Not only did teachers enjoyed using it, but also their collaborative attitude and creativity improved by playing with the cards: interacting with tangible elements allowed for more flexibility and usability than usual digital environments devoted to LD development. One drawback of such a paper-only approach is in the lack of saving and retrieving facilities, as it is difficult for participants to continue working on their collaborative design at a distance, or in a later session. Above all, the result of the design effort cannot be easily exported to an LMS platform to be deployed in a learning environment [9].

We have therefore developed three versions of a serious game, all based on the 4Ts Model [10], to support groups of teachers in the design of collaborative learning activities. We have been exploring various combinations of tangible and digital mix-ins: initially the game was fully tangible; we subsequently developed an "augmented", half-tangible-half-digital, version of the game [4]. In its most recent implementation, the game is completely digital, and allows for the direct manipulation of software representations of cards on a board through a gaming interface. In the following, we will present the 4Ts Model, and describe the digital version of the game.

2 The 4Ts Model

The 4Ts model was developed in 2011 and then validated during a workshop conducted at the Alpine Rendez-Vous of the STELLAR Network of Excellence [11, 12], which was attended by a number of researchers active in the field of learning design and online collaborative learning.

The model addresses four main dimensions of the design of collaborative learning activities [10]:

- The **Task** learners should carry out (e.g., writing a report, solving a problem etc.)
- The **Team**(s) that learners should be grouped into to carry out the Task and the corresponding interaction mode(s): pairs, small groups, plenary class etc.
- The **Time** schedule learners should adopt
- The **Technology** needed to carry out the Task (e.g., forum, wiki etc.)

During the design process of a collaborative learning activity, designers make decisions about these four dimensions, on the basis of the following boundary conditions (see Fig. 1):

- the expected learning outcomes, i.e. the learning objectives pursued by the activity;
- the content domain addressed in the learning activity;

- various contextual constraints, such as: the number of students who will take part in the activity, their age, previous competences, special needs; timeline restrictions; particular characteristics of the working or operative environment, etc.

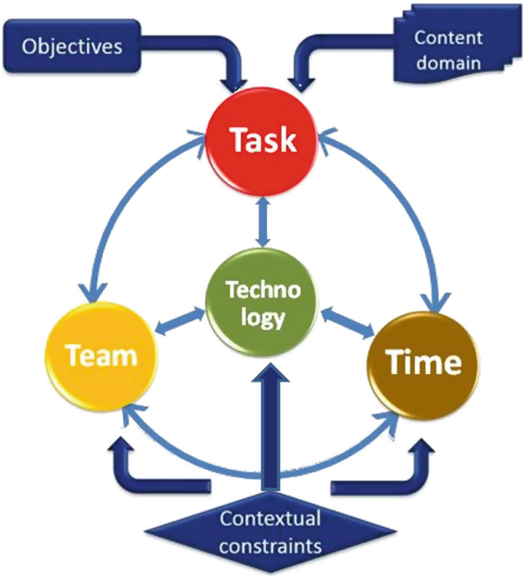

Fig. 1. The four dimensions of the model

The four dimensions of the model are not mutually independent: rather, they are tightly intertwined: a decision regarding any of them inevitably influences all the others. To support teacher and designers in the decision making process involved in LD, these dependencies should be made explicit. To this end, the game based on the 4Ts Model aims to support players in the exploration of these four dimensions.

As we shall see in the following, we have also identified a well-defined pattern language, in order to allow novice teachers to build their design on pre-defined structures rather than from scratch.

3 The Game

The game is hosted on a board that represents Time on four columns, each corresponding to a week (see Fig. 2). Each column has slots to accommodate cards from five different decks [13]:

- The **Task deck** (red cards): possible assignments for the students
- The **Team deck** (yellow cards): possible group structures
- The **Technology deck** (green cards): possible kinds of device, either hardware of software, to support the learners activity. Currently, the game only allows for a

maximum of two technology boxes per task; in the future, we might explore the possibility to specify more than two technologies for each task.
- The **Technique deck** (blue cards): possible collaborative patterns.

Each column can contain one Technique card, and one or two activity specifications; each activity consists of one Task card, one Team card and one or two Technology cards.

Regardless the deck they belong to, all cards share the same structure: they contain a short definition of the element they represent, and highlight suitable associations with other cards. For instance, the Forum card (belonging to the Technology deck) suggests compatible team and task arrangements that learners can effectively perform using a discussion forum.

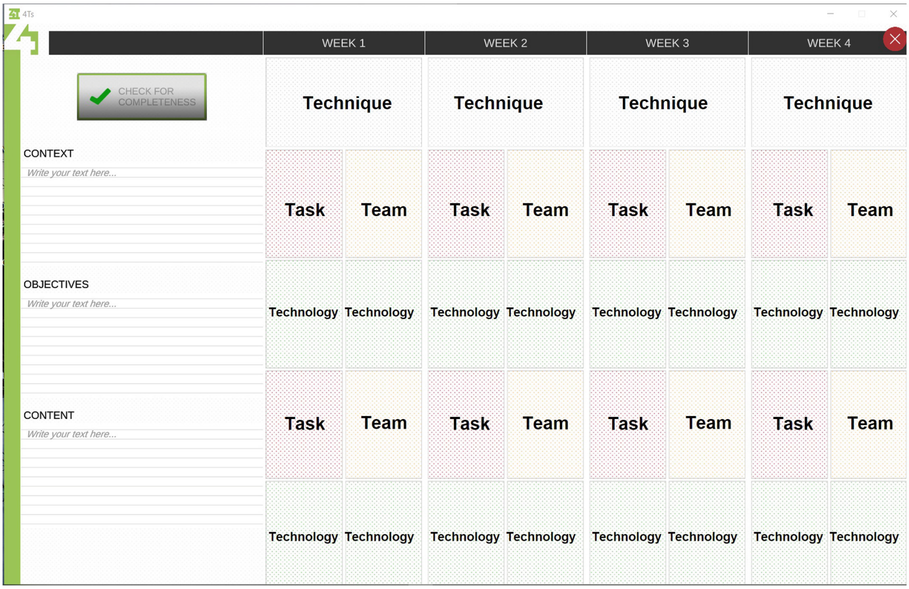

Fig. 2. The Board structure

Please note that the board allocates some space (on the left side of Fig. 2) to text fields that designers should fill in with information about the context, the objectives and the content domain associated to the activity under design. As already stated (see Fig. 1), these boundary conditions heavily affect most design decisions, and should therefore remain visible to designers throughout the conceptualization phase.

3.1 The Card Decks

Figure 3 shows an example of for each type of card, namely a "Writing a report" task, a "Small Groups" team, and a "Forum" technology card. Tables 1, 2, and 3 describe the sets of Task, Team, and Technology cards, respectively.

Fig. 3. Examples of Task, Team and Technology cards

Table 1. The set of task (red) cards.

Writing a report	Writing a short text following a set of instructions The report can range from a simple for-and-against list on a particular topic, to a full narrative description
Studying	Reading and studying assigned materials - text, audio or video recording, reference material, etc.
Finding materials	Conducting a search (free or guided) in any source of materials to locate information and documents on a given topic. This task, and the strategies for performing it effectively, are considered to have intrinsic educational value
Preparing a list of questions	Producing a list of questions, items, etc. on a given topic. The value of the task lays in the preparation, rather than in the final outcome/list. In the case of the list of questions, these might be posed, for example, during an “Interview with an expert”
Commenting on someone else’s work	Providing feedback about the work of others, with suggestions about how that work might be improved This is usually preceded by a task that involves producing something, e.g. “Writing a report”, “Producing an artefact”, “Preparing a Presentation”. The Task concludes when the feedback is shared with the author(s) of the work
Preparing a presentation	Preparing a presentation that will inform others about a given topic under examination. This usually leads to the task “Giving a presentation”
Carrying out an assignment	Completing one or more exercises or similar that have been set by the teacher
Giving a presentation	Presenting work to others. This is usually preceded by a preparation task like “Preparing a presentation”, “Writing a report” or “Producing an artefact”
Solving a problem	Solving one or more problems that the teacher has set

(*continued*)

Table 1. (*continued*)

Interviewing an expert	Posing questions to an expert in order to obtain further information and enhance understanding of a given topic. This is usually preceded by the task "Preparing a list of questions"
Assuming roles	Deciding who is to assume the different roles within a fictional situation enacted as part of a role-play activity. Examples of roles/characters may include team coordinator, rapporteur, defeatist, optimist, bureaucrat, efficientist, technophile, technophobe, etc. Once learners have assumed roles, in the following phases of work, they have to play them
Producing an artefact	Producing an artefact of any kind: a model, a map, a drawing, a video, a piece of software, etc. The artefact may be an original produced from scratch or perhaps a revised/reworked version of an existing work generated either by the same author/s or by someone else. The activity concludes when the artefact is handed in to the teacher and/or shared with others
Debating	Holding an organised discussion that examines a particular question or issue, often with the aim of reaching a shared conclusion, or to highlight various aspects

Table 2. The set of team (yellow) cards.

Individual learners	Individuals working separately
Small groups	Groups of learners numbering three to eight people
Pairs	Learners working in twos
Medium-sized groups	Groups of learners numbering nine to nineteen people
Large groups	Learner groups numbering twenty members or more
Plenary	The entire learner population addressed, be it a single class or a whole cohort of students

Table 3. The set of technology (green) cards.

Forum	A tool for asynchronous many-to-many communication, usually text-based
Presentation software	Applications like PowerPoint or Prezi for creating slide presentations to be shown to a live or online audience
Interactive whiteboard	A large digital display unit with an interactive surface that allows you to display content (text, images, videos, etc.) from a connected computer but also to manipulate these and add notes and drawings
Wiki software	A system for people to create and edit web pages in a collaborative manner using a web browser

(*continued*)

Table 3. (*continued*)

Video-conferencing system	A system that allows a group of people to hold a synchronous meeting online, thus avoiding the need to gather physically
Selected study materials	Reference materials on a given topic that the teacher has sourced and then presents for study - may include articles, papers, books, lecture notes, website links, audio-visual materials, etc.
Source of materials for learning	Any general information source, like the Internet or a library, that learners access to search for data, documents and the like
Text editor	An application like Word or Google Docs for creating and editing documents either offline or online - when used in a group, it allows members to work together on the same document, either by adding contributions or commenting on what others have written
Projector	A device for projecting the video signal from a computer onto a screen, so that it can be seen by a potentially large audience
No technology	In face-to-face situations, non-mediated interaction may be considered an alternative to forums or videoconferences
Materials and tools for practice	Any tool or material the teacher makes available to learners for practical activities. These include things like maker kits, educational software, apps, simulators, etc.

3.2 How Participants Play the Game

A group of designers play the game with the goal of designing one or more collaborative learning activities: after having defined learning objectives, contents and constraints of the activity, designers read and analyse the available cards, discuss, negotiate among the group the proper design decisions, and select appropriate cards to lay down on the board. Card after card, a coherent description of the learning activity emerges from the board.

The design resulting from a session of the 4Ts paper game consists in the state of the board, with all the technique, task, and technology cards properly positioned in the board slots.

Figure 4 shows an example of the status of the game board during a design session. Participants have planned for the first week a task consisting in a web search students will carry out in small groups over a set of referenced web sites. During the second week, larger groups will be preparing slide presentations to deliver to the whole class.

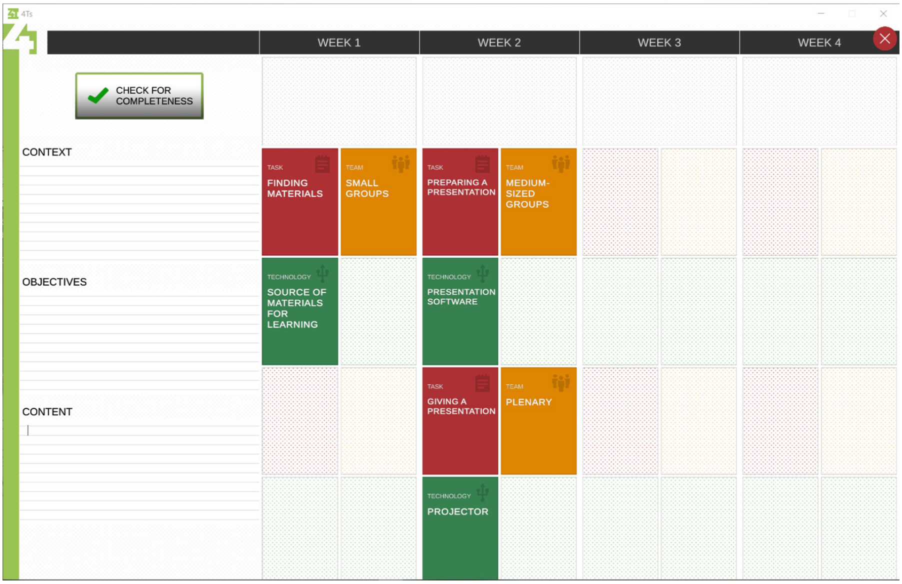

Fig. 4. The status of the board during a design session

3.3 Scaffolding for Novice Designers

A fourth type of cards, namely the Technique cards, is particularly useful to provide some scaffolding for participants who are novice in the CSCL field, because these cards allow starting the design from an existing pattern, rather than from scratch.

Techniques allow the organization, structuring, and scaffolding of activities, so that students who will take part in the activity being designed, will be able to collaborate effectively in order to achieve the expected learning outcomes. Techniques cards provide the elements for the pattern language we have mentioned in a previous section: each Technique card (blue colored) represents and suggests a notable collaborative pedagogical design patterns. The Technique card deck includes the following elements, but this set is open to future extensions and integrations:

- JIGSAW
- PEER REVIEW
- CASE STUDY
- PYRAMID
  - FOR LIST PREPARATION
  - FOR PROBLEM SOLVING
- DISCUSSION
  - TOWARDS ASSIGNMENT
  - TOWARDS ARTEFACT
  - TOWARDS REPORT
- ROLE PLAY

3.4 An Example of Technique Card: Jigsaw

As an example of a Technique [14], let us consider the Jigsaw pattern, a research-based cooperative learning technique invented and developed in the early 1970s by Elliot Aronson and his students at the University of Texas and the University of California [15, 16].

A Jigsaw activity comprises two phases:

- In phase 1 a complex issue is subdivided into 4-5 *segments;* learners form small groups, each group addressing one segment so that each member of the group becomes "expert" in that segment.
- In phase 2 groups are broken and reshaped, so that in each new group there is at least one "expert" for each segment of the previous phase: each group includes all the knowledge to solve the whole original issue.

The Jigsaw organization can be depicted as in Fig. 5:

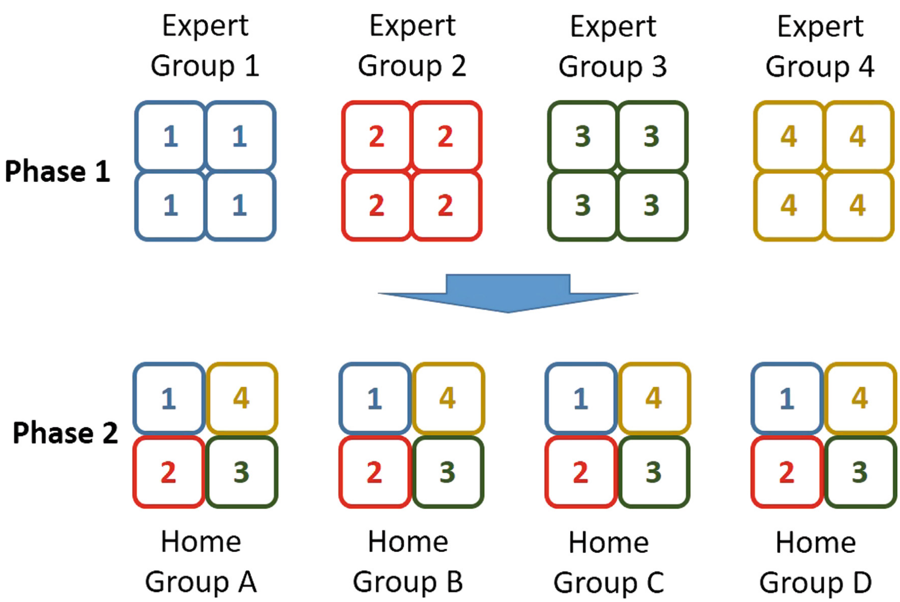

Fig. 5. Group articulation in the Jigsaw classroom.

Table 4 below shows how a Jigsaw activity can be represented within the 4Ts Model.

Table 4. The Jigsaw in 4Ts perspective.

Time	Phase 1–1st week	Phase 2–2nd week
Task	Individual study of learning material Collaborative development of a shared artefact (e.g., report, presentation etc.)	Problem solving activity to carry out collaboratively exploiting what has been learned in previous phase Plenary discussion
Team	"expert" groups	"home" or "jigsaw" groups
Technology	Discussion forum	Discussion forum

Figure 6 below shows the Technique card representing the first phase of the Jigsaw pattern. Note that, beside a short description of the technique, the card suggests proper task, team, technology, and time options. These are just hints, as several different combinations of 4T cards may suitably implement the technique.

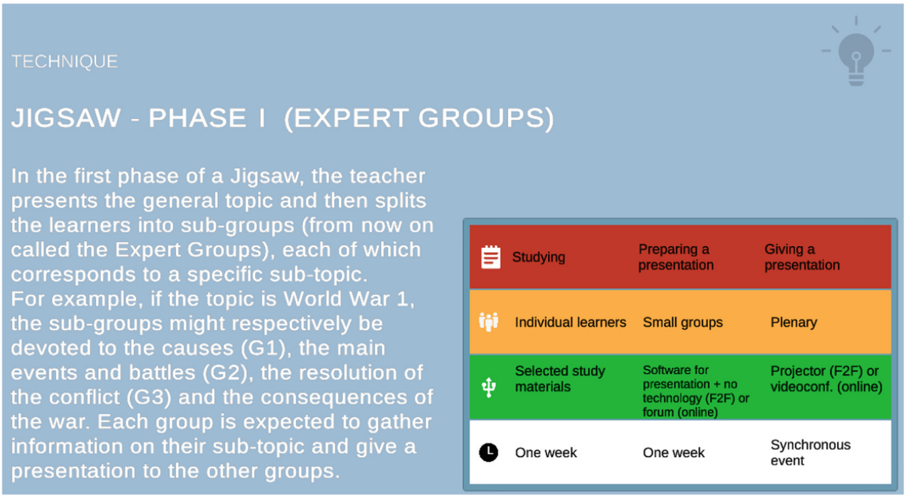

Fig. 6. A *Jigsaw – Phase 1* Technique card.

Figure 7 shows the status of the board after that participants have fully defined a Jigsaw activity.

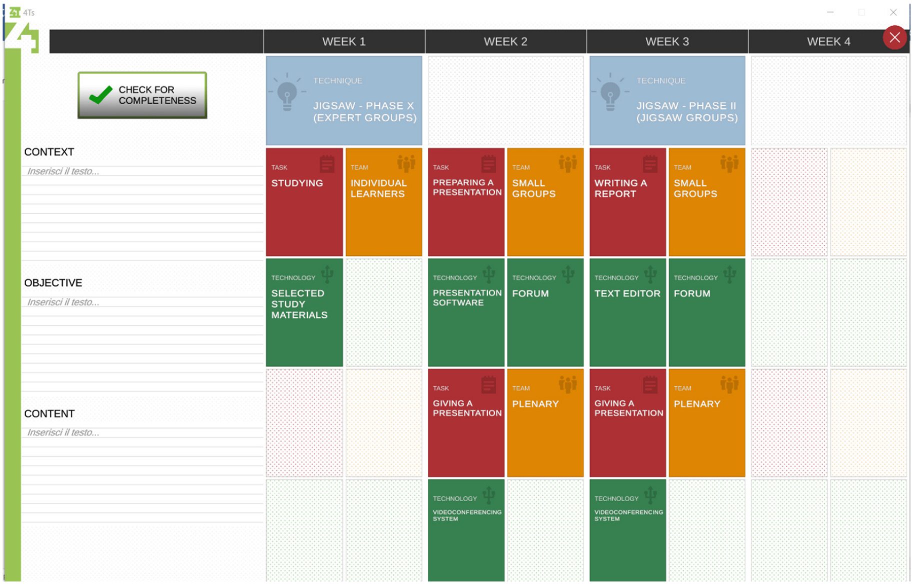

Fig. 7. The board for Jigsaw

4 System Functionality

As outlined before, the digital implementation of the game offers some valuable advantages over the initial, cardboard-only version. The software system that implements the game can perform a number of checks on players' moves, provide on-demand feedback, support multiple sessions and playing at a distance, and allow for subsequent deployment of the designed activity.

Whenever participants place a new card on the board, the system checks the board status to assess its consistency. Some combinations of cards are not allowed because do not make sense (e.g., an individual learner using a videoconferencing system, or because a task card that is incompatible with the technique card specified for the same week). In these cases, the system points out the incompatibility, as shown in the example of Fig. 8.

If technique cards have been used, participants can also ask the system to check if the technique has been fully specified.

If participants are stuck and do not know how to proceed, they can ask the system for suggestions: given the current status of the board, what card could be laid in a given slot?

The system produces a persistent, computational representation of the design. It is therefore possible to record and re-build easily the contents of the board at any given time, to allow for session break and resume.

Being the result of the conceptualization phase, the board final state should be easily reusable as the input to tools that support the design process; with this respect,

Fig. 8. The system highlights an incompatible combination of cards: the first phase of the Pyramid technique cannot be carried out in small groups.

the computational representation of the board allows for the integration of the 4Ts Game with other LD tools, in order to cover the whole design lifecycle [17].

5 System Architecture

The architecture of the augmented 4Ts Game encompasses three layers. The layer at the top represents the user interface: board and cards. The middle layer is in charge of the business logic: system initialization, persistency management, syntax checks, output formatting etc. Finally, the knowledge base at the bottom is responsible for representing the rules of the game (as outlined in the cards) and performing the semantic checks.

Queries to the knowledge base perform the following:

1. Correctness check: does the board currently contain a correct combination of cards?
2. Completeness check: does the board currently contain a complete combination of cards?
3. Card(s) suggestion

The user interface layer is implemented in Unity™ [18]. The middle layer is implemented in C#, whereas queries and responses returned to the business logic are expressed in XML syntax. The knowledge base is implemented in Prolog; thanks to the decoupling offered by an HTTP-based interface, the knowledge base sub-system can be located in a separate network node (e.g., a server in the cloud). This also allows for the collection of experimental data to validate the usability of the system and its pedagogical effectiveness.

The implementation of the digital game is in its final stages, with prototypes undergoing extensive testing.

6 Conclusions and Future Developments

The 4Ts game aims to scaffold the design of collaborative learning in Technology Enhanced Learning environments by making explicit, through the Technique, Task, Team and Technology cards and the board representing Time, the (mostly tacit) knowledge that expert designers have developed through experience. As a consequence, the game is particularly suited to the training of designers with little experience in the design of CSCL activities. In this context, one of the limitations of the game (the limited flexibility of its knowledge base) is also an asset, because it provides guidance based on clear-cut rules and consolidated design patterns. For experienced designers, however, this lack of flexibility could become too restrictive of their creativity in the design of innovative teaching approaches.

Future research directions include validation experiments of the game in authentic situations; usability evaluation of the interface with both real users and experts; comparison of the digital game with previous paper-only and mixed-tangible versions.

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The Challenge of Online Sport and Exercise Sciences University Programs

Sport and Exercise Sciences Degrees in Italy: Comparison Between Online and Traditional Teaching Models

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Abstract. Sport and Exercise Science degrees in Italy have special purposes because the curricula provide, in relation to specific aims, the deepening of some lessons and activities, with internship, workouts, practical activities, seminars and similar placement. The distance education methods in e-learning universities has been continuously developed but doesn't provide the whole solution for the physical and sport activities in Exercise and sport sciences degrees. The aim is to identify specific organizational issues about practical activities and to recognize the technological products to help the development of unique aspects of the practice to achieve the learning outcomes. To improve the current vision of the online education, it is utilized the archive research method regarding virtual and robotics knowledge augmented on the reality applied to distance education. In this way the main technologies, such as Nintendo, PS, Xbox and others, could be utilized for enlarge the education opportunities. For the law aspects have to consider the specific mode to validate the activity in the same manner to play currently with an appropriate modification of rules.

Keywords: Practical activities · Virtual reality · Robotics

1 Introduction

In Italy until the end of 20th Century the highest level of training in physical education field was managed by the Istituto Superiore di Educazione Fisica (ISEF) where the teaching/learning was mainly focused on practice activities. The main purpose of the ISEF was to promote the progress of sciences applied to physical education and to provide the scientific basic and technical culture for the preparation and improvement of those who wished to dedicate themselves to the teaching of physical education and to technical employments in the sport field, and for over fifty years they have represented the only training path to teach physical education in the high (first and second grade) school, while CONI (National Olympic Italian Committee) and the National Sport Federations had developed the training for coaches and sport educators [1, 2].

In 1998 the legislative decree n. 178 provided the opportunity for transformation of the ISEF in faculties and degree courses in Sport and Exercise Sciences. This transformation led to a diversification of curricula because of the development of new professional profiles in sport and exercise sciences. Due this transformation opportunity

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four-year degree course in Sport and Exercise Sciences was funded and it was aimed at acquiring adequate knowledge of cultural, scientific and professional methods and contents in the following areas:

- prevention and adapted physical education, aimed at subjects of different ages and subjects with disabilities;
- sport techniques aimed at training in the various disciplines;
- managerial, aimed at the organization and management of sports activities and structures.

Following the reform of University in Italy who introduced the "3 + 2" European system, bachelor's degrees in Exercise and Sport Science are grouped in a single class of degree (entitled L22), whereas master's degrees in Sport Science are grouped, according to the different and specific learning outcomes, in three classes of degree: 1. Management of Physical and Sports Activities LM47; 2. Preventive and Adapted Physical Activity LM67; 3. Sports Science and Techniques LM68.

Nowadays, Sport and Exercise Sciences degrees are not limited to train physical education teachers (currently to teach physical education at secondary school it is needed a master's degree in Sport and Exercise Sciences and a teaching specialization course), but they offer curricula aimed for training of various graduation profiles for job positions in management of sport, sport science and adapted physical activity and sport [3].

1.1 Traditional and Online Sport and Exercise Sciences Degrees

Since 1998 degree courses have been adapted to the University reforms [2] and currently Italian Universities offer 92 degree courses in Sport and Exercise Sciences (38 bachelor's degrees and 54 master's degrees) mainly based on traditional teaching/learning methods and where the learning outcomes are achieved through lectures, seminars; individual study; technical-practical demonstrations in laboratories or in the field, individual practice intended to obtain practical skills; and internships, while 4 universities with 7 degrees course (4 bachelor's degree and 3 master's degrees) based on online teaching. In Italy the early online Universities were established in 2006. These universities foster innovative learning modalities, developing research strategies for most advanced technological solutions and integrating nonresidential communication tools, such as virtual learning environments, videoconferencing, mobile learning apps e.g., and complimented with face-to-face activities like workshops and seminars. These online activities replaced every subject with no need of any compulsory activities as is prescribed by the law of university training course, to enhance the expertise of high-school students in physical education and sport. However, online universities could also implement bachelor's and master's degree in physical education and sport, because it is not forbidden by the law.

A peculiarity of Sport and Exercise Science degrees is that "special purposes. The curricula of physical activities provide, in relation to specific goals, the enhancement of some lessons and activities, with placements of facilities, training and sport organizations, businesses, public administration structures and laboratories; in addition to that, we offer exchange programs at other Italian and foreign universities, included in the framework of international agreements" [4]. For the application of these aspects for training course of education, the ministerial decree 16th March 2007 [5] requires 25 European Credits Transfer System (ECTS) in internship form and practical workouts to develop physical and sport skills, performed in appropriate facilities.

Due to the different methods between online and traditional degree courses, the aim is to identify:

- online activities that can substitute face-to-face learning activities typically used in traditional campus-based teaching.
- on-line training activities that can substitute the internship and physical and sport activities used in traditional campus-based on working out
- The use of good practice to involve both eLearning distance and applied one properly prescription of the current laws for the exercise and sport science program.

2 Method

This study is based on an argumentative theoretical approach and will be completed in two steps. First, legislative document will be analyzed and rules identified necessary for the accreditation of degree courses. Secondly, investigative research on new technologies appropriate for virtual environment and their ability to interface with human movement. Finally, the integrative of these two stages and the implications to distance learning environments will be discussed.

3 Results

The content of four laws was examined [5–8] to investigate the relationship among them and, consequently, to search the hypothesis of problem solution is to perform the internship with both work outs and eLearning distance.

1. According to Ministerial Decree 4 August 2000 "For the special purposes, the curricula of degree courses of the physical activities and sports class provide, in relation to specific objectives, the deepening of some lessons and activities listed, with placements in facilities, training and sports organizations, businesses, public administration structures and laboratories, in addition to visits of study at other Italian and foreign universities, including in the framework of international agreements" has the duty to implement a complete course of job placement or other similar activities to ensure the regular process.
2. According to Ministerial Decree 16 March 2007 "The physical and sport disciplines are conducted for a number of not less than 25 CFU in the form of internships and practical work conducted in appropriate facilities for dimensions and specifications provided for the activity and the number of students." The problem is how the university can realize the course on-line the real with in presence activities and so it could be solved with practical activities with training skills by virtual environments trough a video game e-learning system.

3. According to Law 289 27 December 2002 comma 5 art 26 "By decree of the Minister of Education, University and research, by agreement with the Minister for Innovation and technology are certain criteria and procedures for accreditation of university courses and distance education institutions empowered to grant degrees, under the regulation in the Decree of the Minister of Universities' and scientific research and technological November 3, 1999, n. 509, at the end of the course itself, without charges on the state budget. The acquisition of the authorization to issue degrees, the institutions must have adequate organizational resources and management able to:
   (a) present a system architecture for flexible and capable to target the different technologies for the management of interactivity, preserving the principle of their usability;
   (b) encourage the integration of coherent and educationally valid range of support services to teaching delivered;
   (c) ensure the selection, design and drafting of appropriate resources for each learning courseware;
   (d) ensuring appropriate contexts of interaction for the administration and management of the flow of learning content, including through the provision of a structured service tele tutoring;
   (e) to ensure appropriate assessment procedures of knowledge according to the certification of acquired skills and competences, to ensure research and development of innovative architecture of el-earning system that supports the flow of multimedia data related to the range of learning offered products".
4. According Decree April 17, 2003, Article 8 commas 2 - Criteria and procedures for accreditation of courses of distance learning universities state and non-state universities and institutions authorized to issue licenses academic - "Instances for the accreditation of university courses at a distance of Telematic (Open) universities that require, for the pursuit of specific objectives training, special training and practical activities, which are governed by provisions of law or European Union, or involving the frequency of laboratories to highly specialized, will be assessed after the conclusion of special agreements with the University of state and non state".

Its compliances to implement a correct way to make a placement planning for bachelor's and master's degree courses in total respect and its mission statement of the online university. We are going to find a solution for these academic activities and to adopt correct process in comply to law.

The perspective of using computer games in virtual environment to educate and train of complex skills is in large diffusion also for mental training methods at high performance. It gives examples from the development of an attention trainer for piloting skills, cognitive trainer for basketball, volleyball and, a recent effort to develop a cognitive trainer, ice hockey. If this teaching method and useful tools is good for high sport performance, why isn't it used in education and training for teachers and coaches? The current theory of motor control system has a significance analogy with the mechanisms and processes of these technologies, particularly the closed loop theory by Jack Adams and the open loop theory by Richard Schmidth [9]. These give some practice responses to how the mind can work when it has merged in virtual environment. Actually, motor imagery theory, which is the theory that substances the mirror neurons system in those movement that needs of an anticipating decision. Furthermore, it talks on the other theory system that is the future development in the virtual environment. With an appropriate education and training, it can use the neural network theory. It is possible to establish deductive rules of an expert system for the prediction of the opponent's move, into a direct confrontation for the fight activities and sports game. Training enables students to use the motor schemes that they acquired during their training (perceptual affordances).

The innovation opportunities are arising from the close collaboration between humans and active environment that increasingly characterizes modern society that means the current theory of Phenomenology of the mind and Perception. This phenomenon, that is enriched and reactive environment, is embodied in very different forms, firstly virtual environments, robots, and the performances go well beyond human limits for example to access and manage great amounts of information. To bring to fruition these capabilities, we have to bring and improve the life quality of us, including the best forms of our job, it must be ultimately driven by human will that follows the intuitive and natural way. So we leave freely to give a maximum effort to machine throughout the appropriate degree of autonomy. The sense of sight, and hearing by eyes, hears, body and kinesthesia, is the interface base for a natural interaction with the external environment. It requires an improvement of the traditional human-machine. The real transmission of the information to the senses must be increased and, in at the same time, new communication modes must be elaborated that build on the human ability to transmit and receive physical cues like gestures, force and tactile stimuli. For this reason we have to conceive and develop Advanced Interaction Concepts and Technologies for improving the communication between the humans and the reactive environment, with special attention to Virtual Environments and Tele-Robotic Systems. The scientific objective is to research on Advanced Interaction Methodologies and Technologies as well as on their usability in specific application domains. These are the following interaction technologies that will have to investigate in this way:

Haptics - Both Hardware and Software technologies relating to the sense of touch (force and tactile feedback) by artificial stimulations and to the communication of manual, handling and body skills. The goals of the findings are the development of advanced Haptic Interfaces, efficient collision detection modules and real-time renderers of the behavior of rigid and deformable objects.

Motion Trackers - Technologies for the real-time acquisition of the movements of the human limbs, with a special focus on the development of flexible structures having continuous distribution of the degrees of freedom.

Extenders - Both Hardware and Software technologies and techniques for the development and empowerment of robotic systems, able to improve the outcomes of singular motion gesture.

Motion Platforms - Methodologies for the optimum design of movement platforms throughout the useful algorithms for the optimizing of the inertial cues.

Unmanned Vehicles - Development of advanced algorithms and special software technique for the semi-autonomous navigation of vehicles in unstructured environments.

Stereoscopic Visualization Systems-Advanced of special software techniques for the real time optimizing of complex scenes on stereoscopic multi-wall displays.

The current usability of the interaction of the technologies is investigated and is more going to investigate in various application domains: Engineering, Architecture and Design, Surgery and Rehabilitation, Static and Dynamic Simulation, Industrial Maintenance, Automotive and Aerospace, Education and Training, Cultural Heritage, Art and Craftsmanship, Sport and Entertainment.

Special tools, as haptics, with its kinesthetic haptic interfaces, and tactile actuators could be the properly solution for the activity that is both with in presence and without physical presence. Particularly, with the term haptics we refer to a set of hardware and software technologies able to elaborate in a way different from the human mind, and so to elicit in the humans’ physical perceptions through the sense of touch. Haptics is a match between human and machine by interaction technology that promises to greatly improve the communication capability with remote and/or virtual worlds, adding the sense of touch to the communication channels, beside the conventional ones based on the hearing and sighting sense. Reflecting to the humans the physical stimulations arising from the contact with virtual or remote objects allows a natural control of the interaction, during, for example, the execution of manipulative or exploration tasks. Differently from the case of visual and audio communication, the optimizing of the physical sensation relating to the sense of touch requires the set-up of a two way real-time communication with the remote or virtual world. Indeed, the physical stimulations of the haptics sensorial system is a direct consequence of the actions performed on the environment. From the technology point of view, the research is primarily focused on the identification and development of suitable sensing and actuation technologies able, from one side, to acquire the movements of the human limbs, that are fed as an input to the system, and, from the other side, to fed to the human the corresponding stimulations, as an output from the system. The devices able to embody these two basic functionalities are named Haptic Interfaces. The research on virtual world is focused in the development of mathematical models and related computing architectures and techniques, able to evaluate in real time the response of the environment to the actions of the human. The set of these software technologies are indicated with the generic term of Haptic Rendering. Furthermore Kinesthetic Haptic Interfaces (KHI) are a class of haptic interface able to exert controlled forces on the human body using as an End Effectors a passive connection part that is permanently in contact with the limb(s) of the operator during both the time in which no contact with the Kinesthetic Haptic Interfaces (KHI) are a class of haptic interface able to exert controlled forces on the human body using as an End Effectors a passive connection part that is permanently in contact with the limb(s) of the operator during both the time in which no contact with the remote or virtual object is established and the time in which the contact is established. The connection part can imitate the shape of a specific tool or be conformed to adhere to the limb surface, like for example in the case of a thimble. KHI allows a satisfactory simulation of interaction with objects that are mediated by the interposition of specific tool (case of indirect contact), as for example in the case of the simulation of a surgical procedure, even if they are currently used also for the simulation of direct contact with the objects. Due to their working principle, i.e. the fact that the device is permanently attached to the operator, a special care has to be devoted to their mechanical design and to the development of their low level controller in order to guarantee the exertion of low resistance forces felt by the operator during his/her free movements (i.e. when no contact with the remote or virtual object is established). This quality of the KHI is indicated as “transparency” of the KHI and it translates in a set of mechanical performances evaluated at the end effectors of the device such as low reflected inertia, low friction and little backlash. Other performances are used to assess the quality of a KHI, such as stiffness and bandwidth that refer to its ability to reproduce statically stiff environment and fast evolving events such as shocks or collision. They said performances of a KHI deeply depend on the kinematics of the device, the positioning and the selection of the basic components of the actuation system and the material and geometry of the links as well as by the gravity, friction and inertia compensation techniques used in the low level controller.

Finally, the tactile actuators are systems that are involved in several application fields (medicine, industry, entertainment, cultural heritage) with purposes of training, rehabilitation, simulation and so on. The full immersion, or the “being there” feeling, depends on the richness and complexity of the set of sensorial stimuli that the user receives from the VR device. The sense of Touch is one of the most important in simulation of object exploration and manipulation. Goals of this research activity are the definition of a reference configuration for a Tactile Actuator and the definition of the design procedure and the implementation tools needed for. The Actuator will be able to stimulate the external perception sensors in the fingertips in order to replicate a tactile perception like the one you feel when you explore and/or maniple an object in the real world.

Both of them teaching/learning modes could have the same common mixed part, utilizing the professional subject of Human movement and sport sciences in similar manner and, on the other hand, all theoretical subjects such as human and experimental sciences. For the internship, workshop/workouts and technical education and practical session in physical activities and sport, it has to enhance the augmented reality, virtual reality, and robotics applied for both of them.

Therefore, the proposal is to convey practical and internship activities in the online mode as it is more in line with the spirit of the legislator in introducing distance learning for university courses. At the same time it is a solution for practical activities and internships, including professional placement, for those (for example, students worker, disabled students) who cannot attend practical activities. Particularly significant would then be the professionalizing meaning of using new augmented reality, virtual one and robotics as a professional field whose roots have development in motor and sports sciences, for example computer gaming, e-sports, or electronic sports that although are not considered true sports by many people, there have been include as part of the Olympic Games program. In 2016 and 2018 there were demonstrations of the ‘sport’ held around the time of the Olympics.

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Smartphones and Exergame Controllers as BYOD Solutions for the e-tivities of an Online Sport and Exercise Sciences University Program

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Abstract. In this paper, smartphones and exergame controllers are proposed as BYOD (Bring Your Own Device) solutions for carrying out the interactive learning activities of an online sport and exercise sciences university program. Such devices can be used as sources of kinematic and physiological data during the execution of some selected physical activities for providing, at the same time, a real-time feedback to the student and a ubiquitous assessment to the teacher. Some use scenarios are presented together with a conceptual framework for integrating such devices (and relevant data stream) in an e-learning platform based on a Cloud and Fog Computing architecture.

Keywords: Exergame · BYOD · Virtual learning environment · e-Learning · Cloud computing · Fog computing · Sport sciences

1 Introduction

Online sport and exercise sciences university programs are becoming accepted alternatives to traditional learning. However, the online teaching of such a discipline may result particularly challenging especially for those courses that heavily involve the practice of physical activities and testing procedures on the field. It is for this reason that blended teaching solutions (rather than the fully online typology) are those most recommended and encouraged by the boards that are in charge of the accreditation of higher education institutions. Nevertheless, the online part of teaching may still be enhanced with innovative solutions, supported by the latest technological advances, to enrich the interactive capabilities of a sport sciences-oriented e-learning platform.

To this aim, smartphones and exergame controllers can be used by the student as sources of kinematic and physiological data during the execution of some selected physical exercises assigned by the teacher. Thus, such devices can be seen as BYOD (Bring Your Own Device) solutions for ubiquitous teaching activities [1].

The term "exergame" is a neologism composed of the terms "exercise" and "videogame" and its first appearance in the scientific literature dates back to 2007 [2].

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The exergame implies that the player moves the character with his own movement rather than using a joystick. The movement of the player is captured by the exergame controller that is, therefore, characterized by motion capture capabilities. Depending on the motion sensor typology that the controller is based on, commercially available exergame controllers can be divided in:

- *inertial sensors* (i.e., accelerometers and gyroscopes), as in the case of the Nintendo Wii Remote[1] that has to be held by the player;
- *stabilometric platforms*, as in the case of the Nintendo Wii Fit[2] on which the player has to stand;
- *optical depth and color sensors,* as in the case of the Microsoft Kinect[3] that is able to capture the player's silhouette and reconstruct an articulated skeleton into a three-dimensional (3D) space.

Exergames have been successfully used in the field of sport and exercise sciences for assigning physical activity programs addressed to overweight sedentary adolescents [3], individuals with cognitive deficits [4] and neurological disorders [5]. Exergames have also been found to positively contribute to sport-specific motor skills learning [6–8], to the point that the scientific community is now discussing on the role that exergames can play in physical education curricula in schools [9]. This is because virtual reality (on which exergames are based) creates a particularly favourable condition for the learning processes (especially for those motor skills that are particularly difficult to replicate in real conditions), since it offers appealing, standardised, safe and repeatable environments [10, 11]. However, the effectiveness of exergame controllers for the ubiquitous teaching of sport and exercise sciences related courses has been not explored yet. Nevertheless, the applicability of such devices can be at least supported both by scientific researches that prove their metrological reliability [12, 13], and by their use as a tool for guiding a monitoring home-based rehabilitation exercises programs [14].

As for smartphones, their use in the school as a tool for the IBSE (Inquiry-Based Science Education) approach has already shown positive effects on motivating students' learning of physics [15]. This because of the rich array of sensors that can be now found on smartphones [16]. Of these, accelerometers, gyroscopes and triaxial magnetometers - sensors to measure the linear acceleration and angular velocity of the device and the local magnetic field, respectively - can be used for the estimatation of movement-related kinematic quantities [17]. Furthermore, using the smartphone's GPS (*Global Positioning System*) sensor it is possible to estimate physiological variables related to energy expenditure and training intensity during human gait [18]. The estimation of training load during aerobic activities, such as running, can be further improved by using a heart rate monitor with chest strap, that can be now easily integrated into a smartphone application [19].

[1] https://www.nintendo.co.uk/Support/Wii/Usage/Wii-Remote/Basic-Operations/Basic-Operations-243993.html.

[2] https://www.nintendo.co.uk/Games/Wii-U/Wii-Fit-U-592631.html.

[3] https://developer.microsoft.com/en-us/windows/kinect.

In recent years, new paradigms for data acquisition, transmission and processing from multiple sources have been proposed and widely used. In particular, the Internet of Things (IoT) paradigm is assuming a big relevance: a wide variety of devices, from simple sensors to household appliances and complex machines, are connected to each other generating and exchanging data. There are many IoT platforms described in the literature and used in a wide variety of contexts. Among them, the architectures based on the Cloud and Fog Computing have recently taken on importance [20]. In these architectures, three different layers, namely the sensors, the edges and the cloud, ensure, respectively, the collection, the local elaboration and the storage of the data.

On the basis of what has been said so far, the objective of this work is to design a Fog and Cloud computing-based framework aimed at: (1) integrating exergame controllers and smartphones as BYOD solutions in the e-learning platform of an online university, and (2) providing teachers with a new form of interactive teaching solution for sport and exercise sciences university programs.

2 Key Issues on the Legislation for the Accreditation of Online University Programs

The first source for the development of a learning model in online higher education in Italy is the Ministerial Decree April 17th, 2003[4]. The Decree was issued by the Ministry of Education, University and Research (MIUR) in agreement with the Ministry for Innovation and Technology and specifies the criteria and procedures for the accreditation of online university programs, defining a technological reference framework for its implementation. In brief, the Decree describes the features of the so-called Virtual Learning Environment (VLE). In 2013, the National Agency for the Assessment of University and Research (ANVUR) issued a set of guidelines[5] for the design of online higher education courses in which the online digital contents were classified as online lectures and interactive teaching.

Online lectures refer to those contents similar to traditional (i.e., face-to-face) teaching and it concerns the presentation/illustration of contents by the teacher. Online lectures can be composed of synchronous activities (e.g., webinar) and asynchronous lectures like audio or video recordings. Interactive teaching is based on the active participation of the student with a feedback from the teacher. Interactive teaching activities can be classified into:

- teaching interventions addressed by the teacher/tutor to the class (or a subgroup), typically in the form of demonstrations or additional explanations present in FAQs, mailing lists or web forums (demonstrations or operational suggestions on how to solve a problem, exercises and similar);
- short interventions carried out by the participants (for example, by means of discussion or collaboration environments like web forums, blogs, and wikis);

[4] https://www.gazzettaufficiale.it/eli/id/2003/04/29/03A05400/sg.

[5] http://www.anvur.it/wp-content/uploads/2013/12/LGPreattivTelematiche_Def231213.pdf.

- structured e-tivities [21] (individual or collaborative), typically in form of reports, exercises, case studies, problem solving, web quests, projects, production of artefacts (or similar variants), made by the students, with relative feedbacks;
- forms of evaluation such as questionnaires or in-progress tests.

Within the Italian online higher education system, ANVUR recommends that, out of the 25 h composing one ECTS (European Credit Transfer and Accumulation System) credit, a minimum of 6 h should be reserved to online lectures and to interactive teaching activities in a minimum proportion of 5+1 h for both of them.

3 Online Teaching Using the VLE Technology

Distance learning courses rely on technological platforms, often with a Model-View-Control (MVC) architecture, capable to store and deliver contents as Learning Objects (LOs), i.e., various educational materials (slide, video, quiz, test, etc.) with a single educational objective. LOs are usually encoded in formats such as SCORM[6] (Shareable Content Object Reference Model), able to track the time spent by the students to use the LO itself, and they are the core of the overall virtual learning platform (the already cited VLE) of any distance university. Professors and students interact with the VLE through a Web portal and other graphical interfaces for the access to the system. Even if sometimes criticized for the rigid structure, recalling a simple transmissive perspective, the SCORM standard is a cornerstone to realize re-usable, trackable and interoperable educational contents [22].

Moodle[7] (Modular Object-Oriented Dynamic Learning Environment) is for sure one of the most widespread online learning environments, mainly thanks to its modularity, to its reusability in different contexts and to the constructivist pedagogy principles it is based on.

As regards more specifically the sources of educational data, present in a typical VLE, they are multifaceted and can be classified according to four main categories [23]:

- *VLE-specific sources*, such as the modules to manage user profiles, to create and handle university programs, etc.;
- *General purpose applications' sources*, not typical only of a VLE, such as, for example, the synchronous (chats, virtual office hours) or asynchronous (e-mail, messages) communication systems, the file versioning systems, etc.;
- *Middleware sources*, providing services useful for the whole VLE, such as for instance APIs, databases, Web servers, etc.;
- *System software*, typical of a specific operating system, of the network protocol stack used for the communications, etc.

The main advantage in using a VLE in higher education, compared to the traditional frontal lectures, is for sure the greater number of students that can access the

[6] https://scorm.com/scorm-explained/.

[7] http://moodle.org/.

educational contents, but also the flexibility and the chance to customize the educational offer. The former advantage is possible mainly thanks to the use of technologies such as the MOOC (Massive Open On-line Course) platforms like those provided by the Khan Academy[8], the EduOpen[9] project, the MIT Open CourseWare[10], Coursera[11] and by edX[12]. However, the advantage of distance learning systems are not limited to this, rather they are multifaceted and can influence the different stakeholders of a VLE itself, be they the students, the instructors, but also the technicians, the managers of the educational institutions and the researchers in the educational field [24]. Among the main advantages of a VLE we can name, for sure, the possibility of integration with different emerging technologies, be they related either to the Cloud and Fog Computing or to Big Data Stream mining [25].

4 Possible Integration of BYOD Solutions into a VLE

An important feature of modern VLEs, very appreciated by the students, is the possibility to experience genuine learning situations, showing concretely concepts that are sometimes abstract [26]. The technological solutions based on Cloud and Fog Computing [27] are very suitable for this aim and for the functional and non-functional requirements of the architecture described hereinafter. As concerns functional requisites, the idea is to implement innovative types of interactive teaching, for some courses of the sport and exercise sciences university program. In particular, the student should be able to perform at home the exercises proposed by the teacher, who, in turn, must be able to evaluate the work of the student. Among the non-functional requirements, one of the most important regards the efficient and secure sending of the data recorded from the BYOD devices. Moreover, the VLE should be able to manage the flows of data coming from many students, and so to scale well. Finally, the continuous availability of the services offered by VLE should be ensured.

Architectures based on Cloud and Fog Computing foster communications and sharing of data among students and between students and teachers with the needed scalability and efficiency. Moreover, the integration of VLEs based on the Cloud and BYOD systems belonging to the students allows the realization of the so-called *situated learning* and of e-tivities in the form of virtual laboratories [28]. Figure 1 shows a possible VLE based on Cloud and Fog Computing. It is a three-layer architecture. The sensor layer is made of controllers for exergames or of smartphones used by the students to detect kinematic data, sent through Bluetooth or Wireless connections towards the computation supports of the Fog layer (personal computer or tablet). Indeed, smartphones can be endowed by themselves of full computation capacities, and so they can be considered, sometimes, belonging to the Fog layer as well. On the

8 http://www.khanacademy.org.

9 http://en.eduopen.org/.

10 http://ocw.mit.edu/index.htm.

11 http://www.coursera.org/.

12 http://www.edx.org/.

computation supports of the Fog layer, dedicated apps can be installed, with the aim of receiving data coming from controllers and smartphones (interfacing with the API - Application Program Interface – of the vendor) and of making elaborations as described in the following.

The data elaborated by the Fog layer are then sent to the Cloud layer of the VLE. In this layer, data are stored in a specific database, which could be NoSQL. At Cloud layer, data could be further elaborated, for example to be prepared for the visualization or the evaluation on the part of the teacher. Collected data and teacher's evaluations are stored in the student's e-Portfolio, where all the performed didactic activities are stored. Finally, the proposed architecture allows one to fully exploit the emerging paradigm of the mobile-based learning [29], where educational objects are exploited in full mobility using mobile devices.

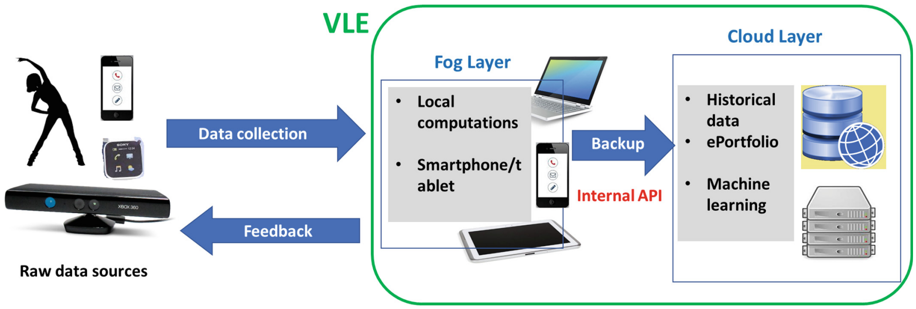

Fig. 1. Example of a possible architecture for the communication between BYOD devices and the VLE based on Cloud and Fog layers.

5 BYOD Solutions for the E-tivities of a Sport and Exercise Sciences Course: Some Use Scenarios

To describe a possible scenario for using exergame controllers and smartphones for the e-tivities of a sport and exercise sciences university program, we focused on one of the courses that usually characterize such a university program, namely "Strength and conditioning". Then, we further explain the uses of such technological supports on the base of three specific educational aims of this course: (1) skills training (learning of the execution of a given exercise technique); (2) strength training (improving muscle strength through weight resistance training); (3) endurance training (improving aerobic capacity).

5.1 Skills Training

For the first aim, we refer to the Microsoft Kinect exergame controller as the technological support for this kind of purpose. Microsoft Kinect makes use of optical depth and colour sensors to capture the player's silhouette (i.e., contour) and reconstruct a 3D articulated skeleton with a known segmental kinematics [30]. Therefore, this device can be used to assess the technical execution of a given exercise, the back squat for example, where a proper technique is fundamental for both the effectiveness of the exercise and for avoiding injuries to the musculoskeletal system [31]. Data recorded by the controller (i.e., the position of given joints centres) can be sent to a dedicated application, installed on the student's personal device (e.g., personal computer or tablet, that acts as a Fog layer) interfaced with the controller by using the API provided by the manufacturer.

The operation performed by the application would consist in comparing the motion captured skeleton, representing the movement performed by the student, with a second scaled skeleton that represents the "optimal" performance model. A graphical overlap between the tracked skeleton and the ideal model could be returned in order to provide the student with real-time visual feedback (Fig. 2). At the same time, the application calculates the main kinematic variables of interest to characterise the exercise execution (e.g., trunk flexion, joints angles, movement velocity, etc.) and it creates a report containing a comparison with the "optimal" execution. Then, this report can be sent to the Cloud layer of the VLE and stored in the student's e-Portfolio so that it can be made available to the teacher for the relevant assessment.

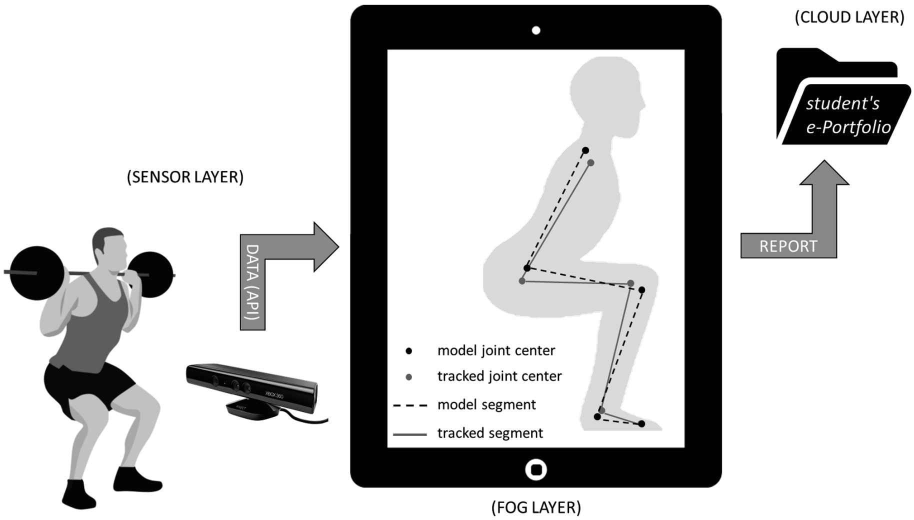

Fig. 2. Example of a possible graphical representation of the visual real-time feedback provided by the application installed on the student's personal device while he is learning the execution of a squat exercise: the skeleton, tracked by the Microsoft Kinect on the basis of the student's silhouette (also shown in the image), is superimposed on an "optimal" scaled skeleton.

5.2 Strength Training

With regard to the second aim, the signals measured by the inertial and magnetic sensors contained inside the smartphone are sufficient to feed those algorithms commonly used to estimate the force applied to the bar and to calculate the lifting velocity of the bar during a resistance training exercise [32–34]. The calculations needed to obtain these quantities from the signals measured by the smartphone's sensors can be carried out by a dedicated application installed on the smartphone itself (the Fog layer). Obviously, this specific use of the smartphone assumes that the device has to be fixed to the bar with a proper fixing solution (belt, strap, tape, etc.). Within the context of an e-tivity, this application can be used to monitor a training session for muscle strength development that can be programmed a priori by the teacher and uploaded in the student's e-Portfolio (Cloud layer): when fixed to the bar, the smartphone would then be able to provide the main variables of interest describing the exercise intensity (e.g., the force applied to the bar and the lifting velocity). On the base of these variables, that will automatically populate the training session assigned by the teacher on the e-Portfolio, the student will be able to characterize the athlete's training zone (e.g., muscle power, maximal strength, hypertrophy, etc.) and figure out whether or not the programmed training session is having the desired effects (e.g., an increase of velocity in lifting a given load with respect to the beginning of the training program).

5.3 Endurance Training

A third hypothetical e-tivity could see the student involved in demonstrating to the teacher his ability to monitor the main variables commonly used for the assessment of the training load (i.e., training intensity) during endurance activities like outdoor running. Running speed and heart rate are certainly among the most important variables for characterizing the development of the aerobic capacity [35]. Running speed can be estimated with a sufficient level of accuracy by using the GPS module installed on the most recent smartphone models [36]. Standard heart rate measurements can be performed by chest-strap heart rate monitors, which are now easily available on the market as low-cost stand-alone modules that can be connected to a smartphone via Bluetooth connectivity [19]. Again, the teacher can upload a given training session program on the student's e-Portfolio. The training session could feature, for example, a specific distance to cover, a specific speed profile to follow, and a heart rate range to comply with.

A dedicated application installed on the smartphone (Fog layer) would get interfaced with the VLE (Cloud layer) to: a) download the training session programmed by the teacher; b) synchronously record position, running speed and heart rate during running: c) provide the student with a real-time acoustic feedback to assist him in checking the consistency between the programmed intensity level and the actual performance. At the end of the training session, the application would then produce a report to be uploaded on the student's e-Portfolio (Cloud layer) and made available to the teacher in a graphic format for the relevant assessment.

6 Discussion and Conclusions

This paper presents a framework for the integration of BYOD solutions, such as smartphones and exergames controllers, in the VLE of a sport and exercise sciences university program, as tools for carrying out the interactive part of online teaching. Such a proposal may provide a cue of reflection both for the academic sport and exercise sciences community and for the national boards of accreditation in the development of new quality assessment criteria for this type of online university programs.

After a brief description of the online learning model recommended by the Italian legislation, we presented an overview of a typical VLE with its basic features. Thereafter, we described an innovative VLE architecture designed to allow the implementation of new ubiquitous exercise teaching models. This architecture is based on a Fog and Cloud computing architecture to allow an easy integration of BYOD devices, such as smartphones and exergame controllers, as sources of movement-related kinematic variables. Finally, we presented some use scenarios describing a way these devices can be used as tools for supporting the interactive part of teaching within the proposed Fog and Cloud computing-based VLE platform.

Smartphone and exergame controllers present the ecological and metrological features that make them a suitable solution for the aim of the present paper. From the economical sustainability point of view, the smartphone is usually already owned by the students, while the (low) cost of an exergame controller could be easily included in the program registration fees. However, the use of such devices for learning activities implies that students should know how to properly use this technology. For this reason, few lessons dedicated to such purposes may be usefully included in the university program.

The integration of e-tivities based on BYOD solutions, considered as a part of the interactive teaching activities of the educational system of an online university program, is part of an innovative framework for the implementation of a personalized and interactive distance learning that could lead to an improvement of the students learning ability. In fact, the use of BYOD solution facilitates ubiquitous and context-aware learning experiences in informal situations, while the possibility offered to the students to use such devices almost anywhere and whenever they want can stimulate their learning process. This solution seems to be able to effectively implement both the interactive component of teaching aimed at the development of skills, and the formative assessment dimension, combined with a significant personalization of the student's learning experience [37].

The solutions proposed in this perspective paper go towards a more constructivist learning approach, giving the student the opportunity to practice and interact with the teacher at the same time on the basis of kinematic and physiological related data collected during physical activities. Moreover, thanks to these data, the student can be either assisted with an automatic or teacher-mediated feedback resulting in a real formative assessment throughout the educational process.

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