Lorna Uden
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Learning Technology for Education Challenges

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Preface

Welcome to the proceedings of the 9th International Workshop on Learning Technology for Education Challenges (LTEC 2020/2021) held at the National University of Kaohsiung, Taiwan, during July 20–22, 2021. Owing to the unique circumstances brought about by the COVID-19 pandemic, LTEC 2020 was postponed and subsequently merged with this year's edition of the conference, which was held in a hybrid format with both in-person and online presentations.

Technology has brought about various changes in the way education is delivered and received. From self-learning to the flipped classroom approach, technology is making a considerable impact on learning and teaching methodologies. Because of the numerous benefits offered, digital learning has become an important part of the education system. Teaching and learning methods have undergone a significant change due to all the trends in educational technology. Every year, new trends emerge to provide something new to the learners. Schools and universities are trying to implement the latest in education technology to improve the teaching and learning process. There are many current trends in learning technology.

Collaborative learning is one of the key features in twenty-first century education, since peer-to-peer learning incorporates the social learning trends that are so widespread in modern society. Collaborative learning technology can enhance problem solving and communication skills and foster creativity, complementing the goals of higher education. This collaborative learning approach helps students to interact with their peers and build their interpersonal skills.

Virtual reality (VR) presents realistic scenarios for students and helps them gain valuable hands-on experience that otherwise would not be available. Their digital environments prompt higher comprehension and retention rates than traditional classroom settings. VR transformative potential will grow exponentially. Lower costs will push institutions to invest heavily in these effective, engaging training tools.

Gamification has been gaining popularity because it increases student engagement. It incentivizes students to learn and practice, improving the overall learning process. Artificial intelligence will continue to increase within educational settings because it helps personalize and streamline instruction. Machine learning can evaluate a student's competencies, find weak areas, and then present supporting materials.

Blockchain technology is a decentralized, transparent way to transact data. There are many ways blockchain can transform education. Schools can use blockchain for cost-effective cloud storage options and for securing student record transfers. Blockchain technology can also make its way into Massive Open Online Courses (MOOCs) and E-portfolios as ways to verify skills and knowledge. Educational institutions are starting to look at learning analytics to optimize learning. Educators can use it to predict student behaviour, design curriculum, and map learning interventions.

Cyber threats have been a cause of worry for many institutions - educational and otherwise. Education institutes are implementing the best data security measures to

protect their online data and their students' interests. Cybersecurity, therefore, is an important research area for learning technology. Mobile learning is gaining popularity in middle management training. Companies updating learning to include the latest mobile and live online learning technology can expect to drive higher levels of engagement and learning effectiveness.

Besides the technological advances, there is also a need for innovative pedagogy, which may include playful learning, learning through wonder, action learning, making thinking visible, virtual studios, and so on.

The aims of LTEC 2020/2021 were to examine how these technologies and pedagogical advances can be used to change the way teachers teach and students learn while giving special emphasis to the pedagogically effective ways we can harness these new technologies in education; to provide a platform for research in the very broad area of educational technology that bridges theory, research, practice, and policy; and to offer participants an overview of the current situation of education and new learning technologies.

The proceedings consisted of 17 papers covering various aspects of technologies for learning including:

- Learning tools and environment
- E-learning and transferability strategies
- Serious games technologies
- Learning practices and knowledge transfer

The authors of the papers hailed from many different countries including Austria, Chile, Colombia, Ecuador, Finland, France, Greece, Italy, Malaysia, Slovakia, Slovenia, South Korea, and the United Kingdom.

We would like to thank the authors, our reviewers, and the Program Committee for their contributions and to the National University of Kaohsiung, Taiwan, for hosting the conference. Special thanks go to the authors and participants at the conference. Without their efforts, there would be no conference or proceedings.

We hope that these proceedings will be beneficial for your reference and that the information in this volume will be useful for further advancements in both research and industry related to Learning Technology for Education Challenges.

July 2021

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Predicting Effects of University Service Quality and Internet Use Motives Towards Study Abroad Students' Depression

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Abstract. The number of students participating in study abroad programs has been increasing for the past decades. In Taiwan, the rising number of incoming study abroad students have also helped in augmenting the oversupply of higher education. However, it is reported that within study abroad situations culture shock does happens. In the current study, it is assumed that the internet has already created a highly connected society. Hence, study abroad depression should be minimized. In addition, with the current drive for the advancement of service quality within higher education, these perceived positive interactions between the school and students should be able to further lessen study abroad related difficulties. With the trend of knowledge management within university institutional research, the collection and understanding of data with regards to study abroad students is quite important for future policy recommendations. To further understand these assumptions, information from a total of 665 study abroad students in Taiwan are surveyed. Service quality (SERVQUAL), the Study Abroad Internet Use Motives Survey (IUM), and the Center for Epidemiologic Studies Depression Scale (CES-D) were used to collect the information. Results show that IUM factors *online habits* and *online facilitation*, and the SERVQUAL factors *tangibles* and *reliability* are able to predict study abroad students' depression. In essence, for study abroad to become successful universities should make use of such tools and provide the appropriate adjustments within their service provisions.

Keywords: Culture shock · Institutional research · Student recruitment · Survey questionnaire · SERVQUAL

1 Introduction

For the past 25 years, international education has evolved into one of the mainstream components of higher education [1]. From the traditional experience of getting a degree from a foreign country, international education has expanded to encompass short-term study abroad, twinning or dual degree programs, cross-country fieldwork or researches, internship and service learning experiences, study tours, and many other variants that might either be credit earning or not [2]. Similar with Taiwan, internationalization for the

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past few years has been quite deliberate with strategies inclined towards sustainability and quality of programs [3].

These deliberate strategies for the internationalization of higher education in Taiwan have brought about the rapid increase in the number of incoming study abroad students [4–7]. Statistics from the Ministry of Education show that the annual intake of study abroad students has increase from around 10 to 19 percent and even to as high as 28 percent per year. However, this rapid growth seems to have reached its peak with the computed annual growth to have gradually slowed down to only around 5% and lower. Some attribute this change to the fact that universities in Taiwan are more focused on recruiting outside the Asian region [8]. To add, major global phenomenon starting from 2013, such as the China's economic slowdown, the exit of UK from the European Union, and the new border policies of the US have all together changed the outlook of global student mobility, hence, brought upon both barriers and new opportunities of collaboration [9].

These new collaboration opportunities have actually opened up the door for more regional cooperation and student mobility [2]. However, within the vast study abroad literature, it is noted that when students are exposed to new situations and environments, they (the students) tend to suffer from various levels of anxiety, confusion, and depression [10, 11]. Hence, in order to better enhance the study abroad student recruitment strategies, the current study shall focus on understanding how depression can be minimize. More important, the data collected can also enhance the capabilities of university institutional research towards knowledge management [12, 13], while at the same time strengthening its role as knowledge managers [14].

2 Service Quality and Study Abroad

Within these past few years, many have started to wonder about the quality and value of participating in a study abroad program [15, 16]. Some say that this is actually a common practice within the academe [17]; denoting the cornucopia of study abroad programs available in the market today. Most primary reasons for study abroad is typically to avail of foreign language gains, however, some studies have shown that only slight improvements are found to be correlated with studying abroad [18–20]. Some even proved that local language immersion program participation and previous foreign language experiences to be far more useful in achieving language performance gain [21, 22]. Even more surprising is that some research have shown that locally held foreign language immersion programs are seem to be more effective than studying abroad [19]. Nonetheless, these only means that student should choose wisely in the type and form of study abroad program they would participate in [23, 24]. Hence, to better understand the inner workings of these programs *service quality* studies have become of high importance.

According to Zeithaml [25], *service quality* can be expressed as the overall consumers' judgment of the product (or services) performance. Consequently, service quality studies have started to become crucial for organizational progress and survival [26]. Furthermore, Gronroos [27] noted that service quality has already become a requirement for firms to become successful and organizations to remain competitive. As with

the current competitive nature of higher education, maintaining a competitive advantage is crucial for sustainability [28, 29]. Together with the increasing role of students in having to *fund themselves* in their university education [30], competition is not only within the domestic sector, but as well as within the international education market, which has all together risen [31–33]. More important is that students are now seen as the primary consumers of higher education [34]; ultimately, issues leading to *service quality* and *satisfaction* are seen as the antecedents for making a *differential advantage* over other institutions.

Among the vast literature of service quality dimensions, the SERVQUAL model developed by Parasuraman, Zeithaml, and Berry [35] captures service quality within five dimensions, namely: a) *Tangibles* - the physical facilities, equipment, appearance of personnel; b) *Reliability* - the ability to perform the desired service dependably, accurately, and consistently; c) *Responsiveness* - the willingness to provide prompt service and help to customers; d) *Assurance* - employees' knowledge, courtesy, and ability to convey trust and confidence; and e) *Empathy* - the provision of caring, individualized attention to customers. These are actually a simplified version of the previous ten dimensions (reliability, responsiveness, competence, access, courtesy, communication, credibility, security, understanding, and tangibles). Within the five dimensions, *reliability* and *assurance* are mainly concerned with the *service outcomes*, while *responsiveness* and *empathy* are functions focusing on the *service process* [36].

Besides SERVQUAL, Gronroos [27] proposed that service quality can be measured using six criteria, namely: a) *Professionalism and skill* - customers see the service provider as knowledgeable and able to solve their problems in a professional way; b) *Attitudes and behavior* - customers perceive a genuine, friendly concern for them and their problems; c) *Access and flexibility* - customers feel that they have easy, timely access and that the service provider is prepared to adjust to their needs; d) *Reliability and trustworthiness* - customers can trust the service provider to keep promises and act in their best interests; e) *Recovery* - customers know that immediate corrective action will be taken if anything goes wrong; and lastly f) *Reputation and credibility* - customers believe that the brand image stands for good performance and accepted values. More important is that the service quality is also separated into two sections (similar with SERVQUAL), the *process* dimensions or how the service process functions, and the *output* dimensions or what the service process leads to as a result from the process [37, p. 177].

Comparing the two models, analysis suggests that the SERVQUAL model seems to be more highly used in various service quality studies. Researchers in various countries have actually adapted SERVQUAL to validate their higher education service quality, such as in Turkey [38], Bosnia [39], Singapore [26], Greece [40], Thailand [41], Egypt [42], Tanzania [43], special educations in Turkey [44], business administration program in Jeddah [45], Iran [46], and many others. More important, SERVQUAL is also used in evaluating the service quality of international education programs such as in Australia [47], and Malaysia [48, 49]. While most of the studies use a modified SERVQUAL survey based on contextualizing the five service quality dimensions, quite a few studies also integrated the importance-performance analysis so as to compare the perceived and the actual service quality situation of an organization [50, 51]. In sum, the use of the

SERVQUAL model in determining the *service quality situations* of universities seems to be a valid conceptual paradigm. More important, service quality feedbacks should be able to provide university institutional research with valuable quality improvement policy recommendations.

3 Methodology

The current study is conceptualized within a quantitative design, wherein surveys are used to collect the information needed for the analysis [52]. Surveys are very useful in the collection of particular information describing the current issues at hand [53]. A total of 665 volunteer study abroad students in Taiwan participated in an online survey that lasted for around 3 months. The 42-item survey included 3 scales, namely: IUM (3 factors, 11 items) [54], the self-developed SERVQUAL (5 factors, 21 items), and the short depression scale CES-D (20 items) [55]. In addition, nominal data on participants' backgrounds and relevant details are also collected within the survey [56]. Data for the IUM and SERVQUAL is collected in terms of students' perceived agreement within 5 Likert [57] type scale, namely: 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. Overall, Cronbach's [58] Alpha (α) reliability of the survey is computed to be at **.86**, which is considered to be adequate (as a rule of thumb α should be greater than .45) [59, 60].

Table 1 shows the study abroad students background demographics. Data shows that the average age of the study abroad student respondents is around **25** years old with the number of male and female participants almost equal. In addition, the students' average duration of stay is around **14** months. As for their study abroad program types, a little over half or around 51% of the participants are non-degree seeking or short-term exchange students, while the remaining participants are degree seeking students (see Table 1 for more details).

Table 1. Participants' background demographics ($N = 665$).

Gender	Age (years)		Duration (months)		Degree seeking	
	M	*SD*	*M*	*SD*	Yes (%)	No (%)
Female ($n = 332$)	24.52	5.85	13.69	22.69	158 (47.6%)	174 (52.4%)
Male ($n = 333$)	26.22	7.28	15.04	23.70	165 (49.5%)	168 (50.5%)

3.1 Study Abroad Internet Use Motives Survey (IUM)

IUM is composed of 3 factors, namely (together with their original Alpha reliabilities): *Online Benefits* (OB, 4 items, $\alpha = .88$) – these are the notions that internet use is able to help reduce both social and academic difficulties. *Online Habits* (OH, 4 items, $\alpha = .86$) – these are the students' behaviors regarding the use of social networking sites (including messaging apps). Lastly, *Online Facilitation* (OF, 3 items, $\alpha = .82$) – these are the items related to how students use the internet to facilitate both social and cultural activities [54, p. 1208].

Table 2 shows the various IUM factors, together with their current Alpha reliabilities, and item means (*M*) and standard deviations (*SD*). Data shows that generally speaking, students are quite adept in using the internet to make their study abroad experience more fruitful. This is further noted with the highest rated item to be "*Look for a place of interest to visit*" with a mean of $M = 4.68$ ($SD = 0.64$), suggesting the facilitation for local tourism in Taiwan. Similarly, the second highest rated item "*Look for a cultural event that I will attend*" with a mean of $M = 4.53$ ($SD = 0.79$), denoting high levels of intention in learning more about the local cultures in Taiwan. In sum, study abroad students in Taiwan are seen as highly capable in using the internet within their social, academic, and leisure activities.

Table 2. IUM factors and items ($N = 665$).

Factor/Items/Cronbach Alpha Reliability	*Mean*	*SD*
Online Benefits ($\alpha = .82$)	**4.28**	**0.73**
OB01. Help me feel accepted	4.18	0.95
OB02. Help me feel more confident in interacting with the local Taiwanese culture	4.35	0.88
OB03. Help me perform better in my courses	4.25	0.93
OB04. Help reduce my academic problems	4.34	0.88
Online Habits ($\alpha = .80$)	**4.28**	**0.73**
OH01. Regularly interact with my friends online	4.38	0.89
OH02. Use email, Facebook or any other online services as a way to communicate	4.33	0.90
OH03. Regularly update my online posts	4.11	1.00
OH04. Have an online account that I use regularly	4.32	0.91
Online Facilitation ($\alpha = .73$)	**4.48**	**0.59**
OF01. Look for a cultural event that I will attend	4.53	0.79
OF02. Look for a place of interest to visit	4.68	0.64
OF03. Look for a leisure activity that I can join	4.22	0.75

3.2 Service Quality (SERVQUAL)

To collect the study abroad students' perception of university service quality, a self-made SERVQUAL instrument is developed with the consideration of several previous researches [41, 48, 51]. To validate the instrument, confirmatory factor analysis is accomplished. Factor analysis is a highly used method in checking whether survey items with similar construct are able to successfully group together [53]. The factorability of the proposed 21 items is first subjected to several criteria for factor analysis. First, the items were checked to having a primary factor loading of above .50 and no cross-loading of above .32 [61]. Second, the Kaiser-Meyer-Olkin value was computed to be **.84** well above the acceptable value [62]. Lastly, the Barlett's test of sphericity was computed to be at 4,294.4 with Chi-square to be significant ($p < .000$) and degrees freedom of 210, signifying acceptable values [63].

Table 3 shows the various SERVQUAL factors together with their items, means, *SD*, including their computed Alpha reliabilities, factor loadings, communalities, and variance explained. It is noted that the study abroad students' perception of service quality is considered to be fairly adequate. This can be seen with the overall mean of SERVQUAL to be computed at $M = 3.59$ ($SD = 54$). In addition, the highest rated item is "*Physical appearance of infrastructures (e.g. buildings, offices, campus grounds)*" with a mean of $M = 4.12$ ($SD = 0.88$), suggesting the effort placed by universities to upgrade their facilities. However, the lowest rated item is "*Faculty provides prompt response to students' inquiries*" with a mean of $M = 2.85$ ($SD = 1.09$), signifying the need for the improvement of quality interactions between students and faculty.

Table 3. Proposed SERVQUAL confirmatory factor analysis ($N = 665$).

Factor/Items/Cronbach Alpha/Variance Explained	*Mean*	*SD*	Communalities	Factor Loading
Tangible ($\alpha = .84$, 16.73%)	**3.88**	**0.70**		
Ta01. Teaching facilities (e.g. classroom, laboratory)	3.93	0.92	.664	.789
Ta02. Campus recreational facilities (e.g. swimming pool, basketball court, gym)	3.97	0.94	.635	.790
Ta03. Library facilities (e.g. collections, digital resources)	3.81	0.96	.519	.689
Ta04. Physical appearance of infrastructures (e.g. buildings, offices, campus grounds)	4.12	0.88	.572	.719

(*continued*)

Table 3. (*continued*)

Factor/Items/Cronbach Alpha/Variance Explained	*Mean*	*SD*	Communalities	Factor Loading
Ta05. Physical appearance of staff (e.g. faculty, non-teaching personnel)	3.78	0.93	.541	.666
Ta06. Professionalism of staff (e.g. faculty, non-teaching personnel)	3.68	1.04	.477	.619
Reliability ($\alpha = .75$, 12.26%)	**3.68**	**0.77**		
Ra01. Providing services as promised (e.g. course offerings)	3.67	1.14	.436	.546
Ra02. Providing on time services as scheduled	3.81	0.99	.644	.760
Ra03. Performing the service right at the first time	3.53	1.13	.548	.723
Ra04. Telling when services will be performed	3.54	1.08	.498	.678
Ra05. Shows sincerity in solving problems	3.86	1.09	.511	.624
Responsiveness ($\alpha = .80$, 11.63%)	**3.42**	**1.08**		
Re01. Staff provides prompt response to students' inquiries	3.08	1.10	.717	.814
Re02. Staff provides appropriate assistance to students' administrative needs	3.45	1.07	.672	.752
Re03. Faculty provides prompt response to students' inquiries	2.85	1.09	.619	.769
Re04. Faculty provides appropriate assistance to students' academic needs	3.71	1.02	.591	.646
Assurance ($\alpha = .58$, 8.73%)	**3.27**	**0.84**		
As01. Value of education from the university	3.72	1.15	.466	.644
As02. Quality of counselling services (e.g. career, psychological)	3.70	1.13	.473	.644
As03. Qualification of faculty	3.52	1.27	.396	.549
As04. Quality of education	3.84	1.09	.556	.703
Empathy ($\alpha = .63$, 7.22%)	**3.70**	**0.77**		
Em01. Place students' interest first	3.43	1.25	.609	.707
Em02. Understand specific needs of students	3.40	1.28	.735	.820

Lastly, to further validate the proposed SERVQUAL instrument, Structured Equation Modelling is used to explain the possibility of relationships among the items and latent variables [64]. Results show that the measurement model has a Chi-square of 5696.35 with $df = 136$, which is significant with $p < .000$ and a root mean square error of

approximation (RMSEA) value of .060 all of which are within the acceptable CFA values [64]. Furthermore, several comparative fit indices such as: Normed Fit Index (NFI) = .93, Non-Normed Fit Index (NNFI) = .94, Comparative Fit Index (CFI) = .95, Incremental Fit Index (IFI) = .95, and Relative Fit Index (RFI) = .92 are also computed; all of which are within acceptable values [64–66]. Hence, the proposed SERVQUAL instrument can be said to be an empirically validated scale.

3.3 Center for Epidemiologic Studies Depression Scale (CES-D)

The CES-D is a highly used 20 items short depression scale. For the current study, the average depression score for the study abroad students is computed to be at $M = 12.17$ ($SD = 8.90$), signifying study abroad students in Taiwan are relatively happy (similar to the previous result noted by Lin and Ching [54]). As a rule of thumb depression values greater than or equal to 16 is considered to be depress [55].

4 Results and Discussions

As for the predictability of IUM and SERVQUAL towards study abroad students' depression, regression analysis is accomplished. Prior to the regression analysis, correlations among the factors are first computed. Table 4 shows the various with almost all of the IUM and SERVQUAL factors correlated with each other, denoting high linear associations each other [67]. In addition, a standard multiple regression analysis was performed between the dependent variable (CES-D; depression) and the independent variables (IUM factors; online benefits, online habits, online facilitation, and SERVQUAL factors; tangibles, reliability, empathy, responsiveness, assurance). Analysis was performed using SPSS regression.

Assumptions were tested by examining the plots and diagrams or residuals with no violations of normality, linearity, or homoscedasticity of residuals were detected [68]. Regression analysis revealed that the model significantly predicted study abroad students' depression, $F\ (8, 656) = 0.20, p < .000$. R^2 for the model was .10, and adjusted R^2 was .09. Table 5 shows the unstandardized regression coefficients (B), intercept, and standardized regression coefficients (β) for each variable.

For each of the individual predictors (independent variables; IUM and SERVQUAL factors), IUM factors *online habits* ($t = -2.32$, $p < .020$), *online facilitation* ($t = -2.95$, $p < .003$) and SERVQUAL factors *tangibles* ($t = -2.30$, $p < .022$) and *reliability* ($t = -3.54$, $p < .000$) each significantly predicted depression (see Table 4 for the means and SDs). Note that the t values are negative, hence, the factors are said to be able to significantly minimize study abroad students' depression.

Table 4. Pearson correlations, means, and standard deviation for the factors ($N = 665$).

	Factors	1	2	3	4	5	6	7	8	9	10	11
1	Age (Years)	1.00										
2	Duration (Months)	.088*	1.00									
3	Online Benefits	−.067	−.158**	1.00								
4	Online Habits	−.099*	−.007	.446**	1.00							
5	Online Facilitation	−.113**	.043	.390**	.415**	1.00						
6	Tangibles	.092*	−.025	.245**	.213**	.157**	1.00					
7	Reliability	−.006	−.074	.194**	.196**	.132**	.370**	1.00				
8	Empathy	−.033	−.066	.208**	.155**	.124**	.243**	.414**	1.00			
9	Responsiveness	.081*	−.062	.182**	.177**	.079*	.456**	.199**	.174**	1.00		
10	Assurance	−.029	.06	.058	.230**	.178**	.126**	.306**	.290**	.178**	1.00	
11	CES-D	.074	.067	−.093*	−.186**	−.186**	−.197**	−.237**	−.153**	−.102**	−.124**	1.00
	Mean	25.37	14.37	4.28	4.28	4.48	3.88	3.68	3.42	3.27	3.70	12.17
	Standard Deviation	6.65	23.19	0.73	0.73	0.59	0.70	0.77	1.08	0.84	0.77	8.90

Note. *$p <$ .05 level (2-tailed). **$p <$ .01 level (2-tailed).

Table 5. Regression analysis for study abroad students' depression ($N = 665$).

Factors	B	SE B	β	*t*	Sig.
(Constant)	35.857	3.252		11.026	.000
Online Benefits	0.799	0.536	0.066	1.491	.136
Online Habits	−1.255	0.540	−0.103	**−2.323**	**.020**
Online Facilitation	−1.898	0.644	−0.125	**−2.948**	**.003**
Tangibles	−1.298	0.564	−0.103	**−2.301**	**.022**
Reliability	−1.801	0.508	−0.155	**−3.542**	**.000**
Empathy	−0.356	0.345	−0.043	−1.032	.302
Responsiveness	0.009	0.447	0.001	0.021	.983
Assurance	−0.102	0.471	−0.009	−0.216	.829

5 Conclusions

The current study used a survey questionnaire and collects information regarding the study abroad students' perceived service quality of their host universities and together with their internet use motives to predict their tendencies to become depress. Results of the study shows that two factors of the internet use motive variable are quite useful in minimizing depression. First, the students' *online habits* which are the tendencies wherein students are able to use the internet (either with their personal computers, laptops, or smartphones) to communicate with their family and friends. This also denotes that students are able to use the technologies that they are familiar with. Hence, availability and accessibility to internet connection would seem crucial. Second, students are able to use the internet to *facilitate* their social and leisure activities. This can be useful as long as the students are able to successfully enjoy or participate in the activities.

As for the study abroad students' perceived university service quality, the results noted that the physical *tangible* properties of the institution matters. This means that the actual infrastructure and facilities should be pleasing to the students. More specifically, these tangibles should have both functionality and appeal to the students. Similarly, study abroad students also values the *reliability* of the services provided. Consistency and accuracy of the services are very important. In essence, these service qualities issues should be continue, while the other non-significant factors should be enhanced. Lastly, findings of the current study shall provide institutional providers and researchers with valuable information with regards to service quality improvement, which ultimately leads to a more fruitful and less stressful study abroad experience.

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Development of a Virtual Laboratory for Nanoscience Experiments Using High-Speed Academic Network Technology

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Abstract. The main objectives of knowledge society are generating, sharing and making available to society knowledge that may be used to increases life quality on Earth. In order to share knowledge worldwide, it is important to guarantee an efficient connection for the scientific community, making collaborative spaces an essential tool. The emerging nanoscience and nanotechnology fields allow scientists and researchers to study different phenomena at a molecular scale. The development of novel microscopes such as SEM, TEM, AFM and spectroscopes such as NMR has foster multidisciplinary research groups where physics, chemistry, biology, engineering, and other careers converge to face questions to be solved from several points of view. In this study, smart virtual knowledge spaces, accessible through the worldwide web through high-speed networks and Grid environments will be discussed. A case study where AFM is used to study cell membranes will be shown as an example of a virtual laboratory.

1 Introduction

This article presents the design of a virtual laboratory including SEM, TEM, NMR, and AFM, using a worldwide connection via high-speed networks such as CLARA, IRIS and GEANT. These networks are next-generation Internet 2-based, which use free software platforms to share knowledge through e-learning, science and Web 3.0 tools. Aiming to expand the internationalization of Colombian universities, we propose a technological modem for a virtual laboratory including remote microscopy services, fostering thus the knowledge and technology transfer through a synergy between software engineering and knowledge management [1]. Concerning the academic and scientific community in Colombia, high-speed academic networks such as RENATA at national level and CLARA at Latin American level have been used. There are also worldwide initiatives supported by governments and integrated into networks of high speed such as Internet2Network in United States, GEANT in Europe and TEIN3 in Asia and Pacific. Nevertheless, in spite of the high quality bandwidths, there is not any model providing an efficient integration among Colombian research groups and the International scientific community via these networks.

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The currently implemented networks offered by the internet service providers (ISPs) around the world, usually obey a classical network structure, which is characterized by a narrow bandwidth. Offering a high-speed access implies an expensive technological implementation which can be afforded in countries such as Korea, Japan and China, but not in developing countries such as Colombia. The new generation networks will include wider bandwidth generating faster access speeds, greater security and quality of service. The current situation evidences the need of substantial improvements in the way content is sent through these applications. These networks are based on Fiber Optic and transmission in wavelengths providing thus wider bandwidths to the end user compared to the 50–100 Mbps speed which is offered to the general user. Another fundamental aspect encouraging the conversion to high-speed networks is the online-education services. Regular Internet users could experience the advantages offered by our high-speed academic network model given that it is independent from the sevices ISPs offer. Users will just need a simple location process and download the corresponding software applications that will be available on the servers. The network will be always the same, but the services will vary depending on their availability and the needs of each user according to the remote experiment (Fig. 1).

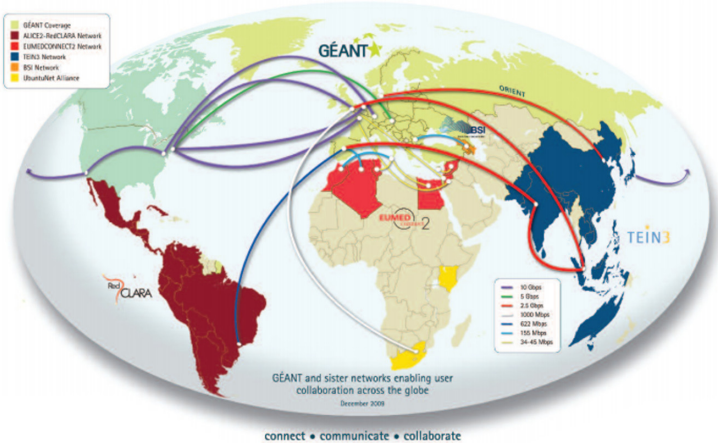

Fig. 1. GÉANT, RENATA provide connectivity to other world regions, placing Europe at the heart of global research networking [1].

1.1 Collaborative Laboratories for Nanoscience

The increasing use of information and communication technology (ICT) has generated a huge quantity of raw data which is typically transferred via Internet. The scientific community is one of the groups that generates data every day which is not always immediately shared. Researchers working on nanoscience and nanotechnology requires international collaborative spaces to achieve significant results in their multidisciplinary projects, with the aim of promoting its worldwide implementation in all disciplines.

The study of new phenomena that emerge at atomic scale below 100 nm thanks to the development of near-field microscopy, allow the iteration of multidisciplinary groups where physics, chemistry, biology, engineering and others come into play and converge to This nano level the academic and production communities must be able to act in this direction to increase intelligent virtual knowledge spaces, accessible through the Web through high-speed networks and Grid environments.

The new developments focus on the results of the reduction in size in contrast to the sizes of current technology, the paradigm shift is based on the development, preparation and experience of new technological tools that expand the computing and computing capacity to Develop new elements that will be applied in all fields of human beings and their environment. The computational power is constantly increasing and the decrease in the sizes of the systems make the structural, electronic and vibrational properties are in the complex plane of quantum mechanics. Carbon is the fundamental basis for the development of nanotubes or semiconductor quantum dots, these are examples in which anisotropy and dimensionality reduction play an important additional role in the understanding and exploitation of nanosystems.

The development of elements in the Nanosciences is extremely expensive due to the complex equipment and the construction of clean rooms, microscopes or atomic spectrometers and the facilities to carry out these experiments, limits the community that has knowledge in such an important subject, this translates in a bottleneck for teaching, research and development of Nanosciences since the required systems and facilities are not available in all parts of the world, In this sense, the new information technology methods provide the methods and techniques to create an optimized work environment to increase collaborative work among researchers. They can be implemented and accessed independently of the location of the knowledge provider and the knowledge search engine. Some points of view of a collaborative work environment are aimed at educational scenarios, others are oriented towards research processes and industrial applications. All of the above to be technician and led to mass development is what constitutes nanotechnology [2] (Fig. 2).

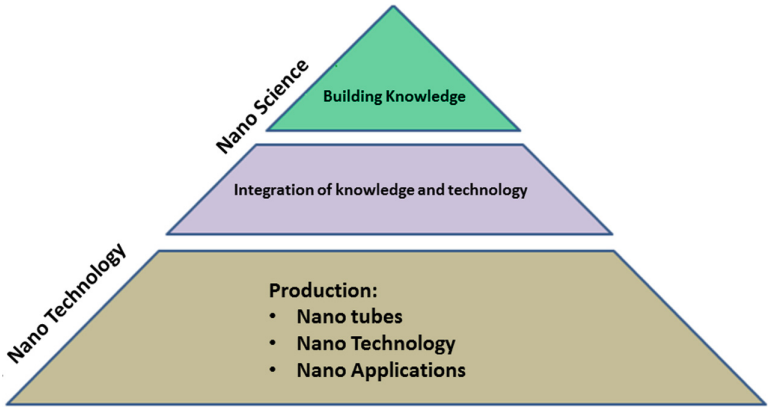

Fig. 2. Transformation of knowledge from nanotechnology to nanoscience [2].

- In medicine, development of nanomaterials applied to health.
- In Communications Technologies, for the development of new devices of low consumption and high resonance.
- New materials for the construction sector based on nanotubes.
- In the chemical, textile and oil industry, water disinfection and new more resistant and intelligent fabrics.
- In electronic and electrical engineering, in the development of various low consumption devices and new alternative energy sources.
- Education and technology transfer, the training of qualified and well-paid staff in all lines of research.
- Transportation, new materials will be created to lighten the existing ones and this will cause less hydrocarbons to be consumed.
- Biology, study of new elements for developments at the bacteriological and molecular level.
- Agriculture, in the development of anti-pest elements, new fertilizers based on nanoparticles (Fig. 3).

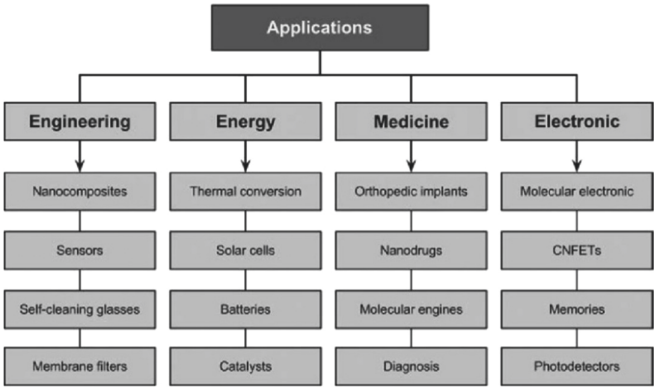

Fig. 3. Areas of application of nanoscience [3].

2 Techniques for Nanoscience Research

2.1 Electronic Scanning Microscope - SEM

The main components of a typical SEM (Scanning Electron Microscope) are: (i) electron column, (ii) scanning system, (iii) detector, (iv) screen, (v) vacuum system, and (vi) electronic controls. The electron column of the SEM consists of an electron cannon, and two or more electromagnetic lenses operating in vacuum. The electron gun generates free electrons accelerating them to energies in the range of 1 to 40 keV. The electron lenses create a small, 10 nm diameter probe focused on the sample electrons [4] (Fig. 4).

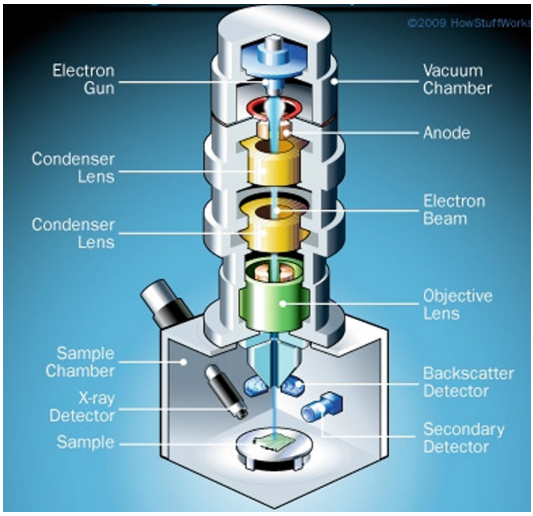

Fig. 4. Components of electronic scanning microscope (SEM) [4]

Typically, the electron beam is defined by the probe diameter in the range of 1 nm to 1 m, the probe or current beam ranges from pA to mA, and the convergence of the probe ranges from -10^{-4} to 10^{-2} radians. The generated electrons are collected by a detector. Then, the resulting signal is amplified and displayed on a computer monitor, where the resulting image is generally easy to interpret (Fig. 5).

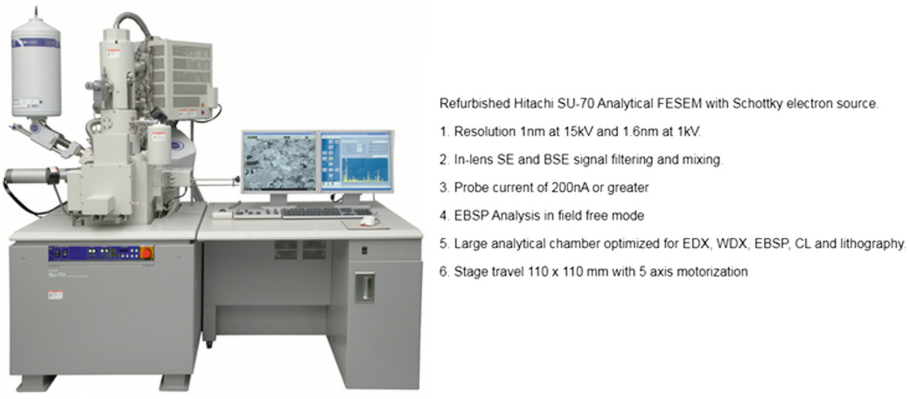

Fig. 5. Hitachi SU-70 network scanning microscope [5]

The electron beam interacts with the sample at a depth of approximately 1 μm. The complex interactions of the beam electrons with the atoms in the sample produce a wide variety of radiation. Understanding the process of image formation is vital for its interpretation. In this case, knowledge of electronic optics, samples with beam interactions, detection and visualization processes are necessary for the successful use of a SEM.

Transmission Electron Microscope – TEM

The way of operation is very similar to that of the SEM, the difference lies mainly in the way it produces the image and the quality of the resolution of the same, in the TEM (Transmission Electron Microscope) the resolution is lower but reaches sharpness in 3D The electron beam is directed on the sample that needs to be cut into very thin sheets, of the order of 50 to 200 nm, a part of these collide and bounce to be absorbed, while the others pass through the sample are those that create the image of the object under observation. The image obtained TEM is in black and white and are two-dimensional images that can be captured in a photographic film (Fig. 6).

Fig. 6. TEM (left) and SEM (right) [6].

A SEM image provides a 3D view of the sample, allowing a detailed study of the shape and size of cells. This is the main advantage of SEM over TEM. However, the SEM has lower power, only reaches 100,000X, and a resolution 1000 times lower than the TEM. Another drawback is that it allows observation of just the sample surface but not their interior [6].

There is one microscope combining both the SEM and TEM where even individual atoms can be visualized (Fig. 7).

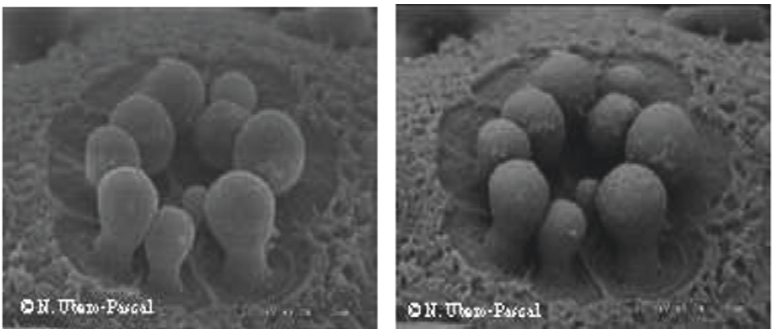

Fig. 7. Difference of the image in a TEM and SEM microscope [6].

Nuclear Magnetic Resonance Spectrometer – NMRS

NMR (Nuclear Magnetic Resonance) spectroscopy was developed in the late 1940s to study atomic nuclei. In 1951, it was discovered that nuclear magnetic resonance spectroscopy could be used to determine the structures of organic compounds. This spectroscopic technique can only be used to study atomic nuclei with an odd number of protons or neutrons or both. This situation occurs in the atoms of 1H, 13C, 19F and 31P that are magnetically active, that is, they have spin as well as electrons, since the nuclei have a positive charge and have a rotational movement on an axis that makes them behave As if they were small magnets. In the absence of the magnetic field, the nuclear spins are randomly oriented. However, when a sample is placed in a magnetic field, nuclei with positive spin are oriented in the same direction of the field, in a state of minimal energy called spin state α, while nuclei with negative spin are oriented in the opposite direction to that of the magnetic field, in a state of greater energy called spin state β [7].

When a sample containing an organic compound is irradiated in RF Radio Frequency by an intense pulse of radiation, the nuclei are promoted to the spin state. When the nuclei return to their initial state they emit signals whose frequency depends on the difference in energy between the spin states. The NMR spectrometer detects these signals and registers them as a frequency chart with intensity, this is what is known as the NMR spectrum. The term nuclear magnetic resonance comes from the fact that the nuclei are in resonance with radiofrequency or RF radiation. Every NMR spectrometer consists of four parts:

1. A stable magnet, with a controller that produces a precise magnetic field.
2. An RF radio frequency transmitter, capable of emitting precise frequencies.
3. A detector to measure the radio frequency energy absorption of the sample.
4. A computer and a graphing program to make the graphs that constitute the NMR spectrum.

To see an NMR spectrum, a small amount of the organic compound dissolved in half a milliliter of solvent is placed in a long glass tube that is located within the magnetic field of the apparatus. The tube with the sample is rotated around its vertical axis. In modern devices the magnetic field remains constant while a brief p [7].

Atomic Force Microscope – AFM

Since its invention, the AFM has become a versatile tool for the study of biological and model samples [8]. As previously mentioned, supported lipid bilayers (SLBs) are one of the typical model samples to study the mechanical properties of lipid membranes. AFM imaging has been used to characterize the topography of lipid membranes, whereas AFM-based force spectroscopy (FS) has been used to study elastic and viscous properties of lipid bilayers.

AFM-FS, relying on approach and retraction force curves (FCs), provides a nanoscale approach to study mechanics of lipid membranes, allowing the study of forces between 10 pN and 10 nN. A FC represents the cantilever deflection as a function of the piezo position, which controls the relative movement between the sample and the cantilever-supporting chip. Both approach and retraction FCs can be recorded, providing diverse

information from the tip-sample interaction such as binding properties, adhesion forces, sample elasticity, folding and unfolding of molecules, which depends on the chemical nature of the lipids composing the SLB and on the chemical nature of the AFM tip surface.

3 Online Experiments Using AFM: A Case Study

AFM measurements will be performed using a Bioscope I microscope equipped with a Nanoscope IIIA controller (Digital Instruments Inc.), equipped with an E scanner having a maximum lateral scan area of 100 μm × 100 μm, using 120 μm long non-conductive silicon nitride V-shaped cantilevers (DNP-S tips, Veeco), with nominal spring constant of 0.24 N/m (provided by the manufacturer).

AFM topographic images will be acquired in tapping mode. The force applied on the sample will be maintained at the lowest possible value by adjusting the set point. All the images would be captured as 512 × 512 pixel images at scan rates of between 1 and 2 Hz depending on the scan size, using a tip oscillation frequency of about 8.5 kHz. AFM image analysis will be conducted using the Digital Instruments Nanoscope software (Nanoscope Analysis 1.5). Height images will be flattened (zero order) and plane-fit (third order) in the x- and y- scan directions. Quantitative height measurements will be determined by section analysis. Temperature of the sample will be controlled by a water bath (Lauda – E100/RE104) when using only a mica disc, and by Peltier cells when using the home-made chambers.

The jump through force from the approach curves will be typically measured from 1024 different curves (32 × 32 FV map) and plotted in histograms (Fig. 9) using a custom-developed software.

In this research study example, we will concentrate on the approach curve (Fig. 8), in order to analyze the jump through force (JTF), which will be explained below. When the AFM tip approach the lipid bilayer, a repulsive electrostatic interaction is observed given the negatively charged nature of the lipid bilayer and the AFM tip (small black double arrow in the FC in Fig. 8). The spatial extension of this interaction depends on the ionic strength of the bulk solution, and is determined by the Debye decay length, typically reaching tens of nanometers. Just before physical contact between the bilayer and the AFM tip, hydration and steric forces associated with the removal of water molecules can produce small repulsive forces [8]. Once contact between the tip and the sample is established, a region of elastic deformation is encountered in the approach curve. Several models have been proposed to analyze the elastic deformation of a SLB. The usual description of the indentation-force relation is based on the Hertz model and some of its derivations. The Hertz model derives from an elasticity theory based on the continuum approximation of interacting bodies [9]. However, it is not adequate to describe the elastic deformation of lipid bilayers over a solid support because it describes one of the interacting bodies as an infinite half-space and not as a thin film like a lipid bilayer. Some modifications have been proposed in order to take into account the finite thickness of the bilayer [10].

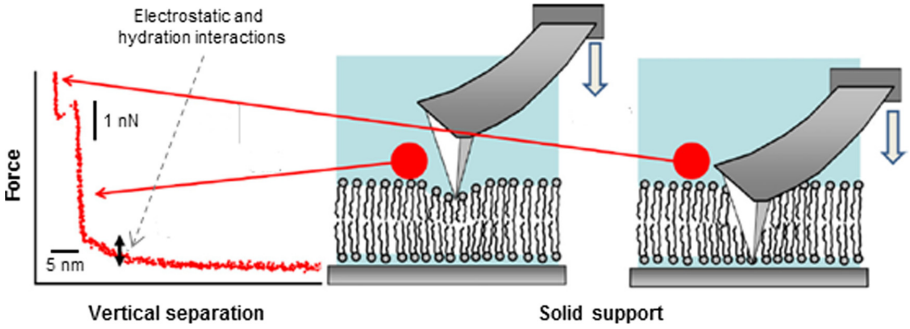

Fig. 8. Scheme of a force curve performed on a supported lipid bilayer. Modified from [17]

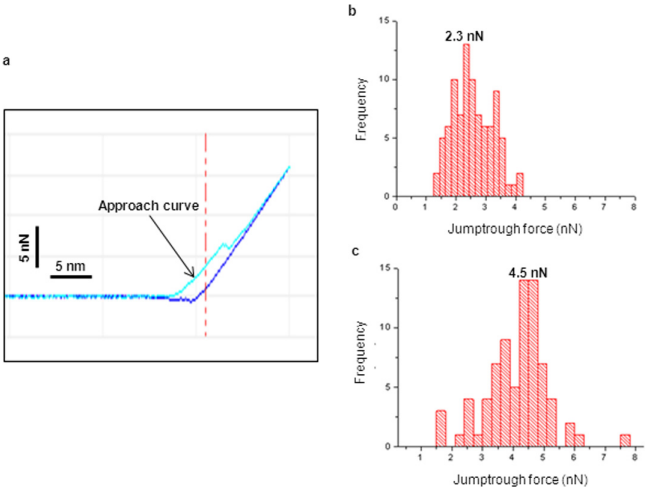

Fig. 9. Force spectroscopy analysis of the effect of Mag-H2 on SLBs. a) Example of a force curve on a DOPC SLB; b) Histogram of the JTF values for a DOPC SLB without peptides; c) Histogram of the JTF values for the same SLB in b) after it has been exposed to 1.5 μM mag-H2

On the other hand, the jumpthrough event, which occurs when the approaching AFM tip pierces the SLB, is reflected by a jump in the approach curve (Fig. 9). The force at which this jump occurs, or JTF, provides information about the mechanical stability of the lipid bilayer, and depends on parameters such as temperature [11], ionic strength, pH [12], indentation speed, and even on the way SLBs are prepared [14]. Considering all the possible parameters which could affect the experimental values, comparing results among different research groups should be done carefully in order to avoid misinterpretations. If FCs are collected from several points in a region of the bilayer, a 2D map of the tip-surface interaction could be retrieved [8]. Each FC correspond to a pixel, and the FCs as a whole form a 3D force volume (FV) map, usually consisting in FCs acquired over a large area in a grid pattern. Each FC can be assigned to a pixel

of a topographic image as a result of the z-position at which a predefined force set-point is reached. Nevertheless, due to the slow acquisition time of the FV map, the lateral resolution of the obtained image is limited.

Combining AFM imaging with fluorescence microscopy, and considering diverse lipid compositions for SLBs, we would obtain plentiful information about the effect of the antimicrobial peptide magainin-H2 (mag-H2) on SLBs.

Finally, the combined AFM-FS experiments will allow us to dissect that an apparent stable SLB, as observed by fluorescence microscopy, can lose its structure, which was reflected by the absence of the jump through event. Therefore, it is evident that mag-H2 affects the lipid bilayer at concentrations before pore formation takes place. Moreover, the exposure of the lipid bilayer to mag-H2 induced an initial increase of the jump-through force measured by AFM-FS. Apparently this result could be interpreted as a stabilization effect of the peptides on the lipid bilayer, contrary to what has been found for other AMPs such as magainin. However, we interpreted this increase of the jump-through force value as due to an increased lateral pressure in the lipid bilayer as a result of a prevented lateral expansion of the SLB.

4 Methodology Developed to Support Virtual Instrumentation

In many portals where there is talk about the access platform to virtual preparation courses either free use such as Moodle or Blackboard with their respective collaborative tools, it is important to verify the real conditions and the adaptation of these portals, to have a physical laboratory that is really accessible virtually; To achieve this it is important to take into account the aspects proposed in Knowledge Management. As a starting point, it is necessary to combine network architectures based on TCP-IP, technologies based on Web development, monitoring functions and digital remote control or real-time remote control, data measurement remotely, and reading user access logs and naturally support real experiments remotely.

4.1 Aspects for the Design of a Virtual Nanoscience Laboratory

The design of a laboratory that supports virtual instrumentation must be based on Information Technology and ICT Communications, all aspects related to communications, sensors, actuators, measuring instruments and controls related to this must be taken into account, therefore it is very important that these devices have interfaces and protocols that support TCP-IP, the development of the virtual Web interface must be friendly, it must have a network control interfaces module, it must support monitoring operations and subsystems for the allocation of schedules for practices and their relationship with theoretical topics.

- Development adapted to the specifications of the virtual laboratory.
- Determine the real-time needs of laboratory operation at the level of hardware, software, network and peripheral input and output devices.
- Must be reconfigurable, topology changes, operating systems must be easily changed.

- Must support multiple technology manufacturers.
- Scalable, if you have multiple students at the same time you must support them.
- Cost efficient, it must be economical with respect to the cost benefit and its maintenance and sustainability over time.
- Robust, must be able to withstand mistakes made in practices or tests by students or related students.
- Isolated, the virtual laboratory traffic must be separated from the real laboratory traffic.
- The laboratory must have practices similar to reality that allow solving real problems.
- The control interface must be based on TCP-IP
- IP network servers based on free software with redundancy.
- You must have a database installed.
- Data storage for data processing under tools such as Data Mining, neural networks, R and data science.
- Must support Grid clients based on TCP-IP and Ethernet standards.
- Use intelligent sensors and actuators with Ethernet interfaces according to the needs and embedded circuits, Zigbee, RFID, WiFi, FPGA, and the like.
- The core of the network must be based on high-speed Ethernet, minimum 10 Gigabyte Ethernet.
- Must have support for the development of distributed applications.
- Develop developments capable of supporting proprietary manufacturer components such as USB interfaces, IEEE 488, 485, embedded Web servers, Opto22 type interfaces, support for analogue and digital inputs and outputs.
- Support of instrumentation devices such as multimeters, voltage sources and similar ones.
- Web connectivity robotic cameras to view and feed labs and microphones.
- Web type client support from Internet and Intranet [15].
- Support of procedure calls through Web servers, applets, Invocation of methods performed in Java, Clients in languages such as C,.Net, C # and other developments.
- Must support XML, OWL and SOAP.
- Grid security at Web and network level and Blockchain Technology [16].
- Verify and test the system to make the necessary adjustments.
- Connectivity via wireless network or cell phone.
- Personnel in charge of the laboratory for the man-machine and maintenance interface.
- The use of large amounts of data, Big Data, and its statistical analysis for predictive purposes (Machine Learning) [17], can be used to analyses the data generated by the virtual laboratory (FIg. 10).

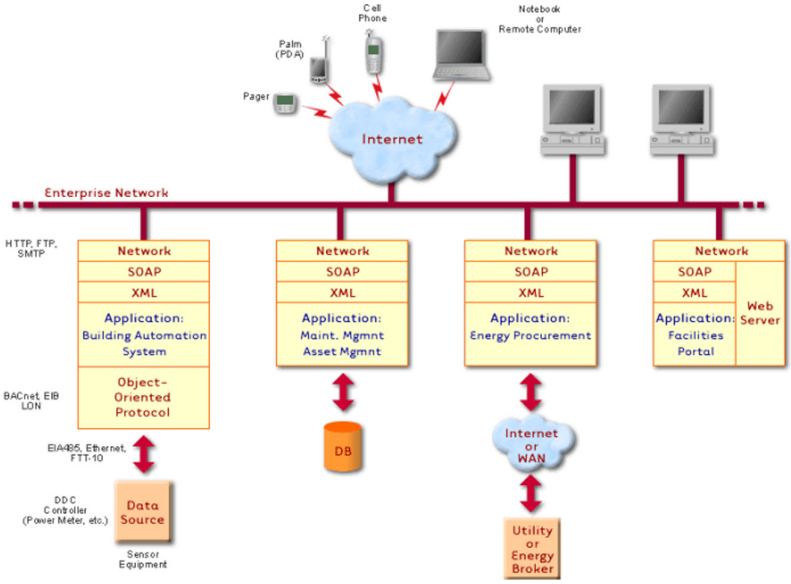

Fig. 10. ITC Grid design of a virtual nanoscience laboratory.

5 Conclusion

This article presents several important aspects for the implementation of a virtual laboratory for work in nanoscience, and many key points for the development of subsequent lines and research groups in Colombian universities under these technological guidelines. The relevant aspects of Grid computing as an innovative technology allow us to use all kinds of resources such as computing power, mass storage and specific applications for research fostering, not subject to a centralized control. In this sense, our model represents a new form of distributed computing, in which resources can be heterogeneous -different architectures, interconnected supercomputers, clusters and other developments-, and are connected through high-speed academic networks.

Nanotechnology offers applications in several areas and lines of research that may generate patents and foster the creation of new technological knowledge in the future. It is important to count with the support of national and international research laboratories offering virtual or remote access to microscopes, which usually are quite expensive and sparse in Colombian universities. Lastly, taking into account the recent creation of the Ministry of Science, Technology and Innovation (MinCiencias) in Colombia, our proposal would highly contribute to boost the publication of high-quality research results in Q1 journals, international research congresses around the world, making Colombia become a world-class country in the scientific community.

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TPACK Within a Flipped Learning Course Design: Reflections from 5 years of Implementation

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Abstract. The implementation of flipped learning course design has been gathering paced with various positive voices being heard from teachers of different discipline. In reality, flipped learning is actually a sort of *reboot* of the previous notion of having the students read and go over the lesson topic in advance, while coming to class ready for discussions and/or participate in activities. The only difference is that the assigned readings now are mostly in the form of digital contents. For the past five years, flipped learning design was implemented on a required course within a university in Northern Taiwan. This required *Educational Foundation* course is also taught in English. Within the entire 18 weeks long semester, 10 topics were carefully selected as the focus of the flipped learning design. Various in-class activities are then designed not only to focus on individual learning, but instead on collaborative discussions and group presentations. At the end of the semester, a short survey questionnaire asking students about their attitudes and satisfaction towards the course were collected. In addition, unstructured interviews with randomly selected students were also accomplished. Within the five years of implementation, results of survey questionnaire showed that students actively joined 76% of the classroom activities with a total satisfaction rating of 3.92 (5 point Likert type scale). Furthermore, collected interviews themes are analyzed using the *Technological Pedagogical Content Knowledge* (TPACK). Lastly, overall results pointed out the importance of pedagogical design in the success of the course implementation.

Keywords: Student engagement · Active learning · Pedagogy · Collaborative learning · YouTube

1 Introduction

1.1 Flipped Learning Design

Within the past few years, the flipped classroom learning design has been reported to provide positive impact on the teaching and learning process [1]. Similarly in Taiwan, the trend of flipped learning has spread like wildfire [2], drawing tens of thousands practitioners to workshops and online discussions [3]. Actually, this pedagogy is not a

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new approach to teaching [4]. Flipped learning pedagogy is the distinct notion of *flipping* [5] or *inverting* [6] the class. More specifically, flipped learning approach is the adaptation of three distinct changes in teaching, namely: 1) the change in *space*; wherein the first contact of the learning material is done outside the classroom, 2) the change in *time*; wherein the time of learning is unstructured with students able to interact with the lesson material at their own pace, and 3) the change in *activity*; wherein classroom activities are now geared towards active learning as against the traditional direct instruction [4].

In addition, the flipped learning model also follows the four pillars of implementation [7]. First, *flexible environment*; wherein learning is channel through various modes or platform, second, *learning culture*; wherein the teaching-learning process is changed from the traditional teacher-centered to the student-centered learning approach, third, *intentional content*; wherein classroom activities are designed so as to maximize an engaged active learning approach, and lastly, *professional educator*; wherein the teacher acts as a facilitator of knowledge and at the same time provide constructive feedbacks to the students. In essence, these key concepts laid the foundations for successful flipped learning pedagogical designs.

Within the literature, the flipped learning pedagogy or rather the flipped style of teaching has shown to have greatly influence various fields of learning. An analysis of 20 flipped learning research used in teaching different subject disciplines, reported that in-class activities are able to successfully promote students' sense of achievement, motivation, engagement, and interaction [8]. While, another review of 62 flipped learning articles on engineering education reported modest to moderate increased on students' academic performance [9]. In another paper on the analysis of 45 studies of flipped learning used in medical courses, results show that some distinct best practices included before-class online discussions and in-class problem-based learning [10]. Still, an analysis of 227 papers which reports the distinct changes in the role teachers played in the teaching learning process [11]. In essence, flipped learning has change the previous traditional classroom experience into a more improved student learning outcome and more efficient use of school resources [12].

In Taiwan, implementation of the flipped learning design is highly encouraged with diverse research findings. Within the foreign language learning in Taiwan, a study showed that students' performance is quite related to their appreciation of the relationship between the pre-recorded lectures and in-class activities within a flipped learning design [13]. In addition, an English writing class utilizing flipped learning strategies showed that the after-class reflective journal are able to help students with different learning styles improve their writing [14], while another study showed that the various in-class activities associated with flipped course design are able to help lessen students' learning anxiety [15]. In sum, all of these studies have acknowledged the important role pedagogical design played in flipped learning courses [16].

1.2 Technological Pedagogical Content Knowledge (TPACK)

With regards to technology integrated teaching, TPACK explained the three core components of a course design, which are the content, pedagogy, and technology, including the relationships among and between them [17, 18]. This framework is actually based on how teachers understand educational technologies and how these pedagogies, contents,

and knowledge, interact with each other to produce effective teaching with technologies [19, 20]. Currently, the most frequently cited framework is described with three overlapping teachers' knowledge (content, pedagogy, and technology) such as: **CK** (content knowledge), **PK** (pedagogical knowledge), and **TK** (technological knowledge), while including their subsequent interactions such as: **PCK** (pedagogical content knowledge), **TCK** (technological content knowledge), **TPK** (technological pedagogical knowledge), and **TPACK** (technology, pedagogy, and content knowledge) [21, 22].

Within the literature, the application of TPACK is quite varied and diverse [23, 24]. TPACK has been used to analyzed how teachers are using technology within social studies courses, results show that besides the balanced of blending technology, pedagogy, and content of the lesson, cooperation between the teachers and in-school information technology (IT) personnel are also seen as crucial in making the lesson effective [25]. TPACK can also be used as a framework for evaluating teachers' competencies in their ability to use various technology tools in online teaching [26]. Similarly, TPACK was also used to evaluate grade school teachers' use of technology in teaching elementary mathematics [27]. In the other way around, TPACK can also be used as a model for course design, such as in nursing education [28] and even pre-service teacher training on IT integrated teaching [29, 30]. In essence, in recent years TPACK has proven to be an important tool in helping frontline practitioners in making the teaching learning process effective.

2 Methodology

The current study is a mixed-method research design, wherein the approach of the inquiry is a combination of both qualitative and quantitative data incorporated in the analysis [31]. For the participants of the study, a total of **277** freshmen students from 2015 to 2019 school years (SY2015 – 46, SY2016 – 56, SY2017 – 60, SY2018 – 53, and SY2019 – 62) enrolled in the college of education at a private comprehensive university in the Northern part of Taiwan took part in a required *English* taught *Foundation of Education* course. Within the entire 18 weeks long semester, **10** topics were carefully chosen as the focus of the flipped learning design. Within the concepts of flipped classroom learning, students are expected to go through, read, and understand the lesson materials in advanced prior to coming to class, while actual class time are reserve for more in-depth discussions, analyzing, and synthesizing of the lesson topics.

For the flipped learning design, 10 lesson topics are chosen, namely: *the meaning of education*, *future skills* (the role of university in developing such skills), *are grades important*, *multiple intelligences*, *Maslow's hierarchy of needs* (its relation to education), *Bandura's social learning theory*, *the role of the 21st century teachers*, *responsibilities of students*, *diversity within the school*, and *study abroad*. For the flipped learning instructions, prior to coming to class, assigned readings and topic related videos (carefully selected web resources and YouTube videos), and together with several guide questions are given to the students one week in advance before the actual scheduled class time. Students are tasks to go through the readings and videos while keeping in mind the provided guide questions. Students are also told that they can also make notes or write down their answers to the guide questions so as to aid them in the later in-classroom discussions.

During class time, students are given a few minutes to recall the topic at hand, while instructions for the activities are given. In-class activities are designed so as to provide opportunities for cooperative learning and critical thinking. In addition, in-class activities such as: *mind mapping*, *poster making*, *World Café discussion*, *brain storming session*, *self-discovery*, *team building activities*, *movie critic*, *group project reporting*, and many others are utilized to promote interactions between the students and the teacher.

At the end of the semester, a short survey questionnaire asking students about their attitudes towards the course and their satisfaction with the course were collected. In addition, interviews with randomly selected students were also accomplished. Data collected were then tabulated and analyzed.

3 Results

3.1 Students' Attitudes Towards the Flipped Learning Design

Results from the data collected from the survey are separated into two parts: attitudes towards the course and satisfaction with the course. Table 1 shows the results of the students' attitudes towards the course during the five years of implementation of flipped learning. For the attitudes towards the course, at the end of each semester, students are asked to reply the frequency in percentage of the entire semester of the 18 weeks of class. For instance, the attitude *actively joins classroom activities* with an average of 76.06%; this signifies that for the past five years students actively joins classroom activities 76% of the time or approximately around **14** of the 18 weeks. This result is quite promising, since students can be considered to be quite interested with the in-class activities.

Table 1. Attitudes towards the course.

Attitudes	2015[1]	2016[2]	2017[3]	2018[4]	2019[5]	Ave.	Weeks
Comes to class prepared	25.40	14.81	20.69	27.27	13.46	20.33	4
Comes to class on time	71.43	74.07	72.41	68.18	65.38	**70.29**	**13**
Listen attentively during class	74.60	64.81	55.17	68.18	63.46	65.24	12
Actively joins classroom activities	87.30	75.93	68.97	75.00	73.08	76.06	14
Accomplish assigned task on time	57.14	64.81	55.10	45.45	59.62	56.42	10

Note. [1]$N = 46$, [2]$N = 56$, [3]$N = 60$, [4]$N = 53$, and [5]$N = 62$. Total number of student participants for five years is 277.
Scale used is frequency in percentage of the semester, wherein 100% means all the time (18 weeks).

Table 1 also shows that students *comes to class on time* with 70.29% or 13 out of the 18 weeks, *listen attentively during class* with 65.24% or 12 out of the 18 weeks, and *accomplish assigned task on time* with 56.42% or 10 out of the 18 weeks. These results are very positive denoting that students are really motivated during in-class activities. However, for the attitude *comes to class prepared*, students reported that only around 20.33% or 4 out of the 18 weeks that students are able to have ample preparation before

coming to class. This means that the students are not able to go into the before-class readings or watch the assigned videos. In other words, students are not able to watch and read the assigned readings. During the subsequent random interviews, students reported that most of the time the problems with the assigned readings or the topic videos are the language used. This denote that students are having difficulties not with the accessibility or time to handle the before-class tasks, but are rather having problems with the English language itself.

> *I have time to watch the videos, but the problem is that I have to stop the video every time I encounter a new vocabulary …* SY2016 #2
>
> *… the topic is interesting, however, the problem is that sometimes the readings are too long and there are many new words that I have to look up in the dictionary …* SY2017 #5
>
> *… it's a good thing I can use the subtitle function and automatic translation while watching the video, however, sometimes I think the translation is wrong … anyway, I will just wait and ask my classmates during class instead …* SY2019 #4

To remedy this situation, before the start of the class, sometimes the students are given ample time to ask about the assigned readings and in some cases provide additional time for students to watch some important parts of the videos again, however, this would actually defeat the purpose of the flipped learning design. Hence, the assigned readings and videos are re-evaluated each year depending on the English language competencies of the class.

3.2 Students' Satisfaction Towards the Flipped Learning Design

For the students' perceived satisfaction and agreement with the five years implementation of the flipped learning design, survey results are shown in Table 2. In general, students are quite satisfied with all of the average ratings around 3.90 (within a 5-point Likert type scale, 5 being the highest). Also note that within the years, students rated the *selection of the course topics* as among the highest item, while also commending the design of the activities.

> *… the activities are very fun and interesting, topics are easy to relate …* SY2015 #2
>
> *What I like the most are the activities … the group discussions and the way we present our ideas …* SY2018 #1

3.3 TPACK Analysis

To further understand how the students felt about the flipped learning design, besides the survey questionnaire, interviews with randomly selected students were also accomplished. TPACK was then used to analyze the interview data grouping similar themes together [32, 33].

Table 2. Satisfaction and agreement towards the course.

Satisfaction and agreement	2015[1]	2016[2]	2017[3]	2018[4]	2019[5]	Ave.
Enhance learner's interest	3.94	3.81	3.95	3.93	3.87	3.90
Teacher's teaching methods	4.10	3.85	3.91	3.95	3.85	3.93
Selection of the course topics	4.16	3.96	3.90	4.00	3.88	**3.98**
Promotes learning	4.08	3.76	3.90	3.95	3.75	3.89
Design of the classroom activities	4.03	3.74	3.84	3.98	3.87	3.89
Overall flipped learning design	4.10	3.83	3.86	3.98	3.85	3.92

Note. [1]$N = 46$, [2]$N = 56$, [3]$N = 60$, [4]$N = 53$, and [5]$N = 62$. Total number of student participants for five years is 277.
Scale used is 5 point Likert type scale perceived satisfaction and/or agreement, wherein 5 is the highest.

Content Knowledge (CK). This is the content of the subject matter to be taught or learned by the students [26]. To understand how students are learning, one key question asked during the interview is *what is the most memorable or interesting lesson topic for you*? Result of the qualitative analysis shows that students' interest on the lesson topics are quite varied, some students would typically mention those issues that they are familiar with or easier to relate, such as: *are grades important*, *study abroad*, and *future skills*.

> *For me … the most interesting part of the lessons is the topic about study abroad. Since, I am planning to take part in our school's exchange program … I want to know more about it …* SY2018 #2
>
> *The topic that we talked about the skills needed to become successful is very interesting … I think I learn a lot …* SY2016 #2

In addition, students also claimed that besides the topic lessons, they also learned *how to work (and learn) with others* and are able to have the *opportunity to practice critical thinking*.

> *An important skill that I learn is how to cooperate with others … the topics are interesting, but the activities are important …* SY2016 #1
>
> *During group discussions, we are able to think outside the box, go beyond what is written in the lesson. The guide questions are also helpful …* SY2019 #2

Pedagogical Knowledge (PK). This is the processes or methods on how the subject matters are to be taught or learned by the students [26]. The core of the flipped learning design is actually how teachers are able to organize the lessons and incorporate the activities. hence, during the interviews, students are asked to share *how they feel about the teaching and learning process*? Majority of the students mentioned the various *group activities make learning easier*, while they are also able organize what they learn *using posters and mind maps* (concept maps).

The activities make learning easier, the most important is that I can discuss the lesson with my classmates and hear about their opinions … SY2016 #2

For me, I like the group activities, wherein students are able to brainstorm, discuss, and plan on how to go about an assigned task. Making posters are fun … SY2017 #3

Technological Knowledge (TK) and Technological Content Knowledge (TCK). This is the technological knowhow of the teachers. more important, it is how technology is able to help the teaching-learning process. For the current study, students are asked about *how they feel about the assigned readings and videos*? Majority of the students mentioned that the *use of YouTube videos is helpful*, since there is a subtitle function which make learning (understanding) the lesson easier. However, still many students are asking if whether the assigned readings can be made available in Chinese.

The videos are very accessible … I can watch it anytime, again and again … SY2018 #2

The good thing is that I can use the subtitle function, but still I have to pause the video and translate … it a good thing that the assigned readings and the videos are related, making the understanding of the lesson topic easier … SY2015 #2

Technological Pedagogical Content Knowledge (TPACK). This is the intersection of the three teachers' knowledge. In simpler terms this is the effective teaching with the use of technology [26]. This is also the combination of the effective use of technology, pedagogy (teaching strategies), and content, and more important is the context wherein the lesson are being portrayed. To understand this, students are asked to give their *comments on the overall design of the flipped learning course.* Results show that almost all of the students are *quite satisfied with the course design.* In addition, students noted that the overall design of the course is *able to promote and motivate learning.*

The course is fun, activities are also interesting … I am able to engage with my classmates … SY2015 #2

4 Conclusion

Over the years, the flipped learning design has been implemented in various types of courses with positive outcomes being reported. For the past five years, flipped learning design was implemented on a required educational foundation course taught in English. To understand better the implications of the course, the current study summaries the findings for the past five years. *First*, findings are typical with other previous studies with students quite satisfied with the overall flipped learning design. *Second*, students are not only limited in learning the course content, but are also able to learn how to collaborate and work with others. *Lastly*, the study also noted the role of the teacher in the overall success of the course, since the facilitation of the lessons is crucial in aligning the activities with the lesson objectives.

A significant different approach of the current study is the utilization of the concepts of TPACK in analyzing the qualitative interview data. The use of the TPACK clearly summarizes the various implications of the flipped learning course design. Using TPACK as a framework, analysis can now be separated for the content, pedagogy, technology used, and their corresponding combinations. Furthermore, the current study also noted the importance of *balancing* the content to the lesson with the capacity of the learner. Since, the current study uses a foreign language (English) as the medium of instruction, it is quite important to maintain an appropriate level of difficulty so as not to sacrifice or discourage the students from learning the lesson content. In essence, the use of TPACK to analyze the course design has been helpful in better understanding how flipped learning can be implemented.

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Show Me the Universe! Perceived Usability and Task Load of an AR Mobile-App in Secondary School Learning

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Abstract. Modern digital artefacts not only affect the way we work but increasingly also the way we learn and teach. The Internet, smart devices, as well as innovative forms of human-content interaction open up new pathways for successful knowledge transfer. The work presented in this paper aims to explore one of these recent developments, i.e. the use of Augmented Reality in school learning. We report on an experimental study in which two cohorts of secondary school students used a smartphone-based AR mobile-app to learn about astronomy and the solar system. The goal of the experiment was to evaluate the app's perceived usability and task load associated with a set of particular learning exercises. Results point to an average perceived usability and moderate task load, independent of the students' gender. Further, we found a negative correlation between the perceived usability and task load, even though this was only significant for male students.

Keywords: Technology-supported teaching · Augmented Reality · Technology acceptance · System Usability Scale · NASA-TLX

1 Introduction

Digitization efforts in teaching can significantly affect students' learning processes as well as teachers' didactic concepts. In particular, opportunities related to interactive simulations and educational games have expanded the limits of knowledge transfer [34]. However, it is often still necessary to convince teachers

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of the effectiveness of these types of digital learning environments and consequently support their integration into the classroom. One of these rather progressive technologies to be used in teaching is Augmented Reality (AR). To this end, the fact that nowadays many children already own and use smartphones may be considered a supportive factor as these devices can act as low-cost platforms for AR content. The presented research aims to measure the perceived usability and task-load of a smartphone-based AR learning application with children at the secondary school level.

2 Background, Related Work and Theoretical Foundation

AR applications, similar to their Virtual Reality (VR) siblings, have been around for more than two decades [37]. Although the two technologies are often associated with each other as they serve comparable areas, they do pursue different goals and have different technological requirements.

2.1 Virtual vs. Augmented Reality

While VR refers to computer-generated 3-dimensional environments in which users can move and interact freely, AR extends the real world with virtual objects. A VR environment is thus an environment in which users completely immerse themselves in a synthetic world, in which the physical laws of gravity, material properties, and time may no longer apply. On the contrary, AR uses the real world as a base, which is consequently also a limiting factor. As such, the two technologies may be put on the two opposite ends of what Miligram and colleagues consider the Reality-Virtuality (RV) Continuum [28] (cf. Fig. 1).

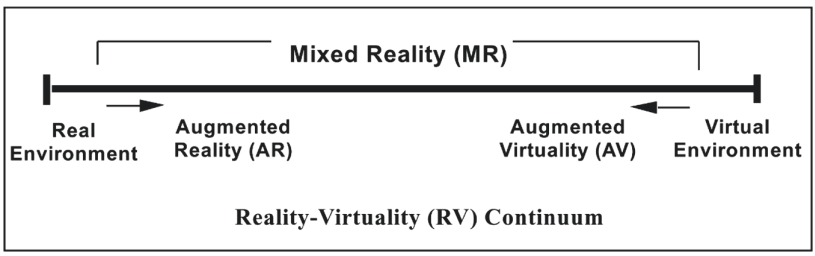

Fig. 1. Reality-Virtuality (RV) Continuum according to Miligram et al. [28, p. 283].

Here, the left end of the continuum defines the real environment, which consists exclusively of real objects; i.e. anything that can be observed directly or through a window or (video) display. On the opposite side are virtual environments, which consist exclusively of virtual objects. These include, for example, computer graphic simulations or interactive VR video games. Everything that is

within these two end-points is referred to as a mixed reality (MR) environment and is usually roughly assigned to one of the two extremes.

Work in the VR/AR field started in the 1960s with Sutherland's 'The Ultimate Display', which was based on the argument that computer technology had already advanced so far that it would soon be possible to give people information, objects, or reactions that were not, as in the real world, bound to physical or mathematical laws [38]. Thus, initial research focused on the development of virtual 3D worlds (i.e., VR). Only years later, the supplementation of real world settings through virtual objects, i.e. AR, became a relevant topic [7]. Although the basic idea of AR was to include mobility, it was only with 'The Columbia Touring Machine' by Feiner and colleagues that the first mobile augmented reality system (MARS) was developed [18].

2.2 Application Areas for AR

Thanks to the increasing proliferation of smart devices (i.e., smartphones and tablets), recent years have seen a number of relevant application areas for AR. In highly individualized, just-in-time/just-in-sequence manual manufacturing settings, for example, assembly line workers may be trained through head-mounted displays (HMD) providing contextualized visual information [11]. AR technology has also found its place in marketing. Pepsi, for example, had an AR camera installed at a London bus stop. There, one could see tigers strolling down the street, UFOs racing towards the bus stop, or huge tentacles protruding from the sewer. These and similar AR 'prankvertisements' aim to create viral campaigns through provocative events, offering viewers an entertainment value, and consequently promoting the exchange of social media content [35].

Medicine is another field of application where AR technology may provide a significant contribution. The greatest medical advances in recent decades have been diagnostic imaging, ultrasonography, mammography, computed tomography (CT), etc. All the visual data connected to these procedures is still displayed on 2D flat screens and thus forces doctors to shift their viewpoints during surgery. It is thus not surprising that the medical industry sees great potential in AR[1]. To name a specific example, Philips introduced in 2017 a new type of navigation technology for mini-invasive interventions on the spine, where, through an optical tracking system, information from a patient and live images of the body are delivered to the screen in the operating room; thus, showing the surgeon exactly where to start so as to achieve a positive result[2].

Furthermore, AR is being used to support navigation tasks. That is, environments are no longer depicted as two-dimensional maps, but rather augmented via arrows mapped onto reality through the camera of the smartphone, indicating directions, street names, and other points of interests. This idea of perceiving

[1] Online: https://hbr.org/2018/03/how-augmented-reality-will-make-surgery-safer [accessed: January 15th 2020].

[2] Online: https://medialist.info/2017/01/13/ar-healthcare-augmented-reality-in-der-medizin/ [accessed: January 15th 2020].

graphical information has also been used by the automotive industry, where navigational information, current speed, or fuel usage are increasingly embedded into car windshields or other types of head-up displays [29]. Finally, AR has seen an uptake in the tourism industry, where it supports destination management [17], in the real estate sector, where it helps to convey future living experiences [43], as well as in learning contexts.

2.3 AR in Learning Contexts

AR fundamentally changes the way learning content is taught, for which it has also received much attention in past research [3]. Using web-enabled devices such as smartphones or tablets, AR programs can provide students with location-specific information at exactly the right time and seamlessly embed data (via image or object markers) in the real context [9]. It has great educational potential because it has the ability to merge virtual and real worlds and thus offers new opportunities to improve both learning and teaching quality [31]. For example, intelligent learning books and learning cards already contain markers, which, when scanned by an AR system, generate additional data for learners [1]. Here, the most prominent examples focus on learning topics such as history, art, technology, biology, or astronomy, where the physical environment is enriched through AR artifacts [36]. AR seems particularly effective for activities in which students learn things that cannot be seen in the real world or without a specific device [12]. Furthermore, it has repeatedly proven to be motivating [8,13,14,39] and to positively influence students' learning outcomes [4,23,26,27].

While this clearly highlights the potential AR technology offers in learning contexts, it is often the low acceptance of end users (both teachers as well as students) which hampers widespread adoption and thus asks for additional studies to gain a better understanding of people's needs and expectations [30]. To this end, influences and consequent challenges of accepting all kinds of technologies in various settings and contexts have been studied for more than two decades (e.g., [19,21,25,33]).

2.4 Technology Acceptance

Next to diffusion and adoption research, which explores factors that influence the adoption and use of innovative systems, it is mainly the body of literature on acceptance which aims at offering explanations as to why an individual decides to use an existing technology. To this end, previous work is predominantly rooted in information systems research, where the integration of technology is perceived a challenge of both product adoption and respective organizational change (e.g. [6, 32,44]).

Numerous models aim to measure the acceptance of information technology-based systems. However, the Technology Acceptance Model (TAM) developed by Davis and colleagues [15,16] is still considered the most influential and widely used framework [24]. It is based on the Theory of Reasoned Action (TRA) [2], which assumes that the user's attitude towards a system is a decisive factor

for its use. Building on this, the acceptance of technology is determined by two main variables; i.e. its Perceived Usefulness (PU) and its Perceived Ease of Use (PEOU). PU is defined as *"the prospective user's subjective probability that using a specific application system will increase his or her job performance within an organizational context"* [16, p. 985]. Yet, while a potential user might deem a particular application system useful, its actual usage may be inhibited by additional efforts caused through difficult or non-intuitive operation procedures. Therefore, Davis defines the PEOU of a system as *"the degree to which a person believes that using a particular system would be free of effort"* [16, p. 985]. Since then, both PU (i.e., TAM2) [42] and PEOU [40] underwent further investigation, leading to a more comprehensive and integrated framework referred to as TAM3 [41].

Coming back to a better understanding of the use and acceptance of AR technology in learning settings, the focus of our initial piece of research was on secondary school students and their perceived ease of using a smartphone-based AR mobile-app. More precisely, we solely investigated the PEOU construct of the TAM framework. To this end, we were particularly interested in students' perceived usability and perceived task load when using the app to learn about astronomy.

3 Methodology

As of 2018, the regulation on digital education of the Austrian Federal Ministry of Education, Science and Research obliges Austrian schools to develop the digital competences of their students. As such, the regulation aims to provide students with the ability to select and use suitable (digital) tools and methods for specific learning scenarios in both school and private contexts. To explore the use of smartphone based AR technology, we conducted a learning experiment with two cohorts of 3rd year students in a secondary school. Preceding the study, we obtained relevant approval from the local education authorities, the head of school, and the students' parents and guardians. Furthermore, our institution's research ethics group cleared the study set-up and utilized materials.

3.1 Experimental Procedure

The experiment focused on the solar system and respective physical phenomena. First, students were informed about AR and the devices they could use it with. Next, the class teacher, who was present throughout the entire experiment, divided all students into groups, instructed them to download the *Areeka*[3] app to their phones or, if necessary, to tablets provided by the school. Subsequently, students received a task sheet, an accompanying booklet, and written instructions on how to use the app and the booklet alongside their standard textbook. Through markers, which were found after each section in the booklet, artifacts and additional information could be visualized on the smartphone or

[3] https://areeka.net/en/.

tablet. Next, students were given 30 min to learn about the solar system, moon phases, as well as lunar and solar eclipses. Students worked individually with hardly any interference by us or the school teacher. Finally, after the worksheets were completed, students were asked to complete a questionnaire investigating perceived usability of the AR mobile-app and perceived task load.

3.2 The Questionnaire

In order to measure perceived usability and task load, we used the System Usability Scale (SUS) [10,22] and the NASA Task Load Index (NASA-TLX) [20]. The SUS is based on 10 questions (alternating between positive and negative usability statements) aiming to measure the subjectively perceived usability of interacting with a system on a 5- or, as in our case, 7-point Likert scale (1 = *strongly disagree*; 7 = *strongly agree*). Answers were then converted to a score (0–100), where previous industry comparisons have shown that average system usability would lie between 60 and 80 [5].

As for the task load, the NASA-TLX questionnaire computes a task load score based on a person's perceived mental, physical, and temporal demand, performance, effort, and frustration when completing a task. Here, we also used a 7-point Likert scale (1 = *very low*; 7 = *very high*). In order to rank the relevance of these sub-scales for a given task, the NASA-TLX recommends pair-wise comparison to generate an order and respective multiplication factor. Perceived scores should then be multiplied by these factors and subsequently divided by 15 (i.e., the sum of distributed scoring points) to generate a weighted score. For our experiment, we asked an experienced secondary school teacher to compare the different sub-scales and generate such ratings, leading to the following multiplication factors: mental demand = 4; physical demand = 0 (note: the teacher did not see any physical demand associated with the given task); temporal demand = 3; performance = 3; effort = 2; frustration = 3;

Finally, the last part of the questionnaire collected demographic data on the children's age and gender. With respect to the analysis, we then derived the following hypotheses as guidance:

- H1: There is a difference in the perceived usability (SUS) of the AR mobile-app between male and female participants.
- H2: There is a difference in the weighted perceived task load (NASA-TLX) operating the AR mobile-app between male and female participants.
- H3: There is a negative correlation between the perceived usability (SUS) and the weighted perceived task load (NASA-TLX) operating the AR mobile-app.

4 Results

A total of n = 49 students (28 female) from two 3rd year secondary school classes took part in this study. Their age ranged from 12 to 14 years with the majority (67%) being 13 years old. With respect to perceived usability, students

evaluated the app with an average SUS score of 71.47 ($SD = 16.82$), which points to an overall acceptable intuitiveness of the app. The difference between perceived usability with female ($Mean = 73.90$; $SD = 13.79$) and male ($Mean = 68.23$; $SD = 20.08$) students was not significant, for which H1 had to be rejected (cf. Table 1 and Fig. 2).

Table 1. System usability scale

SUS	Male	Female	Total
Average	68.23	73.90	71.47
Standard deviation	20.08	13.79	16.82
Confidence interval 95%	[59.09, 77.37]	[68.55, 79.24]	[66.64, 71.47]

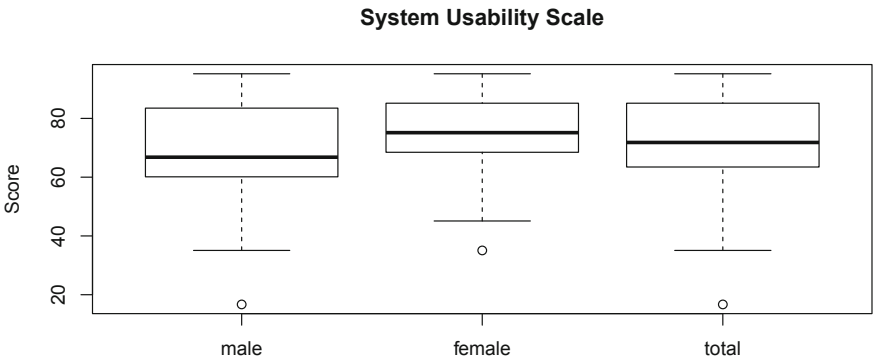

Fig. 2. System usability scale

Looking at the perceived task load, students evaluated the interaction with the app to be moderately demanding, expressed by an overall weighted NASA-TLX score of 3.34 ($SD = 0.76$). Again, the difference between genders was not significant ($female : Mean = 3.38$; $SD = 0.76$ | $male : Mean = 3.29$; $SD = 0.76$), for which H2 had to be rejected as well (cf. Table 2 and Fig. 3).

Finally, investigating a potential connection between perceived usability and weighted perceived task load, a Pearson correlation highlighted a significant negative relationship ($r = -0.33$; $p = 0.019$). This, however, seems to be gender-dependent, as the data shows a very weak and not significant correlation with female students ($r = -0.08$; $p = 0.080$), whereas the correlation with male students is strong and highly significant ($r = -0.61$; $p = 0.003$) (cf.Table 3). Thus, H3 may only be partly supported.

Table 2. NASA task load index

NASA-TLX	Male	Female	Total
Average	3.29	3.38	3.34
Standard deviation	0.76	0.76	0.76
Confidence interval 95%	[2.94, 3.63]	[3.08, 3.67]	[3.12, 3.55]

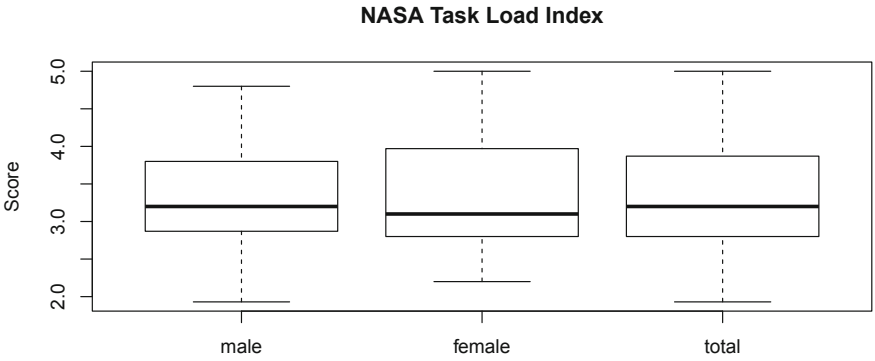

Fig. 3. NASA task load index

Table 3. Pearson correlation between SUS and NASA-TLX.

Correlation	Male	Female	Total
Coefficient r(47)	−0.61	−0.08	−0.33
Significance level p	0.003	0.080	0.019

5 Conclusion and Potential Future Work

Previous research has pointed to various challenges when using AR technology in learning settings [8]. The goal of the above presented study was thus to investigate secondary school students' perceptions on usability and task load when using a smartphone based AR mobile-app to learn about astronomy. In doing so, we focused on the overall perceived ease of use as one of the two determinants for technology acceptance put forward by Davis [16].

Our results have shown that students, regardless of their gender, perceive the app to be intuitive and its use for study tasks to be moderately demanding. Hence, it seems that at least from a student's point of view, one important threshold for AR acceptance in learning settings is met.

However, we also found a gender-dependent negative correlation between perceived usability and task load. That is, male students rated the perceived usability of the app lower when they perceived the overall task effort to be higher. While this may seem justified, we did not find this significant connection with female students, which may be an interesting direction for future research.

Other fields for further investigation may include aspects of perceived usefulness (i.e., the second important determinant for technology acceptance), the effects of AR usage on students' motivation, or potential effects on learning success.

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Self-regulated Learning Strategies and Digital Interruptions in Webinars

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Abstract. In a world of increasing digital interruptions, the concept of self-regulated learning offers a promising approach for dealing with challenges in online and blended learning contexts. This study (N = 176) investigates which self-regulating strategies learners apply during webinars in a blended learning environment. Also, it explores the relationship between self-regulating strategies and digital interruptions. Quantitative data were collected in a self-assessment questionnaire focusing on strategies for self-regulated learning and interruptions through digital devices. The results indicate a gap between self-reported learning strategies and the participants' behavior due to interruptions during webinars. While the participants reported to actively use learning strategies related to goal setting & organization, learning environment, and metacognition & learning strategies, they also estimated to spend approximately 15% of webinar time on non-course-related activities.

Keywords: Self regulation · Self regulated learning · Digital devices · Interruptions · Distractions · Higher education · Laptop use · Mobile phone use

1 Introduction

Digital devices, like laptops, tablets, or smartphones, have become a perpetual companion in lecture halls and seminar rooms. Along with these devices, also the discussions about their various impacts on students' academic performance have come into play (Elliott-Dorans 2018, Kay and Lauricella 2011). Without a doubt, digital devices offer a great variety of advantages for student learning, as they provide access to study materials, enable students to look up additional information, or offer a comfortable possibility to take notes (Carter et al. 2017). Nevertheless, a distracting effect of digital devices in class cannot be denied (Kraushaar and Novak 2010, May and Elder 2018, Wei et al. 2012). Nowadays, students are used to being connected with their peers at all times (Felisoni

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and Godoi 2018). Therefore, it does not come as a surprise that the most common non-course-related activities during class time are activities where students stay in touch via social media and texting applications (Rabl et al. 2019). While the negative effects of digital distractions are discussed with increasing awareness in academia, students' perceptions of the effects of their own behavior vary (May and Elder 2018, McCoy 2016, Sana et al. 2013). On the one hand, as the example of an exploratory study by Clayson and Haley (2012) shows, students are convinced of their successful multitasking during lectures, even though their class grades indicate the contrary. On the other hand, McCoy (2016) revealed that 89% of the participants were aware of the distracting effect of their digital device usage during class. Also, Rabl et al. (2020, under review) found that 60% of the respondents reported a somewhat or strongly disrupting effect of using computers in a traditional classroom setting for non-course-related activities on their own learning. Moreover, more than 75% of respondents shared this perception for webinars in a blended learning context.

In response to growing concerns about digital interruptions, the concept of self-regulated learning (SRL), which refers to students actively shaping their individual learning processes (English and Kitsantas 2013), offers a promising approach, in particular for the challenges in online and blended learning contexts. Although the concept has been thoroughly researched in face-to-face classroom settings, there is a need to further explore the concept of SRL in non-traditional learning environments due to its high context-dependency (Zimmerman 1998). Besides, research has shown that students use different self-regulating strategies in different learning settings (Broadbent 2017). Therefore, this study investigates how students assess their self-regulating abilities during webinars in a blended learning context and it raises the question, "Which self-regulating strategies do learners apply during webinars?" It also aims to explore the relationship between self-regulating strategies and digital interruptions.

2 Self-regulated Learning

Over the last three decades, a huge compendium of literature has evolved around self-regulated learning, including various definitions and models. Although the details may differ, there appears to be general agreement with Zimmerman's definition that SRL describes the extent to which learners actively design their own learning processes, in a metacognitive, motivational, as well as behavioral way (Zimmerman 1989). Self-regulation can be loosely described as an active and volitional behavior, which can be developed over time. Hence, it is neither an individual's mental ability nor a fixed trait (Kizilcec et al. 2017). A broad stream of literature refers to a self-regulated learner as someone who masters his or her own learning and who is well equipped with metacognitive skills like planning and organizing, self-instructing, self-monitoring, and self-evaluation. Besides, self-regulated learners are aware and in control of their own mental processes (Barnard-Brak et al. 2010, Broadbent and Poon 2015, English and Kitsantas 2013, Kizilcec et al. 2017). Individuals with a distinctive ability for self-regulation have proven to learn faster and to outperform their colleagues with weaker self-regulation skills (Kizilcec et al. 2017). Furthermore, a high degree of self-regulation relates to directing one's behavior and motivation towards a valuable goal, which is crucial for a successful learning process (Adam et al. 2017). SRL is described as an inherently

constructive and self-directed process, in which learners use their mental abilities to gain control over their thoughts, feelings, motivations, and finally also their actions (Adam et al. 2017, Boekaerts 1999). To specify this constructive and self-directive process, also the terms dynamic and iterative are used, as some of the self-regulating skills and strategies are gained before others (Barnard-Brak et al. 2010). Schunk (2001) described the development as a cyclical process, where personal, behavioral, and environmental factors come together.

2.1 SRL Models

There are two established models that stand out from a large body of literature on SRL. First, there is Pintrich's model (1995) that focuses on different learning strategies of successful self-regulated students. They are able to steer the following three aspects of their learning processes: Firstly, self-regulated learners are able to adjust their observable behavior, their motivation, affect, and their cognition to the requirements of a particular situation. Secondly, self-regulated learners are able to set valuable goals and to monitor and evaluate their performance with regard to the intended goals. Thirdly, the prefix "self" has to be taken into consideration – individuals have to be in charge of their own actions. If a professor, a friend, or a parent triggered it, a change in behavior is not considered self-regulated.

Second, Zimmerman's (2008) model of SRL sketches the structure of self-regulatory systems with three cyclical phases: forethought, performance or volitional control, and self-reflection. Each phase is linked to certain accompanying beliefs and strategies. In the preparatory phase, task definition, goal setting, and strategic planning take place. The performance phase is about the actual task and subsequently about controlling and monitoring it. Here, structuring the environment, managing one's time, asking for help, or controlling one's efforts play an important role. And finally, the appraisal or self-reflection phase focuses on strategy regulation, which refers to the learners' ability to critically assess their own behavior (Jansen et al. 2017, Zimmerman 2008). Zimmerman's model (2008) emphasizes that a self-regulated learner is not only actively involved in the individual learning process during the phase of performance, but also prior to the actual performance by setting goals or developing a learning strategy. What is more, student involvement is also required when a certain task is completed by reflecting on the performance and comparing the outcome to the initial goals (Jansen et al. 2017). Both models have played a pivotal role in the past and current discussions on SRL concepts and influenced the development of manifold SRL measuring tools.

2.2 Importance of SRL in Online and Blended Learning Contexts

Compared to traditional classroom settings, some characteristics inherent in online and blended learning contexts highlight the particular need for self-regulating skills in order to succeed in non-traditional learning environments. Online learning features a high degree of flexibility with regard to location, time, and pace of task completion. Compared to traditional classroom studies, there is less support and guidance from instructors (Kizilcec et al. 2017), hence requiring students to show more autonomy (Jansen et al. 2017). What is more, students need a wide range of learning strategies since knowledge

transfer is not necessarily triggered by instructors (Ledermüller and Fallmann 2017). Therefore, success in online learning contexts is heavily dependent on students who can actively shape and structure their own learning processes despite the higher degree of required independence (Broadbent and Poon 2015). As Jansen et al. (2017, p. 7) put it: "Students must actively plan their work, set goals, and monitor their comprehension and the time they spend on learning. These activities can together be defined as self-regulated learning (SRL)."

Several researchers have already shown the importance as well as the positive impacts of self-regulatory skills on students' academic performance in traditional learning environments (e.g. Winters et al. 2008, Pintrich and Groot 1990, Kramarski and Gutman 2006, Barnard et al. 2009, Jansen et al. 2017). Nonetheless, the growing importance of self-regulating skills in non-formal and especially online learning settings, as for example in MOOCs, should be emphasized here as well. From a lifelong learning perspective and in the light of a rapidly increasing need for continuous education, the importance of independent, responsible learners cannot be emphasized enough (Buhl and Andreasen 2018, Littlejohn et al. 2016). With increasing flexibility, the growing demand for autonomy and independence, and the need for active knowledge acquirement throughout one's individual learning biography, self-regulation becomes an even more important success factor in future online learning (Barnard et al. 2009).

2.3 Digital Interruptions as Challenges of Online Learning Environments

Due to the necessity of using digital devices in online and blended learning settings, students are constantly exposed to the potentially disruptive nature of laptops and other mobile devices. While digital devices can enhance learning (Berry and Westfall 2015, Houle et al. 2013, May and Elder 2018), they can also harm students' academic performance (Carter et al. 2017, Fried 2008, Jacobsen and Forste 2011). Any break from an ongoing activity due to the occurrence of a new activity on top of the ongoing one (Miyata and Norman 1986) is considered an interruption, presuming that the original activity is resumed at a later point (Baethge et al. 2015). While distractions are only caused by external stimuli (Jett and George 2003), interruptions can either have an internal or external origin (Baethge et al. 2015). Taking into account that internal interruptions add a preparatory phase in which a conscious decision is made before changing to the interrupting activity, they are considered more disruptive and costly in terms of time (Katidioti et al. 2016).

3 Context and Methods

We conducted this study with two cohorts of first-semester Bachelor students of business administration. The courses in the respective study program are organized in a blended learning format that combines face-to-face learning with online learning experiences (Garrison and Kanuka 2004). Each course lasts six weeks and consists of one synchronous webinar per week (1 webinar = 120 min), one synchronous on-campus day (360 min), and asynchronous flexible learning throughout the course.

As part of a research project focusing on self-regulated learning and digital interruptions, students were asked to complete two self-assessment questionnaires (Survey

1 & Survey 2) at different points of a course. The questionnaire relevant for this study (Survey 1) was completed after the third webinar of one course and was mainly designed as a tool for quantitative data collection.

3.1 Sample

In total, we asked 211 first-semester Bachelor students to participate in this study. 176 responses were obtained, 48.86% of the participants male, 51.14% female. The average age of the participants was 27.56 years (SD 6.70), ranging between 19 and 55 years. On average, participants can account for 7.87 years of work experience (SD 6.79) and work 34.01 h per week on average. 75.60% did not have any prior experience with part-time or job-friendly study programs or educational trainings. We presume that a non-sampling bias can be excluded, as the previously reported characteristics of the two cohorts in terms of age and gender appear to be representative of the total population. The student population of this blended learning program is characterized by its heterogeneity in terms of age, work and educational experience, and current working hours. This diversity is well-reflected in our sample.

3.2 Instruments

After comparing and evaluating previous studies, we developed a tool based on metacognitive strategies and resource and task management strategies in order to assess the participants' self-regulating abilities. The questionnaire to measure self-regulation in a blended learning context was developed by combining items from different well-established tools (Barnard-Brak et al. 2010, Pintrich 1995), with a special focus on online learning (Kizilcec et al. 2017). Overall, the survey consisted of 34 questions and contained items related to the preparatory, the performance, and the appraisal phase of SRL (see Sect. 2.1). When answering the questions about their adopted learning strategies, students were asked to think about an average webinar, either from the course "Accounting & Controlling I", completed by the student cohort of 2018, or from the course "Fundamentals of Law", completed by the student cohort of 2019. More specifically, the questionnaire included items of the following dimensions, based on the sources listed:

(1) Goal setting: Setting of long-term as well as short-term goals and sub-goals in order to raise the necessary effort to reach these goals (Schunk 2005, Zimmerman 2008).
(2) Elaboration: Using different sources of information within the learning processes, applying previous knowledge, and linking it to new content (Niemi et al. 2003).
(3) Self-evaluation: Assessing own performance by comparing it to previously set quality standards, reflecting on and critically examining the personal learning process (Schunk 2005).
(4) Strategic planning: Planning of learning activities (Kizilcec et al. 2017) due to higher demand for personal learning strategies in blended learning settings with flexible and individual activity completion.
(5) Help-seeking: Seeking help to deal with difficulties in understanding and obtaining necessary information from the right people (Jansen et al. 2017, Kizilcec et al. 2017).

(6) Peer learning: This dimension takes a closer look at whether there is an exchange of knowledge and information between course participants during on-campus days, synchronous and asynchronous online phases. For some online settings, like MOOCs, peer learning plays a minor role because students are rarely in touch with fellow students since work is mostly done individually (Jansen et al. 2017). Due to the blended learning concept, where students know each other and meet on a regular basis, team or group work plays an essential role.
(7) Environment structuring: Choosing study times and places in order to reduce the risk of distractions resulting from the greater autonomy of online learning (Barnard et al. 2009).

Items of the dimensions *Goal Setting*, *Elaboration*, *Self-Evaluation*, *Strategic Planning* (including *Time-Management* items adopted from Barnard-Brak et al. (2010)), as well as *Help-Seeking* were taken directly or based on Kizilcec et al. (2017). *Environment Structuring* items were taken from Barnard-Brak et al. (2010), items on *Peer Learning* from Pintrich (1995). A detailed list of the questions used in the survey is available upon request). For each subscale, a seven-point endpoint defined Likert scale (7 = strongly agree; 1 = strongly disagree) was used.

Questions about digital interruptions focused on the types of digital devices students used during webinars, their learning environment, the types and reasons for interruptions during webinars, and on course-related (CR) and non-course related (NCR) activities during webinars based on a survey instrument by Ravizza et al. (2017). Finally, demographic data such as age, gender, and working experience was collected. We conducted a pre-test with five participants with different backgrounds (i.e., academic faculty, business professionals, and students) to ensure comprehensibility and avoid ambiguity.

3.3 Data Collection

Following ethical clearance, we contacted all students of the Bachelor cohorts 2018 and 2019. Students of the cohort 2018 were introduced to the study before the start of the course "Accounting & Controlling I", students of cohort 2019 before the start of the course "Fundamentals of Law". These courses were selected specifically as they both took place in the middle of the first semester, followed a similar course structure, and assessed students' performance in a final written exam. Survey 1 was conducted immediately after the third webinar (out of six webinars in total).

4 Data Analysis and Results

4.1 Students' Self-regulating Strategies in Webinars

Our goal was to explore students' perceived self-regulating strategies in an online learning context, or more specifically, in webinars. To do so, we first re-coded one item ("Even if I am having trouble learning, I prefer to do the work on my own.") and then took the reliability of all SRL items into consideration, which revealed a standardized coefficient alpha of .911. By eliminating three items ("I ask myself if there would have been other

ways to learn after I finished learning.", "When studying for a course, I often try to explain the material to a classmate or a friend.", "When studying for a course, I often set aside time to discuss the course material with a group of students from the class."), the value would have improved only marginally (alpha = .912). Therefore, all items were included in the subsequent analyses.

We conducted a confirmatory factor analysis (CFA) in order to reduce the high amount of variables to a smaller set of factors and to validate the scales used in this survey (Harrington 2009). Next, we performed a principal component analysis and rotation method Varimax with Kaiser Normalization, expecting to extract six factors based on the previously discussed theoretical concepts. Due to a factor loading of above .32 on the second-highest factor (Tabachnick and Fidell 2001), we dropped four items and repeated CFA. We identified five factors and labeled them, based on discussions within the research team, as follows: Learning Environment, Goal Setting & Organization, Metacognition & Learning Strategies, Help-Seeking, and Peer Learning. An overview of the factors, their reliabilities, and the number of each factor's items are shown in Table 1.

Table 1. Extracted factors.

Strategy	# of items	Example item	N	Min	Max	M	SD	Alpha
Goal setting & organization	6	I set realistic deadlines for learning	176	1	7	5.15	1.06	.826
Learning environment	4	I choose the location where I study to avoid too much distraction	176	1.5	7	5.86	1.09	.839
Metacognition & learning strategies	4	When I am learning, I try to relate new information I find to what I already know	176	1	7	5.55	1.09	.824
Peer learning	4	When studying for a course, I often try to explain the material to a classmate or a friend	176	1	7	3.84	1.45	.770
Help-seeking	3	I try to identify others whom I can ask for help if necessary	176	1.75	7	4.72	1.17	.806

Overall, the table illustrates that students show a relatively high level of perceived strategy use throughout the SRL subscales and they report to use SRL strategies from the fields of goal setting & organization, learning environment, and metacognition & learning strategies more often than peer learning and help-seeking.

4.2 Self-regulation and Dealing with Interruptions in Webinars

As initially stated, students in an online learning setting seem particularly tempted to yield to different kinds of internal and external interruptions. On average, participants reported to spend a total of 18.08 min (SD 21.12) or 15% of a 120-min webinar on non-course-related activities such as checking social media, reading or writing e-mails, texting, shopping online, reading the news, checking sports scores, watching videos, or playing games. For a better explanation of this behavior, we analyzed the correlation of the different subscales of self-regulated learning with the duration of non-course-related activities by applying Spearman's correlation coefficient for non-normally distributed data. We found a weak positive correlation between the amount of time students spend on checking sports scores and the subscale "peer learning" (.238). Weak negative correlations were shown between e-mailing and the subscale "goal setting & organization" (−.212), online shopping and "metacognition & learning strategies" (−.221), reading the news and "goal setting & organization" (−.266), as well as playing games and "learning environments" (−.220).

5 Discussion

Our study found that, overall, students reported to use learning strategies related to *goal setting & organization*, *learning environment*, and *metacognition & learning strategies* to a high extent. These findings are consistent with Zheng et al. (2015) and Kizilcec et al. (2017) who reported the helpful aspect of goal setting and strategic learning in the context of MOOCs. Students in online and blended learning contexts are continuously surrounded by digital devices that bear the danger of triggering internal as well as external interruptions. Therefore, students should actively create an individual learning environment to optimize their learning (Adam et al. 2017). The participants of this study seem to have realized this connection, as the aspect of the *learning environment* was rated highest among the five extracted dimensions of SRL. Although the importance of the social context or environment has already been mentioned by Zimmerman in 1989, SRL was rather portrayed as an individual activity at first, whereas the role of the social environment has only evolved over the last 20 years. However, social context plays a key role in framing and influencing student self-regulation (Hadwin et al. 2010), which should not be disregarded, particularly not with respect to social media as means of interruption. Another finding of this study is that students seem to apply metacognitive learning strategies to a high extent. These strategies include a certain level of awareness and control of their thoughts (Broadbent and Poon 2015) through the use of tactics such as referring to one's prior experiences. This result may partly be explained by the relatively high average work experience of the survey participants (~8 years).

Similar to our study, where help-seeking seemed to play a minor role for the participants, also Kizilcec et al. (2017) found that help-seeking was related to low goal

attainment and identified it as a less common regulating strategy. But, when researching the differences between self-regulating strategies in online and blended learning contexts, Broadbent's (2017) results indicate more frequent use of self-regulating strategies in online settings, except for help-seeking and peer learning. In contrast, our participants showed the lowest levels in exactly these two subscales despite their blended learning environment. Considering the significant positive relationship which has been detected between peer learning and academic achievement (Broadbent and Poon 2015), our participants' low engagement in peer-based strategies has to be questioned. One explanation might be that students prefer the interaction with teachers over peers when they have questions or need clarification (Puzziferro 2008).

Nonetheless, when considering the amount of webinar time used for non-course-related activities, we have to critically question the application of these strategies. On average, the participants estimated to spend about 15% of their webinar time on non-course-related activities. Considering that the participants work an average of 34 h per week and study at the same time, the question of why webinar time is not fully used becomes even more pressing. In addition, this raises the question of why students' level of self-regulation and their handling of interruptions does not match. One answer might lie in our individual reward system: Clayson and Haley (2012) compare distracting student behavior, such as texting, to addiction with similar consequences on the dopamine reward system in the brain. This helps to explain why we as instructors feel like fighting an unbalanced fight when struggling for our students' attention. Another possible explanation for this gap might lie in students' 'multitasking' during webinars. Media multitasking actually divides attention which consequently hinders metacognition (Lee et al. 2015) and thus harms students' self-management. The insights gained from this study may be of assistance to students when reflecting as well as instructors when designing learning environments.

6 Conclusion, Limitations and Outlook

This study set out to investigate students' self-regulating strategies during webinars and to explore the relationship between self-regulating strategies and digital interruptions. While students reported high use of learning strategies related to goal setting and organization, their learning environment, and metacognition, we identified a gap between their self-reported learning strategies and behavior during webinars. Overall, the participants' self-regulating skills do not seem to keep them from spending valuable synchronous webinar time on non-course related activities.

On a practical level, we, as instructors, need to be aware that we are up against some challenges when holding webinars. Even though our students might know about digital interruptions and their effects, we should not expect their behavior to match. These findings should encourage us to foster our students' SRL skills through specific activities and measures. In order to develop our students' self-regulation skills, we can support them by providing channels for peer learning in an online environment, by tapping into their prior experiences, and by fostering their creativity.

The present study has several limitations that should be noted when interpreting the findings. First, a major limitation of this study was the small sample size. Second, due to

the self-assessment questionnaire, social desirability response bias cannot be excluded. Third, participants were asked to estimate their behavior during an average webinar of one particular course. An essential next step would be to ask for estimations at different points in time for more than one course and pair these with data collected by tracking software in order to develop a realistic scale on digital interruptions.

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e-Learning and Transferability Strategies

Swapping Learning Management Systems: Self-Regulated Learning, Program Completion and Academic Achievement

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Abstract. An assessment was carried out of the effects of an online Learning Management System (LMS) switchover in a French university. For this assessment, the research involved three comparisons between the academic years before and after the switchover from Blackboard Learn™to Moodle™. The comparisons were of 1. students' perceptions of use of regulation of learning strategies 2. rates of program completion 3. academic achievement. Participants were undergraduate students enrolled in their final year of a graduate program in education sciences. No significant differences were found in perceptions of regulation of learning although a slight difference in academic achievement was found. More significant were the differences in completion rates. Findings are discussed and recommendations are suggested for further exploration of online environmental features and designs and their relation to self- and co-regulation of learning, program completion and academic success.

Keywords: Self-regulated learning · Completion · Academic achievement · e-Learning · Learning environment

1 Context

In 2003, two French universities and the French National Center for Distance Education (*Centre National d'Éducation à Distance*, or CNED) finalized their agreement to implement education sciences online distance learning programs. Graduate and postgraduate studies have been open to students ever since. According to Albero and Simonian [1], the success of the online campus named *Formations et Ressources en Sciences de l'Éducation* (FORSE) is due to conceiving the learning environment as an ecosystem that involves the participation of all actors both to set the campus up as well as to maintain its long-term operation. To this end, an ecological approach was adopted. It included negotiating

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between partners three constituent parts: the technical choice of a Learning Management System (LMS) for permanent access by users; means and the approach to the production of learning materials as well as the way to address student tutoring; finally, the financial matrix including specifying provision in terms of the number of students to be enrolled in each diploma program.

The first LMS that was put to use was WebCT. The software was reliable and stable, although austere in appearance. Web pages with explanations for the students were added over time but using the bulletin boards required one to be computer savvy [20]. WebCT was later acquired by the company that owned Blackboard. It evolved into being Blackboard's LMS now known as Blackboard Learn™. Blackboard Learn was finally replaced by an implementation of Moodle™starting with the academic year 2018–19.

An assessment of the effects of the switchover was proposed. It involved running a survey with students enrolled in the program leading to graduation in education sciences at one of the universities the year before the switchover and again after it took place. The survey was intended as a means to measure changes if any, in the ways students perceived how they conducted their learning. The theoretical framework that was used is Self-Regulated Learning (SRL). Program completion and academic achievement were also studied for the comparison.

The graduate program offered through FORSE is open to candidates who have already successfully completed the first two years of a higher education graduate program in the social sciences. Nevertheless, provision does exist, to enable people to access if they have completed a minimum of two years of preparation toward graduation in other fields and who can demonstrate sufficient professional experience in education, including participation in training within the field of education. The third and final year of graduate studies is the only graduate program provided on the digital campus.

FORSE also includes postgraduate studies comprised of a general first-year followed by two possible tracks to be chosen from for the completion of the postgraduate Master's degree. One track is geared toward instructional design and education consulting with studies lasting one extra academic year. The other track is geared toward research for which the completion of a stretched one academic year is to be completed over two years of further studies.

The bulk of students enrolled in FORSE programs follow the third-year graduate studies. In 2017–18, 662 students were enrolled through one of the two universities and 36 students followed the graduate program without enrollment through a university. The latter cannot attend exams and cannot obtain the diploma. In 2018–19, 700 undergraduates were enrolled through one of the two universities and 29 followed without enrolling at a university.

The number of enrolled students in the first-year of the Master's program was 194 and 225, during 2017–18 and 2018–19 respectively. Second-year Master's students enrolled in the instructional design and education counseling program were 88 and 83 during each of these academic years respectively. Students enrolled in the two year research oriented program were 67 and 54 during the same years.

The total number of students in 2017–18 was 1011, in 2018–19 students numbered 1062.

The research was conducted with participants from the graduate program enrolled at Lumière University (Lyon 2) where 418 students were enrolled in 2017–18 and 401 students were enrolled the following year, after the swapping of LMSs.

1.1 Swapping LMSs

The decision to switch from one LMS to another was the result of several considerations. CNED was in charge of providing and maintaining the technical infrastructure. The use of Blackboard Learn was licensed to CNED on Blackboard's servers. This was costly. While CNED was concerned with cost, academics at the universities were concerned with control over the digital environment. Control of the digital environment was thought to be essential as a means to break away from the initial educational model. The model was based on CNED's long-standing practices when textbook-style printed material, including exercises, were posted to distance learners before the Internet age. Completed exercises were then posted back to correctors to be assessed in an ongoing process of dispatching materials, receiving student work and returning feedback using postal correspondence. Similarly, the LMS used with FORSE was thought of initially as a distribution means of textbook material and a reception means of students' exercises to later be evaluated by correctors. The textbook material was written by academics from both involved universities and was updated every few years. The material took the form of down-loadable PDF files. Although this was the basis, instructional designs varied according to programs and tutor practices. Tutors also used other information and communication based technologies in accordance with their preferences and those of their students. E-mail and video-enabled chats were common. The model was perceived as outdated by academic personnel at both universities. The switchover was to provide an opportunity to engage partners in thought on conditions needed for these changes and for future adaptations.

Over the years, academics made ongoing requests to CNED for control over the appearance, ergonomics, choices, available services and digital provision in general. Resistance was met with frustration. The switchover was hence an opportunity to renegotiate the design of the digital environment. CNED had already made the choice to use Moodle^{TM}as the backbone. This choice was met with acceptance as the LMS was familiar and recognized for its strengths. It has been widely used in French universities.

Setting aside considerations for more flexibility of the system in order to enable to progressively change ways in which the LMS was being used, the choice of services available to users, accessibility and ergonomic considerations were other issues that university staff wanted addressed. Once choices were determined, they were to be implemented through the tweaking of the users' interfaces, to the degree that the LMS enables these design and ergonomic features to be adjusted. A small group of academic personnel from each university formed

a think tank to discuss changes. They shared ideas with the steering committee of FORSE based on feedback from tutors and other educational staff.

Discussions lasted approximately one year. An ongoing struggle between the think tank members' wishes and the software team at CNED, who were using a sandbox to test the implementation, took another year before considering it ready for deployment. At the beginning of September 2018 the new LMS was ready and was operative.

A study to compare the ways students went about their learning, student program completion and academic achievement before and after the LMS switchover was suggested. This paper is a report of the outcomes of the study.

1.2 Previous Research

A search for previous studies that had sought to compare the use of the same LMSs as in this study after a switchover uncovered only one paper [16]. Perceptions of faculty and students were studied primarily with regard to ease of use and satisfaction. Unfortunately, the study does not stand up to standards of scientific reporting. Questions used were not included. Findings were merely reported in terms of percentages, e.g. percentages of participants stating the new LMS better or worse than the previous. More to the point, in other studies comparing LMSs, subjects were facing a choice of using one LMS or the other, or had access to both, then appraised them. In the present study, the academic program was identical while participants were students in two consecutive academic years embodying two unrelated samples. Furthermore, the research described in this paper used a sound theoretical framework to study the perceived process of learning through the lens of SRL. In this research, program completion and academic achievement were studied as well.

2 Theory

2.1 Self- and Co-regulation of Learning

For the purpose of comparing ways students carried out their learning, the framework of SRL was used. Panadero, in his 2017 review of SRL, stated that "Self-regulated learning is a broad field that provides an umbrella to understand variables that influence students' learning" [15]. Many models have attempted to conceptualize SRL and although they differ, the majority of them refer to three general phases of regulation through which learners proceed cyclically [17]. The phases refer to three time-frames during which regulation strategies are thought to be evoked or enacted. These are anticipation strategies occurring before the actual cognitive activity of studying the matter being aimed at; strategies occurring during the actual cognitive activity of studying; and, appraisal or assessment strategies occurring after developing the coveted knowledge. The model used for this research [7], includes a fourth decision-making phase. Decisions are the indication of the use of deliberate regulation strategies; ones that are chosen

consciously. The individual and collective regulation of learning scale (*Échelle de Régulation Individuelle et Collective de l'Apprentissage*, or ERICA) [13] was developed in conformity with this model. The scale enables studying six macro-level [5] SRL strategies learners believe to use. The strategies are mapped to the theoretical cyclical process which comprises anticipation strategies, control and monitoring during the actual cognitive pursuit of the targeted knowledge, assessment strategies that follow, and decision-making that ends a regulation of learning cycle and which may lead to the start of a new cycle. Two macro-level strategies measured with ERICA are mapped to the anticipation phase, they are Individual Anticipation of materials and References (IAR) and Individual Environmental Control (IEC). One measured strategy is mapped to monitoring of the learning process – Individual Tracking and Monitoring (ITM). Two strategies are mapped to the assessment phase. These strategies are Collective Evaluation of Content (CEC) and Individual Evaluation of Method (IEM). One strategy measured with the scale is mapped to decision-making – Collective Decisions for Method change (CDM). Table 1 summarizes the phases and measured strategies.

The scale has been used to study similarities and differences in perceived use of self- and co-regulation strategies in learning environments comprised predominantly of digital interfaces [9,10,12]. Several studies have also been carried out with students in face-to-face learning settings [10,14].

In hypermedia environments, successful self-regulated learners use strategies to enhance the effectiveness of their learning [2]. It has been suggested that these individual, reciprocal and collective strategies [11] are brought into play according to the perceived affordance of the environment [19]. Digital environments can be designed in ways to scaffold the use of strategies [3,8]. Environments may also be perceived by users as not offering such support or even as constraining. In such cases, individuals and groups may resort to regulating their learning using other means, perhaps using other online digital services for example. The question of whether a change in the digital environment around which the learning is organized would modify the strategies perceived to be used by learners is one that this research sought to address.

2.2 Completion and Academic Achievement

Persevering in the face of difficulties has been addressed using the term persistence. For example, persistence of learners enrolled in Massive Open Online Courses (MOOCs) has been studied [6]. Persistence as an ongoing process can be studied using indicators at different points in time (see Evans, Baker & Dee [4] for an example). Contrary to MOOCs, on the digital campus FORSE, which is not designed around the concept of openness of access to the masses, completion as a general indicator for persistence was studied for the two academic years 2017–18 and 2018–19.

For academic achievement Grade Point Average (GPA) scores were used as an indicator.

Table 1. Phases and learning regulation strategies measured with ERICA [13]

Phase	Code	Regulation strategy	Item example
Anticipation			
	IAR	Individual Anticipation of materials and References	At the beginning of a course I look into various documents to know what it is that needs to be learned in order to succeed in the course
	IEC	Individual Environmental Control	I set myself up in a place where I will not be distracted when I am learning
Monitoring			
	ITM	Individual Tracking and Monitoring	I keep track of my learning activities in a logbook or a journal
Assessment			
	CEC	Collective Evaluation of Content	I sometimes discuss the state of progress in my studies with other learners
	IEM	Individual Evaluation of Method	I sometimes question my learning method
Decisions			
	CDM	Collective Decisions for Method change	The learning methods I use are the result of a choice made with others in which I took part

3 Method

Data was self-reported. Participants used an online version of the ERICA questionnaire. It was administered via a server using Drupal™software and an installed Webform module. Students were asked to respond during the second semester of each academic year. Responses were recorded from January 20 to April 9, 2018, when Blackboard Learn was in use, and from January 19 to April 12, 2019, when Moodle was being used as the LMS.

Students were free to respond if so they wished. Confidentiality of provided data was guaranteed, ensuring data treatment would be automated using software. Reporting of the research results was guaranteed to not include participants' names. Compliance was ensured with the General Data Protection Regulation (GDPR) law of the European Union and with local regulations.

An extraction from the university's administration database containing GPAs for each entire year of enrolled students, provided information enabling to compute completion rates. Students who did not complete the year carried a code in the database to designate this. This code was used to measure the rate of completion. The same data extracted from the university's administration database also provided GPA scores, enabling to compute rates of academic success. The grade point system is based on a 0–20 point score. A GPA of 10 and above confers the academic degree *Licence*, the French equivalent to a Bachelor's degree.

4 Results

Participants in this study were third-year undergraduates enrolled in the online digital campus FORSE at Lumière University (Lyon 2) between 2017 and 2019. In 2017–18, 418 students were enrolled in the program at that university. In 2018–19, 401 students were enrolled in the program at the same university.

All reported analyzes that follow were done using statistical software R, version 3.6.1 [18].

Students did not receive incentives to participate in the research. The percentage of ERICA respondents taken from the total number of students enrolled in 2017–18, was 36.36%. The percentage of respondents for the year 2018–19 was 34.16%. Respondents to the online ERICA questionnaire for the year 2017–18 were 131 female students and 19 male. Two respondents chose not to disclose their gender. Female students represent 86.18% while male students represent 12.50% of respondents for that year ($n = 152$). Respondents for the year 2018–19 were 122 female students and 15 male. Female students represent 89.05% while male students represent 10.95% of respondents for the second year being compared ($n = 137$). The proportion of women and of men is not statistically significantly different between the two years (Fisher exact probability, $p = .052$).

The median age of ERICA respondents for each of the compared years was respectively 34 and 32 years old. The difference in ages between participants of the two compared years was nonetheless not statistically significant, $t(287) = -1.70, p = .091$.

4.1 Self- and Co-regulation of Learning

As a first step in comparing self-regulation perceived strategy use, descriptive statistics for each cohort of students were looked at, i.e. participants during 2017–18 when Blackboard was the LMS being used, and participants during 2018–19 when Moodle was the LMS in use. Table 2 provides results for descriptive statistics and for internal consistency measures for each regulation of learning strategy measured. Measures were consistent. Cronbach's alpha reliability measures (α) ranged between .79 and .90 for measures of strategies in both cohorts.

A comparison between cohorts of perceived use of self- and co-regulation strategy use, was carried out next. To this end, a multivariate analysis of variance was performed. No significant differences between the cohorts surfaced, $F(1, 246) = .77, p = .596$. Between-subject effects on each variable were also computed, with no evidence found of significant differences between cohorts for each regulation of learning macro-level strategy.

4.2 Completion and Academic Achievement

The number of students in the 2017–18 cohort that had followed their studies up until the end of the program, fulfilling all requirements and taking all examinations, was 281. These students, who persisted during the academic year represent 76.2% of enrollments in the graduate program. Drop-out rate was hence 32.8%.

Table 2. Internal consistency and descriptive statistics of measured regulation strategies per academic year

	2017–18					2018–19				
Strategy	α	Min	Max	M	SD	α	Min	Max	M	SD
IAR	0.82	0.4	4.0	2.53	0.84	0.81	0.4	4.0	2.59	0.80
IEC	0.90	0.0	4.0	2.92	0.89	0.87	0.4	4.0	2.95	0.81
ITM	0.88	0.0	4.0	1.66	1.28	0.86	0.0	4.0	1.45	1.18
CEC	0.89	0.0	4.0	1.83	0.98	0.85	0.0	4.0	1.66	0.89
IEM	0.79	0.2	3.8	2.21	0.68	0.79	0.2	4.0	2.25	0.65
CDM	0.84	0.0	2.8	0.62	0.67	0.82	0.0	3.2	0.70	0.67

Note: Values for measured regulation strategies span from 0 to 4.

The number of students in the 2018–19 cohort that had followed their studies right up until the end of the program, fulfilling all requirements and taking all examinations, was 200. The number of these students is only half of that year's enrollments. Those who completed the academic year stand for 49.9%. Drop-out rate was therefore, 50.1% for that cohort. The drop in the number of students who persisted until the end of the program is statistically significant, $\chi^2(1, N = 819) = 25.42, p < .001$.

Academic achievement, gauged by the number of students who had graduated among those who completed the program, was 98.9% in 2017–18. Failure rate was hence 1.1% for the year during which Blackboard was still being used. Academic achievement in 2018–19, based on the same measure of the ratio between diploma receivers and the number of students fulfilling all requirements was 95.5%. Failure rate for the year Moodle replaced Blackboard as the digital campus' LMS, was 4.5%. The drop in the ratio of the number of graduates over the number of program-completing students was statistically significant (Fisher exact probability, $p = .033$).

Final GPA scores credited to students in 2017–18 ($M = 13.23, SD = 1.43$) were compared with scores students were credited the following year, in 2018–19 ($M = 12.72, SD = 1.59$). An F test for equal variances in unrelated samples was first used to check homogeneity of variance ($F = .81, p = .262$). As no imbalance between variances was found, a true t test was performed, $t(217) = -2.48, p = .014, d = .34$. Results indicate that grade means indeed differ between 2017–18 and 2018–19.

5 Analysis of Results and Discussion

Significant differences in self- and co-regulation perceived strategy use were not found between the 2017–18 and 2018–19 cohorts. Although demands for more control and flexibility in using and shaping the interface by academic personnel were partially granted, the initial effort was to reproduce an environment offering similar services. At the time that the new LMS was being launched,

fundamental changes in text-based resources and the overall instructional design had not been modified. The attempt of the three involved institutions to reproduce a digital environment with a similar structure, comparable services and the same digital textbook-like resources, as well as the fact of wishing to maintain the core instructional design and educational staff, may have well led to similarly perceived strategy use by students. Self- and co-regulation strategies are deployed by learners in conjunction with their perceptions of the surrounding learning environment [19]. The attempt to reproduce a similar environment, both in terms of roles actors played and ways interactions took place with educational staff as well as the attempt to structure the digital environment similarly, may have had a notable effect on learners' perceptions of the way they conduct and manage their learning tasks and processes within these environments. The hypothesis that the relative enduring similarities between environments were linked to similarly perceived SRL strategy use needs to be substantiated. Reproducing the major characteristics of the environment had also enabled to preserve the instructional design. It is perhaps the latter which had a marked effect on perceptions that students had of their learning strategies. The consequence of having changed LMSs hence seems to have been negligible. As mentioned, some changes had nevertheless been introduced to the environment, though not to a point which would have modified the instructional design. Despite the generally preserved structure, several of the changes that had been made were seen by staff as enabling more control over the environment while other staff members saw the implementation of the new LMS as a setback.

In future studies in which digital environments are changed and their effects are studied, a comparison of self- and co-regulation perceived strategy use; for example, of the undergraduates with those pursuing the postgraduate program, may shed more light on this hypothesis. Within FORSE, the overall instructional design of the postgraduate program is different from that of the undergraduate program. If indeed no significant differences in strategies are to be found between consecutive years for undergraduate cohorts while independently no differences are to be found between postgraduate cohorts, this would reinforce the hypothesis that the instructional design is a prime factor affecting perceived strategy use. If it were to be found that from one academic year to the next, no significant differences are found while SRL strategies remain differentiated between each program strand, this would strengthen the assumption that reconstituting an environment in its broader sense is of greater importance when considering a change in LMS software.

Completion rates have nonetheless significantly dropped. Two-thirds of students persisted until the end of the academic year 2017–18, handed in all assignments and attended examinations. During the following year, after the new LMS was put to service, only half the students persisted. Dropout rates during the third year graduate studies have varied in the past, though comparisons with data from this study are difficult to make as a result of some changes in the graduate program that took place before the study began. Previous to the two studied years in this paper, up until 2016–17, students could opt from the start

to complete the third-year graduation studies over a period of two years. Those students who did opt to study over a period of two years in 2016–17 were still following their studies through in 2017–18. This may explain the higher completion rate of students at the end of 2017–18.

A slight drop in academic achievement was also noted, from 98.9% to 95.5%. Finally, GPA scores dropped too, from 13.23 to 12.72 points (out of 20). Both drops, in academic achievement as well as in GPA scores, were statistically significant. Many factors could have contributed to the plummeting, in particular of student persistence. Analyzing data from years to come, should enable to establish if these changes were momentary or lasting. It should enable to narrow down the number of possible factors that may have contributed to changes by determining if the findings of this study were due to an exceptional event that led to the abrupt changes in completion and to lower grades plus the slight drop in academic achievement; or rather, the manifestation of a phenomenon related to other factors than the swapping of LMSs. Future analyzes should enable inspecting factors, eliminating some unlikely to have played a role and to formulate hypotheses that could be put to test in future studies.

6 Conclusion

The hypothesis that the stability in perceptions of self- and co-regulation strategies used by students is due to the constancy in the program design, learning materials and services as well as the overall instructional design, is plausible but will require further studies. As to the drop in completion rates, a finer grained study of factors that underlie it will no doubt be required. With future data collected at the end of following academic years, patterns, if any emerge, will enable to discern what fluctuations in completion may be due to. By better understanding factors contributing to fluctuations, improvements can be made to counter any adverse effects and enhance any contributing features to the persistence of students in the programs offered via FORSE as well as perhaps provide insight regarding means to favor completion in other digital educational environments. As to GPA scores and academic success, although significant drops were found, they were slight and may be due to variations in the composition of cohorts and their dynamics. Other factors may also play a role in grade attribution by tutors and instructors. Again, comparisons with results from years to come will be valuable to examine.

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E-Learning Ecosystem's to Implement Virtual Computer Labs

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Abstract. Biomimetics is a discipline that seeks solutions emulating the designs and processes in nature, comes from the words bio that means "life," and mimesis means "imitate". This discipline is also known as biomimicry, which is the science that studies nature as a source of inspiration for innovative technologies. In this sense, the ecological approach, combined with technology such as social networks and cloud computing, can open a new way of understanding online learning. Based on the above, this article presents an e-learning ecosystem in order to put into operation virtual computing laboratories using an ecological approach. This ecosystem helps to deeply understand online learning interactions and how they affect the quality of learning, with an analogy of a natural ecosystem, based on the three models of cloud computing services, known as Software as a Service (SaaS), Platform as a service (PaaS), and Infrastructure as a Service (IaaS). This ecosystem will allow interacting with all kinds of resources and services on-demand with massive, ubiquitous and open access, so that they satisfy the new concepts of immersive and global education, and do not register technological barriers.

Keywords: e-learning ecosystem · Cloud computing · Massive open online courses · Virtual desktop infrastructure · Bring your device

1 Introduction

Biomimetics is the name of science, which emulates nature to find practical solutions to our problems; it is a discipline that seeks solutions emulating nature's designs and processes, where there is a considerable opportunity to learn elegant solutions to man-made problems [1]. In this sense, the ecological approach, combined with information technology, can open a new way of understanding online learning. The key concept is the idea that teaching, and learning can be seen as a process of transforming information into knowledge.

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The educational literature reveals several ideas and new technologies to address the future of education, such as e-learning ecosystems, cloud computing, social networks, virtual laboratories, virtual reality, virtual worlds, MOOCs, BYOD, etc. [2].

E-learning appears as the first response to the challenges arising from the trend towards the growing globalization of education, and this inclination means eliminating obstacles that limit access to education, which makes education available for all, regardless of location and physical and social accessibility barriers. Some notable successes worth mentioning, such as the development of massive open online courses (MOOC) [3], and initiatives that work around the challenging concept of immersive education, such as "Immersive Education Initiative" and "The Immersive Learning Research Network (iLRN)" [4].

Technological services are required to meet the demands of modern education, that configure the new e-learning implementations that, in addition to offering benefits such as centrality, usability, scalability, and ubiquity, which allow us to have full training.

The market for software solutions for e-learning is extensive, but most tools have different approaches, which means they cover only specific tasks. For example, tools such as Learning Management System (LMS) and Massive Open Online Courses (MOOC) support the organization and distribution of resources and activities, while they have not excelled in interaction and collaboration [5]. On the other hand, social networks and cloud computing services are used in the generation, collaboration, and exchange of content and resources [6].

According to Gumber, the most powerful reasons for teachers not to incorporate technology into their classes are due to technological barriers, which are the most difficult to overcome [7].

From the above, new e-learning implementations require new models, approaches, and tools to guide their implementation and, thus, support collaboration and the creation of new products and technologies online.

Cloud computing services are having an influence on online education through their adoption and use. Also, it contributes to the implementation of e-learning systems, which makes possible the exchange and collaboration of varieties of resources and tools under demand with massive, ubiquitous, and open access. It allows universities to concentrate more on teaching and research activities than on the implementation and configuration of sophisticated IT software systems [8].

This article is aimed to present an e-learning ecosystem model to implement virtual computing laboratories based on the analogy of a biological ecosystem. In which, all components, dimensions, and agents of a natural ecosystem are related; thus, a combination of technological tools is used to promote the pedagogical transmission of content. The proposed e-learning ecosystem uses the three cloud computing service models as a technological component: Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a service (IaaS) [9–12].

2 Literature Review

Online training or e-learning marks a real revolution in the way of conceiving learning experiences, which influences technological elements, social factors, teaching and teaching roles, communication dynamics, teaching-learning relationships, training content, or the process's methodology.

However, despite the euphoria that online training has produced, and the extraordinary development of technological tools, training systems, and digital content, a degree of disappointment and skepticism cannot be hidden when learning outcomes are analyzed and the level of student satisfaction.

If you review the history of e-learning, you can talk about generations that have marked its development. The first generation is characterized by the development of technological environments and digital content and has moved to the proposals of the e-learning model and, therefore, to a concern for the development of implementation and interoperability strategies with Online training environments, efficiency, and quality. The second generation is marked by the crucial role given to the human factor as an element present in all phases of the teaching-learning process; the redefinition of the teaching role in e-learning is the fundamental characteristic of this phase [13].

Thus, it is necessary to define new e-learning ecosystems, taking advantage of the new technological tools that we have available to generate new communication modalities and new attributions and profiles of the teacher and the student.

The training does not consist of delivering only information to the student, and it must go beyond technological mediation and learning objects, we must talk about human interaction, both among students and with teaching profiles, which is where it is located success in training initiatives, that is, information must become a formative experience in the student's mind, which in Aristotle philosophical terms he called "patient understanding" and "agent understanding," that is, the cognitive distinction between memory and awareness [14].

2.1 E-Learning Ecosystems

In this era of the digital revolution, new pedagogical environments have emerged, being necessary to know what the models are, implementations, and the didactic bases on which the roots feel. Within this framework, the "Social Software for Learning Environments" emerges, which sets in motion the use of new technologies in educational projects. It can be said that this model is based on three differentiated but interconnected supports:

- The first support has to do with the context by which it is produced. This context is framed in cloud computing, which modifies the way of doing, communicating, and thinking, which gives rise to a new culture of the digital society.
- The second support is the culture of the digital society, where new educational scenarios arise that are classified according to use and form true virtual learning communities; thus, participatory, and collaborative learning is given thanks to the use of mobile devices.

- The third support is the pedagogy that unites three theories: the constructivist theory, ecological theory, and perception theory, which add to the internal process of the subject, the bidirectional interaction between subject and medium.

With the three supports described, a digital learning ecosystem is generated whose habitat is formed by true semiotic environments configured by ICT [15]. The species of this habitat will be the technological tools, the pedagogical principles and the contents, in a continuous joint activity through the pursuit of learning objectives [15].

According to Chang and Guetl [16], when making an analogy between a natural ecosystem and an e-learning ecosystem, the following components are identified:

a) Learning communities (biodiversity): Learning communities are groups of people who interact and collaborate synchronously or asynchronously.
b) Technological services and e-learning programs (species): Formed by static and dynamic learning supports and involve the content and pedagogical aspects and may include infrastructure, platforms, and software for the management, execution, and monitoring of the learning.
c) Training in the learning ecosystem (habitat): Characterized by being one of the most important parts of an e-learning ecosystem, which are affected by external and internal factors and by dynamic and changing conditions, which impact potential especially in the system, such as changes in the knowledge policy, in the educational strategy or changes in the curricula. There are also other factors, such as cultural, institutional, and social influences that should be considered [17].

The components and dimensions of an e-learning ecosystem are presented in Table 1.

Table 1. Components and dimensions of e-learning ecosystems

Components	Dimension
Teaching process actors - learning (biodiversity)	Virtual learning community (teachers, students, society)
Technological services and e-learning programs (species)	Technological tools Pedagogical principles Content management
Training in the learning ecosystem (habitat)	Key features of e-learning Government policies Study plans Culture

Prepared by the Author.

According to [17], when making an analogy between an e-learning ecosystem with a natural ecosystem, it conceptualizes the "teaching and learning" flow as the "energy-matter" flow, which makes it possible to transform "information into knowledge",

flow which would be supported by the characteristics of technology services, content management, pedagogical principles [18, 19].

2.2 Cloud Computing

Significant advances in cloud services allow devices to be connected anywhere, anytime and represent one of the driving forces behind modern computing. This fusion of intelligence and connectivity in a wide range of devices complements the growth of internet-scale services to create a new paradigm based on cloud computing, which allows educational institutions, which often lack resources, Making the most of information technology, thus expanding the quality and accessibility of education, especially to remote places and rural communities [20].

The cloud can help overcome the current limitations of mobile learning concerning the limited processing and storage capacity of the devices, mainly through the provision of sufficient computing and scalability resources [21]. In this way, applications can run on mobile devices, while the most computed tasks, such as virtual machines, run in the cloud [22].

Students can also use their mobile phones to access, share, and synchronize learning content stored in the cloud with the appropriate quality of service (QoS) anytime, anywhere [23]. In this scenario, where education faces a paradigm shift in ownership and use of computer equipment, the institution's computer lab is no longer the main place to do the internship; as students increasingly, they use their computers in school tasks.

2.3 Problem-Based Learning

Problem-based learning is the best didactic guarantee for an effective contribution to the development of key competencies and to learning the contents of the curriculum. Starting from concrete and real problem, instead of the traditional theoretical and abstract model, the improvements in the ability to retain knowledge, as well as the opportunity to develop complex competencies, seem evident.

The pedagogical principles based on problem-solving and task completion are: [24–26].

Principle 1: Formulation of the problem and approach of the task. - The real problem that needs to be solved and the tasks to be performed are raised. The problem must include a wide range of activities that the student will frequently encounter in professional life, for which he must follow a set of steps or instructions that lead to solving a real problem. The instruction centered on the problem is contrasted with the instruction centered on the subject or by chapters, where the components of the task are taught in isolation.

Principle 2: Activation. - Learning is promoted when the previous relevant experience is activated. In traditional instruction, it begins with new subjects without inquiring if students have had previous experience; therefore, it must first be ensured that the relevant information is activated to use as a basis for new knowledge. Activation is more than simply helping students remember previous experiences or provide relevant experiences. Activation also involves stimulating the structuring of mental models that can be modified or adjusted to allow students to incorporate new knowledge into existing knowledge.

Principle 3: Demonstration. - Learning is promoted when instruction demonstrates what should be learned instead of simply delivering information. Knowledge is presented on two levels: (a) information and (b) examples. The information is general and refers to many cases or situations. The examples are specific and refer to a single case or a single situation.

Principle 4: Application. - Learning is promoted when students are required to use their new knowledge or problem-solving skills. Merrill (1994) cited research that shows that adding practice and examples to information increases learning. Most of the theories of instructional design advocate the application of knowledge and skill as a necessary condition for effective learning.

Several authors emphasized the importance of involving practice in solving real-world tasks or problems, and are amazed that, with this almost universal agreement on the importance of applying knowledge to real-world tasks.

Principle 5: Integration - Learning is promoted when students are motivated to integrate (transfer, share) the new knowledge or skill in their daily lives. The real motivation for students is to learn situations that serve them in their professional lives. Students have integrated instruction when they can demonstrate an improvement in skills when they defend and use their new knowledge in their daily lives.

2.4 Objectives of eLearning

To fulfill the set of missions that are their own, the training must be structured around four fundamental learnings, known as pillars of knowledge: learn to know, that is, acquire the instruments of understanding; learn to do, to influence the environment itself; learn to live together, to participate and cooperate with others in all human activities; Finally, learn to be, a fundamental process that includes elements of the previous three. Of course, these four paths of knowledge converge into one since there are among them multiple points of contact, coincidence, and exchange.

3 E-Learning Ecosystem

Based on the concepts, theories, and experiences of researchers and institutions, the literature review suggests incorporating new e-learning ecosystems into the new ecosystems, the dimensions presented in Table 2.

As a pedagogical dimension for the e-learning ecosystem, the instructional principles, proposed by David Merrill, based on problem-solving have been selected and realization of tasks, which has the following principles: Demonstration, Application, Integration, and Activation.

As a technological dimension for the implementation of remote computer labs, several tools have been selected for each of the cloud service models such as:

- The platform as a service (PaaS) model that allows the implementation of LMS, xMOOC, content managers (Files: Videos, electronic books, etc.), virtual scenarios, service deployment, certification, and evaluation platforms.

- The infrastructure as a service (IaaS) model: to support virtual machines, virtual laboratories, computer networks, web services, virtual desktops.
- The software as a service model (SaaS): to support cMOOC, Content managers, social networks, forums, chats.

Table 2. Components and dimensions of an e-learning ecosystem.

Components and dimensions of an e-learning ecosystem					
Actors (biodiversity)	Technological services and e-learning programs (species)				Technology
	Pedagogy (problem resolution)	Technology	Technology		Educational pillar
			Technological resources	Cloud services	
Learning community (teachers, students, society)	Demonstration	Technology	-LMS -xMOOCs -Content Managers (Files: Videos, e-books)	PaaS	LEARN TO KNOW
	Application	Technology	-Virtual machines -Virtual laboratories -Computer networks -Web services -Virtual Desks	IaaS	LEARN TO DO
	Integration	Technology	-cMOOCs -Content Managers -Social networks -Forums, Chats	SaaS	LEARN TO LIVE
	Activation	Manage Monitor Optimize Evaluate	-Virtual Scenarios -Deployment of services -PaaS certification platforms LEARN TO BE	PaaS	LEARN TO BE

Prepared by the Author.

These dimensions are interrelated with each other and lay the foundations for generating an educational result, reflected in the fulfillment of the educational pillars.

The relationship between the dimensions of the proposed social cloud ecosystem is indicated in Fig. 1.

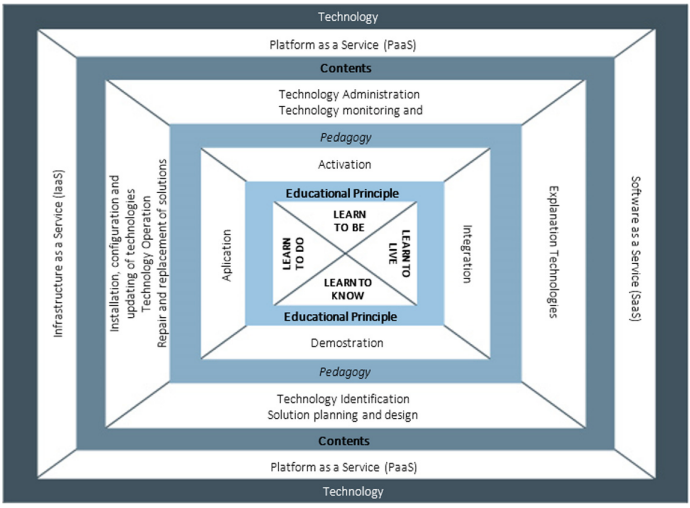

Fig. 1. Components and dimensions of a social cloud ecosystem.

With these relationships between components and dimensions of an e-learning ecosystem, the model to implement virtual computing laboratories is proposed, which establishes as support the technological tools of each cloud computing service model, supported by a pedagogy for teaching IT content, to comply with each of the educational pillars, as shown in Fig. 2.

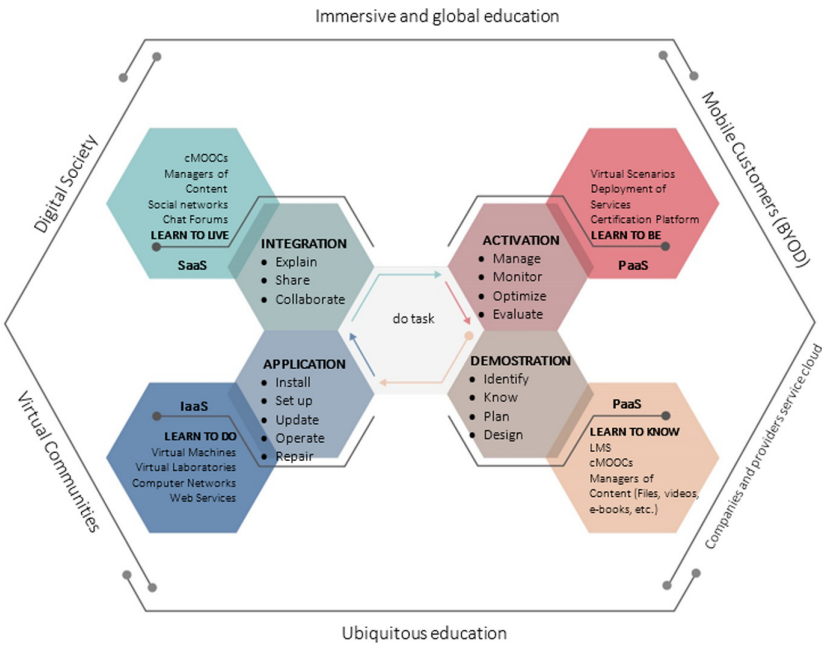

Fig. 2. Proposal: E-learning ecosystem to implement virtual computer labs.

The technological tools of each cloud service model support the fulfillment of a particular educational pillar:

- The PaaS model allows us to meet the educational pillar, learn to know, and the educational pillar learns to be.
- The IaaS model allows us to comply with the educational pillars learn to do.
- The SaaS model allows the educational pillars to be learned to live together or learn to live together.

The tools of each of the cloud computing models is an important technological support in the student's training, and if one of these models is not present, an educational pillar would not be fulfilled, which has an impact on the education of poor quality [27].

The model highlights the application of theoretical content, reflected in the resolution of problems and the completion of tasks for laboratory practices, supported by access to a set of virtual resources and online tools.

Depending on the problem to be solved or the task to be performed, the contents can be published through an LMS or an xMOOC, with a set of resources (files, videos, web pages) and activities (questionnaires, tasks, forums, books, consultations, etc.) collaborative work is promoted through cMOOC and social networks, and access and use of virtual resources is done through virtual desktop services.

Resources, such as videos or virtual machines, are produced by both the teacher and the students, but resources available on other cloud platforms can also be used; these resources are normally shared and organized in social networks, forming learning communities.

The model manages to relate the instructional principles (Pedagogy) to one of the cloud services (technology), to cover IT content and practices, and thus comply with the educational pillars.

The "learn to know" educational pillar is fulfilled by providing the contents, concepts, procedures, and skills that the participant must learn to identify technologies of devices, networks, servers, and cloud computing. It is supported by demonstration as an instructional principle and uses the cloud computing service model called Platform as a Service for the formal publication of resources such as videos, files, slides, and electronic books.

4 Ecosystem Implementation

To apply the model, an e-learning ecosystem was implemented through a virtualization infrastructure using OpenSource oVirt (https://www.ovirt.org) and OpenUDS tools for the deployment of online virtual laboratories.

oVirt is an OpenSource software project, KVM (Kernel Virtual Machine), which allows users to run operating systems based on GNU/Linux and MS Windows, on 32-bit and 64-bit architectures, and is based on different projects co-community like Libvirt, Gluster, PatternFly, and Ansible. It provides centralized management of virtual machine resources, processing, memory, network, and storage. Its architecture is shown in Fig. 3.

To facilitate the management of the life cycle of virtual laboratories, the OpenSource OpenUDS (Open Unified Desktop Service) project was used, which extends the concept

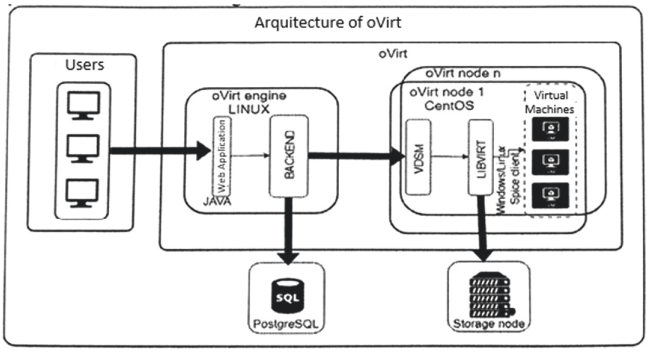

Fig. 3. The basic architecture of oVirt.

of DaaS, allowing virtual laboratories to be used as a cloud service. OpenUDS allows the centralized management of all issues related to virtual laboratories, such as, allocation of access schedules to virtual machines, creation of networks that differentiate and control access to virtual laboratories, enable and deny the access to infrastructure resources, and allows the user centralized management of all virtual machines. The OpenUDS architecture indicated in Fig. 4.

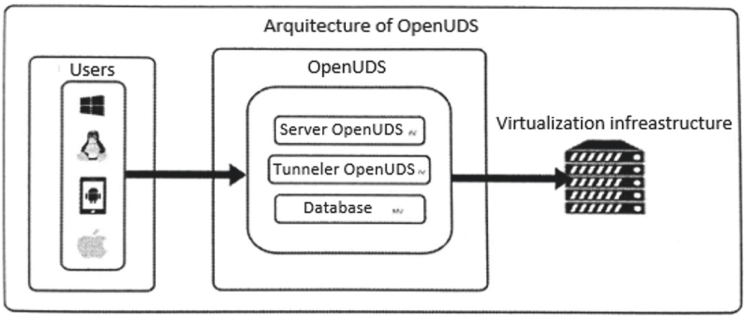

Fig. 4. OpenUDS architecture.

This ecosystem was implemented in the data center of the Faculty of Information Technology and Electronics of the Polytechnic School of Chimborazo, for which six physical servers were used, it is currently in a test phase, and will help to obtain a deep understanding of several aspects such as:

- The way teachers and students use the e-learning ecosystem.
- Challenges and difficulties face
- How can they improve the current use of the ecosystem?
- How do students learn and interact online with their peers, virtual machines, content, etc.?
- Evaluate the learning experience.

With all this information, an analysis is being carried out to understand better the interactions of the different components of the ecosystem, for which the following research question has been raised: Do the interactions between components, dimensions, and agents of an e-ecosystem Learning allows to generate a habitat favorable to education? and the results will be published in an upcoming article.

5 Conclusions

Through the proposed e-learning ecosystem, it is possible to establish and describe the complex and necessary interactions that occur between each of the components, dimensions, and agents of the ecosystem. Among the most important we have, interactions between learning communities, between communities of learning and technology, between components and technological agents, between content and learning communities, between material and resources with technology, etc.

An ecosystem in ecology is complex and involves biotic-biotic, biotic-abiotic, and abiotic-abiotic interactions. The following interactions can be identified in the model: Biotic-biotic interactions: interactions between teacher - administrator, teacher-student, administrator - student. From online collaboration, student-student communication is crucial, and by analogy, it would be called symbiotic relationships. Symbiosis means living together and describes a close and often long-term interaction between different biological species within an ecosystem.

Biotic-abiotic interactions: Interactions between learning community, technology, and content.

Abiotic-abiotic interactions: Interactions between technological dimensions, between cloud computing services, LMS, MOOCs.

These interactions are pivotal to gain a deep understanding of e-learning eco-systems and to promote effective electronic learning practices. The interaction between abiotic and biotic components shapes the quality of learning outcomes and training.

For educators, the model will help to design, describe, and evaluate current online learning practices. For students, it will help to explain how teaching and learning occur in their studies and will help them find higher value from their learning experience.

Also, the model will allow the evaluation of ecosystems in terms of design, navigability and accessibility, content, interactivity, assessment, and student participation.

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Transferability of Methods and Strategies for Advancing Gender Equality in Academia and Research: A Case Study of an Online Course Aimed at Academics and Professionals

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Abstract. The European Union has been encouraging a move towards gender equality since its 6th framework programme. In its 8th programme, H2020, the EU points scientists to documentation outlining the concepts of sex/gender, inviting those applying for funding to state how and why their research will impact gender and how the project will foster gender equality.

However, it is often difficult for scientists from the science, technology, engineering and mathematics sectors who have not received training on gender issues to include a gendered approach in research. Even when this does occur, it is often limited to ensuring an equal number of men and women in project activities.

The Systemic Action for Gender Equality (SAGE) project produced an online course suited to the research funding application path. The course targets academics and professionals seeking to advance gender equality in the workplace. It enables them to understand the basic principles and biases favouring gender imbalance in research organisations and learn to use methods and strategies to progress toward a gender-sensitive organisation and research path.

Supported by adult learning theory and social constructivism, this case study explores how gender-sensitive methods and strategies can be applied to developing and implementing an online education path. It also discusses the limits and opportunities and the theoretical and practical implications of the move towards gender-sensitive research.

Keywords: Gender equality · Gender-sensitive organisation · STEM · Online course

1 Introduction

It is widely believed that research performing and financing organisations (RPO and RFO) should be gender-sensitive. The European Union (EU), its Member States and National funding organisations are taking action to help organisations applying for research funding to consider sex/gender in their research methodology and their projects.

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Promoting a gendered research path requires learning formal, discipline-focused knowledge and knowledge of cross-cutting topics. A systematic review of gender-focused online courses did not reveal resources helpful in learning how to achieve the learning aims described above.

2 Literature Review

To understand why the need for a gendered approach to scientific research is still widely unanswered, it is useful to go back over the path taken in Gender and Technology studies. Gender and Technology studies aim to promote increasingly democratic forms of technology, based on an ever more conscious use. To achieve this aim, they identify and reveal how technology can be implicated in gender inequalities. Technology is only one way in which gender is expressed in the relationships between people and groups and, ultimately, in society. The concepts of masculinity and femininity have been shaped by the division between the sexes [1], and the related attribution of different values for those skills and sectors where women are predominant.

In the 1970s, radical feminists and ecofeminists initiated a critique of the inherently patriarchal nature of technology, and of technoscience more generally [1]. This critique has evolved through four main phases: the study of women in technology; the study of gender and technology; the understanding of a reciprocal shaping between gender and technology; and finally the postmodern perspective that adds other dimensions, such as identity and age, to the field.

The first studies reflecting on women's role in technology date back to the late seventies, almost contemporary to the first analyses of women's role in science [2]. Ecofeminism [3] and radical feminism [4], initiated two parallel paths: a critical reading of technology and the patriarchal aspects it concealed.

In the late 1980s, the emergence of constructivist approaches offered new insights, leading to an analysis of how gender is socially constructed, including the use and appreciation of technology. At the same time, researchers began reflecting on how technology influences relations between people, creating and modifying social and technological relationships, which can therefore no longer be considered unchangeable a priori [5].

In the years since, the Internet led to a radical change in the use of computers, which has also become an instrument of communication and interaction. The change opened up new fields of analysis for gender and technology studies. Technology was seen as a mixture of objects but also of culture, and as such implicated in the construction and evolution of individual identity [6, 7], including gender identity. In the 2000s, the Internet, cyberspace and virtual reality became objects of study and interpretation. Both technology and gender have been seen as socially constructed, in a process of mutual modelling that made it difficult to understand technology without understanding gender [8].

Contemporary perspectives analyse people's role in shaping emerging technologies and their corresponding uses, opening up new avenues for a gendered analysis: technologies for surveillance and the protection of privacy, the role of women in the open-source movement, the lack of genderisation of technology manufacturing companies, big data analysis, serious games.

Alongside this theoretical process, an analysis of the number of women working in the ICT sector reveals discouraging data. Transparency is progressing, with the first

diversity reports published in 2014 by the biggest tech companies, including Google, Facebook and Apple. They all reported that women made up around 30% of their overall staff, with the figure dropping to 15% to 20% for specifically tech roles. At Facebook the figure increased from 31% in 2014 to 36% in 2018; the numbers of women in technical roles are all still significantly lower, although there has been an increase from 15% to 22%. In 2017, women were accounting for 16.7% of employed IT specialists [9]. The proportion of women among doctoral graduates in the ICT field in 2016 was 21% in EU28 [10]. Gorbacheva et al. identified three issues related to gaps in the research on gender imbalance in the IT sector: dealing with "the consequences of gender imbalance in the IT profession, the factors that cause it, and solutions to address it" [11]. They observe that "although many intervention programmes have been implemented in this area, gender diversity in practice has not improved significantly" [11].

The EU has had a particularly relevant impact on encouraging programmes designed to increase the participation of women in technology and at gendering knowledge. In 2011 the European Commission established an expert group 'Innovation Through Gender' to conduct a comprehensive review of this domain and involved the peer reviewed Gendered Innovations project, initiated at Stanford University in 2009. The group involved more than sixty experts from across Europe, the United States, and Canada. The case studies analysed by the expert group offered new insights in basic science, engineering and technological development, environment, food & nutrition, health & medicine, transport, as well as communicating science. These fields reflect priorities set in the 8th European Framework Programme Horizon 2020, covering the period 2014–2020 and in the 9th Programme, Horizon Europe, covering the period 2021–2027. The Gendered Innovations project currently involves 98 experts from across the U.S., 28 EU Member States and Canada.

The EU choice of giving scientists practical methods for "sex and gender analysis" and using the Gendered Innovation website as a major reference point for applications for funding is influencing hundreds of EU scientists in a vision of sex and gender that may be useful in gendering the research path. However, the risk is evident that this vision becomes their only perspective for addressing gender issues in other domains, for example in their work environment. "While gender diversity is commonly understood to refer only to the gender composition of research teams, fully realizing the potential of diversity for science and innovation also requires attention to the methods employed and questions raised in scientific knowledge-making" [12]. Not only the website, but also articles referencing the work done with the Gendered Innovation approach refer often to a polarised vision of "women and men", although they do recognise the importance of demographic diversity, including age, class, ethnicity and nationality, in influencing research in important ways.

There is a gap between current theoretical perspectives on gender and technology and how the EU is asking scientists to engender knowledge. The lack of educational and professional training in the ICT sector makes it more difficult to fill this gap. The case study described in this article aims to contribute to the offer of strategies and knowledge on the promotion of gender equality and diversity based on scientific grounds both in the technological and gender fields.

3 The Case Study

3.1 The Context

Through its 8th and current 9th Research and Development Framework Programmes (Horizon 2020 and Horizon Europe), the EU is promoting direct support for Gender Equality in Research & Innovation policy. It recognises Gender Equality Plans as the main policy instruments used in the European Research Area to advance gender equality in research funding and performing organisations. The EU has three macro objectives: gender equality in scientific careers; gender balance in decision making; and integrating the gender dimension in research content. Additionally, gender aspects of scientific careers and decision-making processes need to be investigated to gather updated evidence for future policy action. Finally, a major challenge for the EU is how to better integrate the gender dimension in research and innovation programmes and projects. In doing this, it directly addresses both the Academic and private sectors. The EU's requirement that gender equality be considered in all parts of Horizon 2020 refers not only to monitoring and guaranteeing the gender balance in research teams implementing the project, but also taking into account possible differences in sexes and genders in research and innovation content. In doing this, researchers without previous training on the "gender dimension" are asked to perform tasks for which they feel often underprepared. While on the Internet there are many reports and toolkits aimed at supporting applicants, no online course follows the different steps in writing a "gendered" research proposal.

3.2 The Project

The H2020 Systemic Action for Gender Equality (SAGE) Coordination and Support Action (CSA) ran from September 2016 to Autumn 2019. SAGE focused on driving stronger action on gender equality in higher education and research. By designing and implementing Gender Equality Plans (GEP), the SAGE consortium developed, refined and tested a replicable gender equality model to be used across EU higher education and research institutions. Designing and producing widely distributable online resources was supposed to deliver comprehensive and integrative gender equality within organisations, by translating gender experts' knowledge and expertise into each institution's mainstream activities and operations.

The SAGE resources, originally planned as described in Table 1, were aimed at Universities and research institutions seeking tools to promote gender equality. As Table 1 shows, the SAGE project originally included among its outputs a Massive Online Open Course (MOOC) based on a traditional university course. The MOOC was one of the outputs produced by the work package titled "Embedding Gender Knowledge in Organisations". The work package aimed to create guidelines and materials for partner and peer institutions to pursue fully 'gender-sensitive' organisations, by incorporating gender into organisational culture, educational curricula, and scientific research content.

Table 1. The gender-sensitive institution educational pack

Modules	Contents	Format
Gendered Content, Culture and Language	Inventory and review of cross-faculty undergraduate and postgraduate curricula content to assess the gender implications of same. Following this, guidelines were developed to address any identified gender inequalities, e.g. including the achievements of women scientists, etc.	Report
Gender Awareness in the Curriculum	A gender session for integration into undergraduate and postgraduate teaching, to ensure awareness of gender is raised among students of all disciplines	A 5 ECTS Gender course for provision on Structured Doctoral programmes
Unconscious bias in the organisation	*How to embed awareness of gender equality issues throughout organisational processes and decision-making*	*Training (during the project life) and online session*
Gender and Organisational Change Session	*A package on delivering organisational change for improved gender equality*	*Available via an online session*
Incorporating Sex/Gender into Scientific Research	*A protocol and online session for distribution to researchers in all fields to enable them to include considerations of sex/gender in their research design and practice*	*Available via an online session*
The gender sensitive institution MOOC	The course components (see above) synthesised into a composite, targeted course for dissemination and exploitation within European and global institutions seeking to advance gender equality	MOOC

The SAGE online course was originally conceived as a MOOC in the project proposal. However, through consultation with the technical service provider, Trinity Online Services Limited, it was decided that an online module would be more appropriate for two main reasons. Primarily, the subject matter is specialised and thus not suitable for a typical MOOC, where a high volume of participants would be expected to enrol at the same time. Additionally, a European project is in general required to produce outputs that are long-term and widely available. Providing resources in the form of an online module means that they are available indefinitely, and participants can work through them in their own time.

The online course is titled Creating A Gender Sensitive Institution. It includes three sessions addressing Change Management for Gender Equality, Unconscious Bias, and

The Gender Dimension in Research (the three lines in Italics in Table 1) (https://www.tcd.ie/tcgel/international-projects/SAGE/creating_a_gender_sensitive_institution/). Alongside the online course, the Course is part of the SAGE Toolkit, providing a workable self-assessment model for broader use by individuals and organisations implementing Gender Equality Plans.

4 Developing the Online Course

4.1 Theoretical Framework

In 1970, Malcolm Knowles, in distinguishing childhood learning from adult learning, outlined new assumptions on adult learners. He described them as being internally motivated and self-directed, bringing life experiences and knowledge to learning experiences, and as being goal and relevancy oriented, practical and keen to be respected [13]. Nowadays the most commonly used terms when referring to adult education are lifelong and lifewide learning, meaning "all learning activity undertaken throughout life, with the aim of improving knowledge, skills and competences within a personal, civic, social and/or employment-related perspective" [14]. This widely used definition has been criticised for being overly simplistic, with two main flaws: the overlapping of lifelong learning with work-life learning and the implicit invitation to learning through life to become better consumers [15].

Although hosted by an Academic website, the online SAGE Course is also aimed at professionals and, in general, those involved in writing and managing research projects. In this sense, they are related to worklife learning. Since, for organisational reasons, it was not possible to interact with the audience using the Course, Knowles's principles and the concepts of lifelong and lifewide learning were applied to create a learning experience that was useful to adults with indirect competence and experience and a clear motivation to improve their research proposals. Particular respect was shown for adult and lifelong learning principles in the choice of terminology and external resources.

4.2 Methodology

The production of the online course involved three phases: secondary and primary research, followed by synthesis and implementation.

Secondary data were collected through a number of activities, summarised in Table 2. A specific search for MOOCs promoting gender equality was not limited to the EU and was initially open to any gender-related topic. Research conducted with the keyword "gender" produced 10 courses for Coursera, 23 for Future Learn and 33 for EdX. The titles and contents were checked, and the final list included respectively 8, 8 and 7 courses focusing explicitly on gender-related issues. However, none of them specifically addressed how to promote gender equality in academia and in the STEM sectors. The team involved in creating the SAGE learning content was composed by four experts in gender studies and in gender and technology. Two members attended also 2 workshops (duration 4 and 2 h) run by experts in the field (Yellow Window, a Belgium-based consultancy group with expertise on gender training, and Portia, a UK-based non-profit organisation that advances understanding of gender issues in science),

addressing the most recent advancement in gendering scientific research. The FIAGES project, focusing on promoting gender equality in STEM academic disciplines and ICT companies and coordinated by a SAGE team member, provided a review of the existing learning resources produced by public and private organisations involved in EU projects in the 7th and 8th framework programmes. FIAGES also contributed through comparable examples from the private sector, in particular information about ICT companies promoting gender equality through mentoring, special groups, specific programmes, reports and analyses.

Table 2. Methods used to select and organise the contents

Primary research	Secondary research
Discussions within partnership	Literature review
Meetings with external experts	Courses led by experts
Team meetings	Examples and models
Testing on finished projects	Comparable examples from other sectors

The primary research activities consisted of discussions within the SAGE partnership during four partners' meetings, in person and online. Among other results, the meetings led to the decision not to create a MOOC but to focus on online learning sessions; these would be uploaded to the coordinator's website and linked to other project outputs. The decision was taken in consultation with the technical team responsible for adapting the contents to the online format, using the Articulate E-learning software.

The FIAGES project contributed through two meetings with external experts, CEOs from companies working in EU-funded proposals. The total duration of the meetings and the selection process (that required and analysis of all 7 projects initially identified) was of 20 h. This led to three finished EU funded projects being selected for use as test beds for the draft sessions of the Course. Five meetings with the local team (duration 1,5 to 2 h each) made it possible to gradually include secondary research data and search for new or different information to fill in the gaps.

Collecting secondary and primary data enabled the team to draft the Course contents and learning experiences (summarised in Table 3). The Course team held weekly review meetings to consider the emerging results of the secondary and primary research, reframe content where necessary, and avoid repeating information that could be sourced elsewhere. The main task was to constantly bear in mind that the information was aimed at academic and professionals interested in implementing practical activities. Theoretical aspects were therefore kept to a minimum, and links to external sources were used to allow those interested to explore theoretical aspects. Over five such meetings, the Course team developed and refined a first draft of the three sessions. This draft was circulated to the SAGE partners and external experts, selected for their critical views of gender studies and the process of gendering the research process. The second draft was used in academic training (with 7 PhD students), session three was tested on three applications

for funding written during the testing phase by academics outside the team, and this allowed subsequent modifications, for better clarity, following their advices.

Table 3. Methods used to synthesise and implement the course contents

5 Results

The Course guides organisations to become more gender-sensitive and to include a gendered perspective in their research activities. It also aims to encourage researchers working on and with technology to consider gender issues. Cultural transformation leading to structural change is necessary if we are to achieve gender equality, as gender equality is still often interpreted as a mere numerical balance of participants in research. Structural change needs to involve gender-sensitive institutional processes and strategies, requiring a vision of gender equality, at individual and organisational levels, that crosses disciplinary boundaries and engages with a variety of gender and feminist perspectives. Institutional and structural interventions challenging behaviour, attitudes and cultures are pivotal in achieving gender equality in a broad sense. Training to overcome gender equality barriers in the workplace focuses on gender-responsive change management, identifying gender bias that influences the gender composition of governance bodies, workload allocation, take-up of work-life balance arrangements, success rates in recruitment and promotion competitions. The first two modules of the Course address these topics. The most common strategies to achieve progress in gender equality refer to 4 macro areas: Institutional Governance, Career Progression, Work-Life Balance and Engendering Knowledge. The third module addresses the fourth macro-area: engendering knowledge.

The Course is based on an inventory and review of existing content, the results of previous projects, and the professional experience of the team members and focuses on the three topics considered more relevant to promote gender equality and diversity in organisations: change management, unconscious bias and gendering research. The three sessions can be explored in any order, as they are not interdependent. However, for those

desiring a broader approach, following the three sessions as they are presented provides in-depth understanding of strategies for a comprehensive approach to gender equality and diversity in organisations and research.

The first session addresses change management, as progressing toward gender equality cannot be performed if the organization and the individuals working in it resist change [16–18].

The second session addresses unconscious bias. Recognising and acknowledging personal biases is considered one of the most important steps towards a more gender-balanced and inclusive workplace [19–21]. Thus, the ability to uncover bias in decision-making processes should avoid or at least limit its negative effects.

Engendering knowledge is considered the most challenging area to work in, as it requires researchers to recognise that most mainstream knowledge has been produced by men; this has an impact on the value assigned to the masculine over the feminine [22]. The third session addresses the importance of including the sex and gender dimension in the research process [23, 24], from conceiving the idea and organising the team to the implementation, dissemination and exploitation phases.

All sessions include videos, texts and quizzes, and the learner is asked to perform tasks that apply the content to real cases. Other resources include links to external websites, videos, reports and scientific resources. The third module guides those who are interested in discovering how they can acquire a different approach in their research field. It provides examples of "engendered knowledge", and offers the opportunity to test the knowledge acquired on three concluded research projects, not including a gendered approach. This possibility for learners to test their knowledge by "gendering" three successful real-life projects is of particular relevance, as it involved negotiating with the project coordinators and partners. The challenge is to reshape the project's outputs (available to the learners through the EU CORDIS website), including a gendered perspective using the strategies and methods suggested by the SAGE online module. From an initial pool of potential projects, the choice was narrowed down to three projects addressing social and medical issues, to interest a variety of academics and scientists, i.e. architects, engineers, sociologists, informatics, psychiatrists, nurses and social workers. The first project explored "Digital Do-It-Yourself" as a complex phenomenon, with social, cultural, technological, economic, and psychological dimensions. These stem from the new possibility of merging physical and information-based components into simple and affordable systems such as 3D printers and Arduino boards. The second project was designed to integrate carpooling into existing mobility systems, using powerful planning algorithms and big data integration from public transport, carpooling systems, and crowd sourcing. The third project aimed at empowering people with treatment-resistant schizophrenia to better self-manage their condition through mHealth techniques.

The external professionals involved in designing and testing the course thought it necessary to include the test beds for three main reasons. The approach gives academic learners who might not be familiar with market-oriented funding schemes access to real EU projects; it shows the added value of a mixed partnership, including SMEs, NGOs, public organisations and academies; and it highlights projects in which impact as well as dissemination and exploitation are important and must be addressed in gendered terms, where possible.

6 Discussion and Conclusion

A lack of formal training on gender-related topics is common in STEM fields. When training is offered, it often focuses on ways of combatting gender-based discrimination. Although several gender-related MOOCs do exist, none of them specifically addresses how to engender research content. Other limitations are the lack of an international perspective and of practical examples enabling learners to test the knowledge they have acquired. In this paper, we described the creation of an online course aimed explicitly at promoting gender equality and diversity in the workplace and engendering scientific knowledge. The purpose of this case study was to design and implement an online course on how to achieve gender-sensitive organisations, focused on change management for gender equality, unconscious bias, and the gender dimension in research. The broader context of the online course is a concerted action co-financed by the EU, in which seven partners in seven EU countries created gender equality plans and a set of learning materials, globally constituting a Toolkit. The international dimension of the partnership enriched the outputs, providing diverse social and cultural perspectives and traditions in gender studies.

One of the article's limitations is the lack of evaluation for the online course, although this is planned for the near future. The three modules have already been tested and used by scientists interested in engendering their research proposals. The course contents have been positively, although informally, evaluated by those who used them in training sessions or real contexts. However, only a more formal evaluation will enable us to understand, through self-assessment and e-assessment, the user-friendliness and effectiveness of the online course.

The study responds to the need to train academics and professionals on a topic - engendering research and working environments - for which there is scattered online information requiring a significant amount of time to understand the process involved. The difficulty in identifying and using proper sources discourages people interested in learning about gender-related issues: they are confronted with concepts outside of their academic and professional training and by the multidisciplinary nature of the gender studies field. The online course enables learners to follow a clear path, guiding them on how to engender all aspects of their research, from the initial idea to the dissemination and exploitation phase, and to achieve a better gender equality in their working environments.

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Description of E-learning in Nursing Education: A Seven-Year Experience at Sapienza University of Rome

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Abstract. E-learning is rapidly growing as an alternative education method in nursing. The aim of the current study is to describe the platform used for nursing education in Sapienza University of Rome that implements an e-learning university course. This e-learning course in nursing is provided by the Unitelma platform. Through qualitative description, this study characterises the platform using descriptive data. Results recommend establishing more multimedia resources in response to the trend of incorporating multimedia items in student assessment to enhance its authenticity. Findings also show that the development of re-sources at Sapienza has focused on the core curriculum pertinent to learning outcomes for basic nursing education.

Keywords: Technology-enhanced learning · e-learning · Blended learning · Digital learning · Program evaluation · Effectiveness · Nursing education

1 Introduction

E-learning (EL) is a key feature of learning technologies in nursing education and is expected to continue to be a prominent method [1, 2]. EL constitutes many technologies and activities, in which the learning process is supported or mediated using these technologies [3]. A meta-analysis of research in nursing education indicates that EL is associated with positive outcomes across a wide variety of learners, learning contexts, clinical topics and learning outcomes [4]. Still, studies have shown several significant barriers hindering the adoption and implementation of EL by nursing schools [5]. The Higher Education Funding Council for England [6] summarised three potential benefits of EL: (1) efficiency, whereby existing processes can be carried out in a more cost-effective, time-effective, sustainable or scalable manner; (2) enhancement, which

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accounts for improving existing processes and outcomes; and (3) transformation, which represents radical change in existing processes or the introduction of new processes. The recognition of the need for continuing education and effective work-based training in support of healthcare professionals delivering high-quality, safe, and effective care is widely accepted [7, 8].

Sapienza University of Rome has been actively adopting EL since early 2013 to align with rapid, nationwide developments in information and communication technologies. The EL course in nursing used at the University of Rome is provided by the Unitelma platform.

To date, Unitelma Sapienza has developed the following courses for and in collaboration with Sapienza:

- five distance learning courses for the recovery of additional training obligations (OFA) (OFA Course in Italian, OFA Course in Mathematics, OFA Course in Chemistry, OFA Course in Biology, OFA Course in Advanced Mathematics for Students of the Faculty of Engineering), with the first four courses in their fourth edition and the last in its third edition;
- the "Risk in Health Facilities" course;
- inter-university degree courses (with the release of a joint Sapienza-Unitelma Sapienza title) in Computer Science (from the 2016–2017 academic year);
- inter-university degree courses (with the release of a joint Sapienza-Unitelma Sapienza title) in Psychological Sciences and Techniques (from the 2016–2017 academic year); and
- inter-university master's degree courses (with a joint Sapienza-Unitelma Sapienza title) in Classical Archaeology (from the 2016–2017 academic year).

Despite the widespread adoption of EL in the field of nursing worldwide, little is known about the current status of EL in Italian nursing education. A recent systematic review on the evaluation of technology-enhanced learning programs for healthcare professionals found a continued need for developing effective and standardised EL evaluation tools, as well as high-quality studies describing the effective evaluation of EL education for healthcare professionals [9].

This paper reports on the use of EL based on experience accumulated in seven years to investigate online learning methods in nursing education. This paper sought to describe the following areas: (1) Quantity of users registered (2) Types of resources available (3) Frequencies in access, and which resources are the most frequently visited. The aim of this study is to describe the platform used for nursing education in Sapienza University of Rome that implements an EL university course.

2 Materials and Methods

The present study was reported by health professionals of Sapienza University of Rome and the Rehabilitation and Outcome Measures Assessment (ROMA) Association [10–22]. This is a qualitative description research study, meaning it seeks to study a phenomenon or process. The methodology of qualitative description has gained popularity

in recent years within nursing and midwifery fields, and Polit and Beck (2014) [23] identified that qualitative description accounted for more than half of the qualitative studies conducted. The EL course in nursing implemented at the University of Rome is provided by the Unitelma platform. Descriptive data about the Unitelma Sapienza platform has been gathered and discussed here.

3 Results

3.1 Mission and History

The University of Rome Unitelma Sapienza is the only Italian online universi-ty maintained by a consortium composed of public enterprises and is directly linked to one of the best Italian public university, the University of Rome "La Sapienza".

Using advanced information technology and methodologies in distance learning, Unitelma Sapienza promotes access to higher education without the constraints of space and time, providing out-of-office services to students and employees who are unable to attend regular educational activities. Unitelma Sapienza especially focuses on the development of research, particularly within the scientific and economic sectors, as well as on the management of information technology, namely focusing on theories, models, processes, technologies and applications for the development of a virtual campus, via the Internet, in higher education. A special focus is also given to tutoring, including tutors concerned with academic activities and those who mainly address student motivation and the achievement of career goals. The incorporation of both types of tutors is designed to increase interactivity with students for a more cooperative learning environment.

3.2 Educational Model

Regarding The EL system adopted by Unitelma Sapienza requires a clearly defined EL model that provides information on the design and implementation of online activities, tutorship methods, technologies used and skills the professionals involved will need. This model is divided into three integrated approaches: delivery, active and/or interactive, and collaborative. Delivery approach: This dispensing approach is aimed at transmitting basic knowledge, including exhaustive and self-consistent contents (e.g., video les-sons, supplementary documentation, etc.). Active and/or interactive approach: This approach complements and completes the previous one, shifting attention from the contents delivered to their applications in specific contexts, including in problematic situations, through various strategies, problem solutions, experiential simulation, and situated learning. Collaborative approach: The collaborative approach is based on peer-education (student–student interaction, in pairs or in groups) and is therefore also based on a form of self-management in the learning process. The teacher or tutor intervenes at the explicit request of the group or to stimulate, motivate or redirect the work of the group towards paths consistent with the task assigned. Unitelma Sapienza's educational and training model is composed of video lessons, webinars and tutorship. To access the courses, the student is given a username and password. To access the lessons, the student is required to access the platform as shown in Fig. 1.

Fig. 1. Student access to the platform

In order to carry out an assisted teaching activity, different formats have been identified for teaching provisions (video lessons) and interactivity (e-tivities, or teaching activities that allow students to consolidate the knowledge acquired through the study of video lessons, requiring interaction between student, tutor and teacher). Formats for video lessons include the following:

1. traditional video lessons (teachers and slides).
2. video case study lessons.
3. outdoor video lessons.
4. teacher–student video lessons or teacher–student video lessons (via forum).
5. video lessons for two participants.
6. video lessons with witnesses.
7. video lessons with a guest.
8. video lessons with only slides.

Each course has several video lessons in which the professor explains the main contents of the course; students have access to video lessons (see Fig. 2).

Fig. 2. Students' access to video lessons

Students can also download the audio file and the PDF of the slides used during the video lesson. Most lessons are supplemented with additional teaching materials, such as books and articles (study activity sheets, etc.); exercises (with answers); bibliographies; and site links. By following the "Download lesson slides" prompt to download the PDF file and printing it, students can obtain a useful aid to follow the lessons, take notes while viewing it and, through these means, create their own "Course Notebook". The slides presented by the professor during the video lesson constitute an important support tool in their studies, allowing students to use them as a basis for their notes in creating a personal notebook. Video lessons can be viewed on any device, including PC tablets or smartphones. Each video lesson is divided into topics and created with a predefined indexing system, which allows for flexible use. One can see an entire video lesson in a linear fashion or follow a non-linear itinerary, choosing the topics one wishes to study in greater depth alongside the connected study materials. The modular organization of the course contents and indexing of topics allows students to develop multimedia learning processes, establishing a more personalised study path. The consultation and study of didactic teaching materials will enable students to prepare more thoroughly by studying in greater depth the various topics introduced in the video lesson and through practical application of the concepts learned. A demo lesson is available at https://www.international.unitelmasapienza.it/demo-lesson.

Periodical webinars are introduced in each individual section of course content, consisting of live web-streaming that students can follow and participate in, based on thematic discussions on issues addressed in the video lessons with active participation from both the professor and tutor. The webinars are synchronic tools with activities carried out on a regular basis. They are designed to enable student participation and support for a more interactive learning process.

Course participants are aided by a dedicated tutor specifically involved in the course at hand; the tutor's task is to support the student in the process of knowledge apprehension and in better facing any obstacles encountered in the training program, helping learners to fully understand a topic before moving on to a more advanced topic.

Further, the EL needs to be able to identify, at any time, the point he or she is in within the training path, the objective of the activity and the level of knowledge progression he or she has made on the contents of the course. For this reason, it is necessary to devise self-assessment tools that support the student's learning path, aiding in the verification of the level of acquisition of knowledge covered by the test topics. These tools are currently in the planning phase of development.

Self-assessment of learning is mainly based on two tools:

- quiz batteries (structured tests with true-or-false or multiple-choice questions that ultimately give students feedback on how much they have prepared and provide the opportunity to continue with video lessons or review the topics already studied) and
- question/answer forums (the student evaluates their own preparation, comparing their own answers with those of the teacher, who, once the instrument has been designed, no longer needs to monitor it).

4 Discussion

EL has become a mainstream method in nursing education over the past decade. The aim of this study was to describe Sapienza University's seven years of experience with EL, using the Unitelma platform. From the given description, it can be argued that the Unitelma EL consortium is a successful model for implementing EL in nursing education at the national level.

This study found that an increased use of EL is in part due to consistent efforts made by nursing educators to develop learning resources that meet their curricular needs in basic nursing education. The broad range of subjects that must be covered in nursing education makes it a considerable challenge to develop resources on all subjects.

This study also shows that the popularity of learning resources offered by Unitelma differs substantially across resource types, specifically demonstrating the current popularity among nursing students of online videos as learning resources. This finding concurs with that of Khogali et al. [23] that students most strongly value animation and video demonstrations among EL resources. It is likely that online videos will continue to be used prevalently in the foreseeable future, as they play an important role in clinical education. It is also likely that the creation and use of educational videos will become more widespread in nursing education with the increasing popularity of social media. This trend may emulate the learning styles of today's nursing students, who are millennial learners living and learning with these technologies [24].

We posit that there are several possible evolutions of EL in the nursing sciences. Other authors in the literature suggest that the presentation of clinical cases warrants future research on clinical case design [25]. Clinical cases can be presented in a variety of formats, from a simple text-based format to the promotion of interaction with a virtual patient in a computer-based simulation environment [26]. It is also plausible to simulate patient encounters using virtual and augmented reality, which is likely to become prevalent technology in the near future and is increasingly garnering the attention of nursing educators [27]. Still, research remains scant on such learning environments. Future research is needed to establish more effective designing of clinical cases to investigate how widely they are used by nursing students and how to design them to better promote students' clinical reasoning skills.

This study has some limitations. First, because this is a qualitative description study, it does not provide quantitative information on the quality of the course or on the experiences of students by means that can be compared with data from other studies. Moreover, this study was limited to the EL format that offers online learning resources through an EL portal. As there are various formats of EL, such as online courses, and several forms of learning resources available in nursing education, precaution needs to be taken in generalising our findings in application to other EL contexts. This study calls for future research to explore what causes these differences to better understand nursing students' use of learning resources. A future study on this would help to advance our knowledge of more effective EL uses that meet the learning needs of today's students and help to improve nursing education by supplementing face-to-face instructions with EL. This study implement the existing knowledge describing the Sapienza University's experience, highlighting how the e-learning setting can evolve in the future. In conclusion,

this study provides implications for future directions of EL in Italian nursing education. From our findings, we can recommend establishing more multimedia resources in response to the trend of incorporating multimedia items in student assessment to enhance its authenticity. Our findings also show that resource development has focused on the core curriculum pertinent to learning outcomes for basic nursing education. To promote student-centred learning, it is therefore important to offer a wider selection of subjects with more depth of study than the core curriculum. To achieve this, resources need to be expanded to support such curricular components.

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Serious Games Technologies

Applying Motivational Techniques and Gamified Elements on Instructional Design Models for Effective Instruction in Secondary Education

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Abstract. Teachers in secondary education are involved in many instructional design activities without formal training in learning and/or e-learning, particularly on motivational theories. Motivational theories provide a basis of instructional strategies and allow reliable prediction of their effectiveness in various web-based platforms. ARCS, motivational theory and ADDIE instructional design model are used to guide the development of instructional design strategies, in order to achieve efficient learning outcomes and enhance the learning process. From this viewpoint, this paper proposes a conceptual framework, based on the orchestration of the models of ADDIE and ARCS, through the implementation of a project entitled "Voyage in space and time" for an interdisciplinary e-course in Byzantine history and Art/Archaeology, built in the Moodle Cloud. The Moodle platform was customized by a set of various learning strategies provided by the ARCS model. These included gamified elements such as restrict access and activity completion, as well as embedded digital storytelling. The project was evaluated by an experimental group of 22 teachers – scientists from different disciplines – by using a questionnaire developed for the research and based on Keller's Checklist regarding the ARCS' acronym categories. The results showed that future students could align to the proposed framework and potentially achieve greater learning outcomes. Therefore, the proposed conceptual framework provides theoretical evidence for the design and delivery of an instructional workflow in secondary education. More specifically, it highlights the actual implementation of motivational theories in the classroom and especially for history courses, as an effective way to enhance students' motivation.

Keywords: ADDIE model · ARCS motivation theory · Interdisciplinarity · Byzantine history and art/archaeology · Digital storytelling · Moodle · Gamified elements · Secondary education

1 Introduction

E-learning plays a very important role in the current learning paradigm, due to its cost and time effectiveness, as well as the lack of physical presence in the learning space. As

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an effect, it is needed to develop well-designed e-learning courses based on pedagogical models and frameworks, appropriately customized for the end users' needs. However, these e-learning demands in combination with the emergence of modern pedagogical approaches challenge instructional designers and e-trainers as for the customization of learning management systems and the integration of the different learning subjects and digital content into them. E-learning professionals are usually oriented to the cognitive side of learning, paying less attention to the affective side. Therefore, they need to use cutting-edge technology into learning methods, customized to each subject but on the other hand, to take into account the audience's affective factors such as motivation, needs, attitudes etc.

Motivation is a mechanism, which influences people to act in a desired way. Motivation theories are very popular nowadays. This implies orchestrating pedagogical theories in an effective way for learning. Consequently, teachers should attract the students' affective factors by using different motivational strategies, techniques and methods such as gamification based on a pedagogical theory, expecting students to become more active in the learning process. On this basis, according to the researchers, the learning motivation is directly related to self-confidence [4], self-efficacy [2, 15], determination [5], personal goals, behaviors and satisfaction [14]. Motivational theories could ground instructional strategies and provide reliable prediction of their effectiveness in various web-based platforms. In order to achieve efficient learning outcomes, ARCS (Attention – Relevance – Confidence – Satisfaction) motivational theory along the lines of ADDIE (Analysis –Design – Development – Implementation – Evaluation) instructional model is used to guide the development of instructional design strategies and to enhance the learning process.

Therefore, the need for well-designed conceptual frameworks emerges to provide the above-mentioned capabilities to all involved, namely e-trainers, instructional designers, e-learning professionals as well as teachers and students. Regarding technology and well-designed e-courses, very promising opportunities to this achievement can be provided by learning management systems such as Moodle. Not only Moodle is very familiar due to its pedagogical philosophy [1], but it also provides a variety of tools which help teachers without any advanced technological background to design instructions. Moodle enables instructors to engage students in the learning process because it provides a set of activities and resources, settings and utilities that could incorporate gamified elements such as forums, quizzes, certifications, badges, restrict access, activity completion etc. [6]. On the other hand, it is a very flexible, user-friendly and easily customized platform, aligned to motivational theories' guidelines.

To this end, this paper serves the current needs. It aims to present a well-designed conceptual framework on Moodle Cloud platform in order to support its educational potential by providing the design and delivery of learning workflow processes. More specifically, the proposed framework encompasses the specific e-learning environment customized by the educational principles of the ADDIE model and the guidelines of the ARCS motivational model. At the same time, it integrates gamified elements putting more emphasis on digital storytelling, in order to provide motivation for interdisciplinary subjects of Byzantine History, Art/Archeology to the students in secondary schools. In other words, this question refers to the educational potential of an instructional design tool when

combined with motivational strategies for an optimum learning process workflow. The rest of the paper is structured as follows: Sect. 2 contains the theoretical background including the three main pillars of 1) ADDIE model, 2) ARCS model and 3) gamified elements and digital storytelling. Section 3 presents the Methodology. Section 4 provides the research results. Finally, Sect. 5 discusses remarks and conclusions.

2 Theoretical Background

This section discusses the theoretical background of the project. It refers to the three pillars of the instructional design and the ADDIE model, the learning process and the ARCS motivational model and the digital storytelling corresponding to gamified techniques. The following paragraphs provide a clear picture.

2.1 The ADDIE Model

ADDIE (Analysis – Design – Development – Implementation – Evaluation) is a design model widely used for instructional design, in order to create technology-based e-learning courses [3, 11]. ADDIE was implemented by professional instructional designer to create a base, on which e-learning programs could take shape. There are, also, some other versions of ADDIE, such as "PADDIE" (Planning, Analysis, Design, Development, Implementation, Evaluation), where planning and/or preparation are added in the initial stage. The model is usually applied on projects, because it is convenient for complex teaching designs. The five phases of ADDIE model are as follows:

1. Analyze. The Analysis phase can be characterized as the "Goal-Setting Stage." In this phase, the focus of the designer should be put on the target audience. Depending on the trainees, the lesson will be adjusted accordingly. The trainer has to research learning resources and determine delivery and assessment strategies. They also have to identify learning space and devices, taking into consideration the learners' profiles.

2. Design. This phase determines setting goals, designing, planning, testing, tools to be used for performance, subject matter analysis, planning and resources. In the design phase, the focus is on exploring technology options, learning objectives, content, subject matter analysis, exercise, lesson planning, assessment instruments used and media selection.

3. Develop. The Development phase starts with the production and testing of the methodology being used in the project. In this stage, designers conduct testing, ensure security and backup, confirm copyright and accessibility. The development stage is nothing else but the realization of the desired project. This phase includes three tasks, namely drafting, production and evaluation.

4. Implement. The implementation phase reflects the tools which the e-teacher will use to achieve the maximum efficiency and desirable results. Updates and redesign help to the best implementation of each project. Feedback will help further for the improvement and understanding of the best tools in each situation.

5. Evaluate. The last phase of the ADDIE model is Evaluation. This is the phase where answers are being given regarding the "what, how, why, when" of the targets that were accomplished (or not) during the project execution. The main goal of the evaluation stage is to assess if the goals have been achieved, and to establish what will be required to enhance the efficacy and improve the results.

2.2 The ARCS Motivational Model

The use of ARCS (Attention – Relevance – Confidence – Satisfaction) motivation theory is a technique widely used in e-learning, as evidenced by other dissertations dealing with Keller's theory and its application to e-learning. According to the ARCS model, learners will be motivated when they feel that they can be successful and worth learning [7]. Clearly, an e-learning environment enables instructors to enrich their lessons with various tools, in this case the moodle tools. Thus, students will be satisfied with the lesson and the chances of succeeding will be much higher. According to Nilson [12], the teacher must stimulate students' imagination, enchant them to acquire knowledge, so as to challenge and invite them into the learning process.

More specifically, Keller [7] developed the ARCS model, which is a four-category training strategy designed to measure the levels of motivation offered to the individual, described briefly as follows:

Attention: This is a strategy designed to focus students' attention and stimulate their curiosity through Perceptual Arousal using real-world examples, Inquiry Arousal which can take place with the active participation of students in games or through student questions and Variability which can be ensured through a variety of tools such as video, quiz, educational games, forums etc.

Relevance: this factor relates to the extent to which the teaching responds to the learner's needs and goals. The subcategories that can be divided into this category are goal orientation, motive matching, and familiarity, which can be built either on past experience or for improvement of students' life.

Confidence: Confidence relates to students' confidence and attitude to success or failure, which can determine students' performance.

Satisfaction: The last factor is student satisfaction, which can be defined as positive feelings about students' learning experiences, in order to maintain motivation at a fair level.

2.3 Gamified Elements and Digital Storytelling

Motivation is inseparably linked to the terms of "Gamification Elements" or "Gamified Elements" because e-courses developed with respect to this approach, consist of gamified practices [17]. These practices in turn are combined with motivational theories and often are evaluated through motivational factors [16]. Certainly, motivation could be enhanced

by incorporating strategies that provide stimuli for interaction between the teacher and the students. Gamification here provides the necessary stimuli. According to Werbach et al. [18] gamified elements are classified into a pyramid of three layers. The first layer at the bottom includes the game components such as badges, points, levels, and quests. The second middle layer includes the mechanisms such as collaboration, discovery, and feedback. The third and most important at the top refers to the dynamics such as emotions, progress, narration, and relationships as well.

From this perspective, narration becomes an integral part of a gamified e-course. Narration is related to a hypothetical scenario, a fictional story, often intended to be a breakthrough in solving a learning problem. Narration provides guidance all over the learning process because it maintains the sequence of the learning task and the interaction with the e-learner. As such, narration could be characterized as an educational strategy formally known as storytelling or digital storytelling when digital media is exploited. According to Lambert [9] the seven following features formulate storytelling:

1. The perspective: What is the main point of the story and what is the perspective of the author?
2. The Scientific Question: A key question that holds the viewer's attention and will be answered at the end of the story.
3. Emotional Content: Serious issues that come alive in a personal and dynamic way and connect the audience with history.
4. Voice Charisma: It's a way to personalize the story and help the public understand the context.
5. The Power of Music: Music or other sounds that support and decorate history.
6. Frugality: Using just enough content to tell the story without tiring the learner out.
7. Pacing: The pace of story and how slowly or rapidly it evolves [11].

Consequently, digital storytelling has many positive effects on learning [13] and is an innovative teaching method that enhances learning skills, stimulates students' interest, and humanizes teaching. In addition, such techniques can be combined and applied to serious games in order to enhance entrepreneurship in educational settings for emerging economies [10].

3 Methodology

This article aims to present a well-designed conceptual framework on Moodle Cloud platform in order to support its (the framework) educational potential by providing design and delivery of the learning workflow processes. More specifically, the proposed framework encompasses the specific e-learning environment customized by the educational principles of the ADDIE model, in which the guidelines of the ARCS motivational model are implemented. The motivations for the ARCS theory implementation are being given via gamified elements and digital storytelling, in order to provide motivation for interdisciplinary subjects of Byzantine History, Art/Archeology to the students in secondary schools. In accordance with the research aim, the research question is articulated as follows:

RQ1. What is the educational potential of an instructional design (macro scenario) based on ADDIE phases and the learning process of ARCS model (workflow) and its categories on the Moodle platform?

In order to give answers to the above research question, a project titled "Voyage in space and time" was constructed, founded on the proposed conceptual framework (Fig. 1). The ADDIE model was exploited in order for the macro-script to be designed. Each phase of the model as well as the subsequent steps are described below.

Analyze: In this phase, the teaching problem was initially clarified. Specifically, in Greek current learning paradigm, students often are not able to understand that there is a connection between historical events and art achievements, and how this connection is established, because this connection is not sufficiently distinguished in the curriculum. Thus, the educational goal was the investigation of that issue by the students through a variety of educational activities. For this purpose, Moodle Cloud was used as the hosting environment of the project. Vyond and Voki were used as video-making tools for the storytelling-gamification elements, embedded in the Moodle Cloud project.

Design: In this phase, a four-step micro-script was designed. This procedure included mainly the goals setting, the provision of supporting material, the number, the content and the sequence of the educational activities referring to the learning goals, as well as the selection and description of the assessment tools. In addition, roles and means were defined systematically and in detail. This means that in this phase, ARCS learning process workflow was enriched with gamified elements, giving greater emphasis on the narration, namely the digital storytelling. The following table (Table 1) presents a matching between ARCS (Categories and Strategies) and gamified elements, corresponding storytelling features and digital tools, as they are indicated by literature and are instrumented appropriately into the conceptual framework.

Development: In this phase, the educational scenario was constructed. It encompassed seven stages – four stops among them related to History, Art, Museology and Present, (Fig. 2). For each stage, a Moodle topic was formulated and covered by a set of activities and resources. Digital Storytelling was implemented mainly through educational videos. According to the educational scenario, four imaginary friends, Orfeas, Alexander, Ismini and Faidra – the heroes of the story – decided to go to Alexander's home library to study for the next day's history test regarding Vyzantium. In this library, they discovered a time machine. Ismini accidentally pressed a button and the heroes got lost in another dimension, another time and place. Suddenly Alexander's grandfather, Nestoras appeared and informed them that if they passed a set of challenges and quests, so as to unlock the time machine at a given historical period, they would go back to the present. Taking this proposal as a chance for succeeding in the history course test, they traveled back to Vyzantium. Students, therefore, had to accomplish the assigned activities in order to help the heroes of the story unlock the time machine and return to the present. In Fig. 1, the educational scenario is imprinted, indicating the micro-script for the first stop, where Orfeas is involved in history subjects.

Implementation: In this phase, the whole e-course was implemented in the Moodle Cloud. It is clear from the figures (Fig. 1, Fig. 2) how a workflow process of ARCS

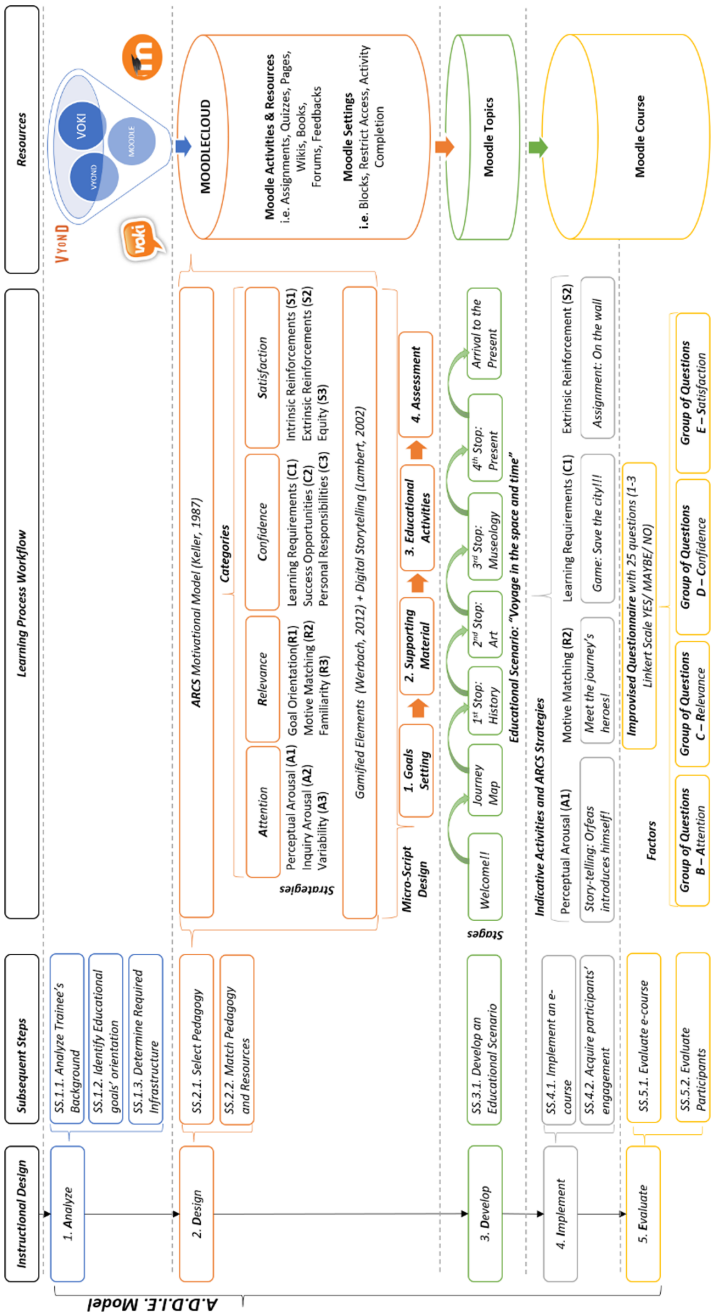

Fig. 1. The conceptual framework

Table 1. Design phase, learning process workflow

Micro-script design	*ARCS categories & strategies [7]				Gamified elements [18]			Digital storytelling features [9]	Digital means
	A	R	C	S	Components	Mechanics	Dynamics		
1. Goals setting	A1 A2 A3	R1 R2 R3	C3	S1			Narration (Storytelling) Emotions	- The perspective - Emotional content - Voice - Music - Frugality	• **Voki** • **Vyond**
	A1 A2 A3	R1 R2 R3	C1 C2 C3	S2 S3		Challenges		- The scientific question	
							Progress	- Pacing	
2. Supporting material	A1 A2 A3	R1 R2	C3	S1 S2 S3	Content unlocking		Constraints progress		• **Moodle Cloud/** - Restrict access - Activity completion - Pages/URLs - Blocks
3. Educational activities	A1 A2 A3	R1 R2	C1 C2 C3	S2 S3	Quests content unlocking	Points feedback cooperation	Constraints progress emotions		• **Moodle Cloud/** - Restrict access - Activity completion - Assignments - Wikis

(*continued*)

Table 1. (*continued*)

Micro-script design	*ARCS categories & strategies [7]				Gamified elements [18]			Digital storytelling features [9]	Digital means
	A	R	C	S	Components	Mechanics	Dynamics		
4. Assessment	A3	R1 R2 R3	C1 C2	S1 S2 S3	Achievements content unlocking	Feedback rewards collections	Constraints progress narration (storytelling) emotions	- Emotional content - Voice - Music - Frugality	• **Vyond** • **Moodle Cloud/** - Restrict access - Activity completion - Rubrics/grades - Locked lesson - Quiz

*A – Attention	R – Relevance	C – Confidence	S – Satisfaction
(A1) - Perceptual Arousal	(R1) - Goal Orientation	(C1) – Learning Requirements	(S1) – Intrinsic Reinforcements
(A2) - Inquiry Arousal	(R2) - Motive Matching	(C2) – Success Opportunities	(S2) – Extrinsic Reinforcements
(A3) – Variability	(R3) - Familiarity	(C3) – Personal Responsibilities	(S3) – Equity

model is accomplished by a set of activities enriched by motivational strategies and gamified element techniques. Each topic/section of the moodle e-course was identical to a stop in the imaginative journey in time. There were four stops on the journey, which means four moodle topics. Each topic ends with a number which was given to students as a praise for their achievement. The four numbers constructed a four-digit code which was able to unlock the time machine.

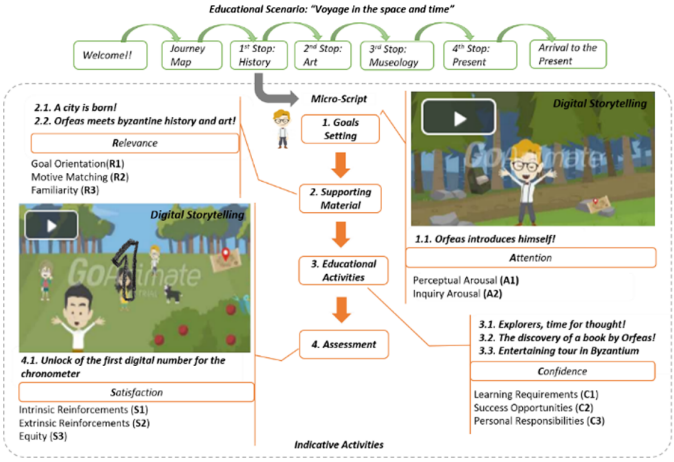

Fig. 2. The educational scenario, the micro-script and indicative activities

In particular, the previous figure clearly presents the embedded storytelling videos. Undoubtedly, these could capture students' attention and maintain their interest in high level. While attention is stimulated through imaginative stories, the digitization of the story accelerates students' cognitive comprehension. On the other hand, students identify with the heroes of the story as each hero presents him/herself by giving information about his/her personal characteristics (i.e. personality, behavior etc.). This means that apart from attention, relevance and motive matching are applied too. In addition, students could gain confidence and satisfaction (Confidence-Satisfaction) through the accomplishment of the educational activities.

Evaluation: In this final phase, the project was evaluated by the participants. The current study was based on a quasi-experimental research design method. The participants, namely the sample of the study consisting of 22 teachers from different disciplines filled in a questionnaire of 25 questions to specifically address the purposes of the research study. The data yielded provide results about the extent to which electronic material (content - strategies) enhance students' motivation regarding the categories of Attention, Relevance, Confidence and Satisfaction. The questionnaire was based on the Motivational Tactics Checklist questionnaire proposed by Keller [8], which is a Likert-type Questionnaire (1 = "Yes", 2 = "Maybe" and 3 = "No").

4 Research Findings

The questionnaire that was constructed for the research needs consisted of 5 groups, introductory questions such as field of study, working experience, gender. The questions in group B of the questionnaire examined the factor of Attention of the ARCS model. Questions in group C examined the Relevance component. Accordingly, the questionnaire group "D" examined the Confidence component. Finally, the Satisfaction component was examined in group "E". In order to determine whether teachers considered the motivation of the learners to be components of the ARCS model, statistical tests, using the one-sample t-test, were performed. The questions from group B to group E were based on the Keller's questionnaire, Motivational Tactics Checklist [8].

For the questions from B group to E group, the respondent could choose from 3 answers (No = 1 point, Maybe = 2 points, Yes = 3 points). Each group of questions consisted of 6 questions per average. So, in case the respondent evaluated inefficiency of motives' giving and answered No = 1 to all the 6 questions of a group, the minimum score would be 6, otherwise in case the respondent estimated that the project was giving motives and answered Yes = 3 points, the maximum score would be 18. In case of uncertainty in the efficiency – Maybe = 2 the base is 12.

Table 2. One-Sample T-Test for B = Attention, C = Relevance, D = Confidence, E = Satisfaction, Test Value = 12

Questions	Factors	N	Mean	Std. deviation	T	df	Sig. (2-tailed)	95% Confidence interval of the difference	
								Lower	Upper
Group B	Attention	22	15,7273	1,51757	11,520	21	,000	3,0544	4,4001
Group C	Relevance	22	15,0000	1,90238	7,397	21	,000	2,1565	3,8435
Group D	Confidence	22	14,7273	1,48586	8,609	21	,000	2,0685	3,3861
Group E	Satisfaction	22	15,5909	1,89383	8,894	21	,000	2,7512	4,4306

The one-sample t-test results (Table 2), showed that the average of teachers' scores in all components was statistically significantly higher than the basis 12, as shown in 8th column: sig (2 – tailed) = 0,000 < 0,001.

The results were rather positively oriented and encouraging towards the current project. However, the limitations of the research are that the sample was small (only 22 respondents), and that the project was not implemented on students.

It would be interesting to proceed with further research on this field, so as to evaluate the efficiency of such learning strategies, on a wider sample consisting not only of trainers, but also of learners. This would ensure a higher level of accuracy and acceptance of these methods.

5 Conclusion

This study was situated in the practice of secondary-level programs. The first part of this study was a thorough review of the applied theories on e-learning education literature focusing on issues of scenario-based methods. From this review, a conceptual framework was created and tested for further application into educational practices in order to be generated in the future. The conceptual framework included five phases as core elements of ADDIE instructional design model in which the four categories of ARCS motivational model were used in order to support learning processing for different disciplines-educational experience. (Fig. 1). Gamification was the way of implementing the ARCS theory, by giving motives to the learners. Finally, indicators corresponding to the categories were proposed to generate the conceptual framework. This constitutes a proposition because well-designed frameworks could be exploited as templates to apply instructional design models (ADDIE) into learning theories, emphasizing on the process of learning (ARCS), intending to guide learning context into every-day e-learning practices.

In particular, the proposed framework will be used in future applied research of interdisciplinary approaches in secondary education. The initial finding of this study is that scenario-based frameworks appear to have considerable potential in enhancing cognitive and affective factors of learning. However, much work remains to be done in the field of designing and delivering these frameworks to every-day practice. Progress in this area will depend upon further testing in different educational approaches with detailed strategies in facilitating students' motivation.

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Avoiding the Risks of Overgamification in Education – A Case of ERPSim

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Abstract. Based on the positive experiences surrounding the introduction of gamification in higher education, as well as the positive acceptance of the ERPSim business simulation game among students, we decided to expand the scope of gamification in the course of ERP (Enterprise Resource Planning) Systems. In addition to the already used simulation game at the beginning of the course, we also introduced additional ERPSim games implemented as workshops within the study course. To avoid potential challenges, we identified and explored the potential gamification-related risks in education through a literature review and considered them when performing the simulation games. The results of this retrospective show that with the use of appropriate approaches, solutions and strategies when extending the scope of gamification, we have adequately and successfully addressed all of the main types of risks, i.e. risks associated with the design of gamification itself, risks connected to the introduction and application of games in the course, and risks related to individual differences between participants.

Keywords: Gamification · Serious games · Business simulation game · Challenges · Risks · ERP

1 Introduction

The increasing use of gamification in higher education [1] is closely linked with addressing current challenges connected to students' interests and their course engagement. The needs of current generations of students encourage the use of new and adapted learning approaches. We used the ERPsim business simulation game within the ERP Systems course first in 2017 [2]. The game was implemented in an introductory workshop complementing a traditional learning approach [2]. The results of our three-year study [3], pointed to the positive impacts of gamification. The students' feedback revealed that the use of a business simulation game for the introduction of the Enterprise Resource Planning (ERP) concepts resulted in improvements in students' knowledge and skills and boosted their intent for future engagement [3]. In 2019, the gamification approach was extended throughout the entire course. We introduced two additional workshops, in which we used three, more-advanced ERPsim business simulation games. Since the students' feedback and acceptance of an introductory workshop was very positive, we did

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not want to compromise it with the implemented extension of a gamification approach. Therefore, our goal was to properly address the challenges and risks that are present when implementing the gamification, with a special focus on avoiding overgamification.

Within the paper, we present the challenges and risks of gamification implementation in higher education, identified within a literature review. Addressing the highlighted areas of risks is necessary in order to achieve a positive impact with gamification. However, when not addressed properly, challenges and risks could have a negative impact on gamification acceptance and students' engagement. With the identified risks in mind, we designed a survey to address students' experiences with the ERPsim business simulation games and at the end of each of the implemented workshops, subsequently collected participants' feedback. This enabled us to explore possible negative outcomes, resulting from the extended use of gamification. The presented study is based on the following research questions:

- *What challenges and risks should be considered when implementing gamification in higher education?*
- *Did we successfully address challenges and risks when implementing ERPsim business simulation games within an ERP systems course?*

The paper is organized as follows. After the introduction, the theoretical background covering gamification and serious games is presented. Section 3 presents ERPsim business simulation games and its use within the ERP Systems course. Section 4 outlines identified risks and challenges when implementing gamification in higher education. The risks and challenges were identified within the performed literature review and are grouped into three categories. Section 5 presents insights into the addressed risks and challenges in order to avoid the negative impacts of gamification within the study course. The feedback gathered from students with the use of questionnaires is also presented. Finally, the paper is concluded in Sect. 6 with directions for future work.

2 Serious Games and Gamification

An increasing interest in game-based learning (GBL) can be noted in recent years [4]. The GBL envelops learning with games in a broader sense [5]. The connection between learning and playing games is known, moreover, several models identifying distinct learning outcomes when playing a digital game are available [4]. According to the primary function of a game, games can be categorized as games for entertainment, games for learning and serious games [4]. Serious games are developed for the purpose of learning and behavioral changes [4, 5]. The term appeared in the late 1990s and was used to contrast between traditional games and a serious educational approach [5]. In early 2000s, the domain was significantly supplemented with a rise in digital games [6]. Serious games put real-life problems into a gaming environment in order to ease their understanding and increase their enjoyment when solving them [7, 8]. They have the ability to provoke participants' emotions and are thus more engaging than traditional learning approaches [8, 9]. As the results of the performed SLR on computer and serious games [4] indicates, the majority of serious games are simulation games.

Simulation games represent a real-life environment in which players have to take on different roles, corresponding to the game domain [10]. Participants are available to perform experiments within the game, wherein different game elements like challenges, conflicts and other things are preserved [10].

Three related terms can be detected within the researched domain: gamification, simulation and serious games. The difference between them can be seen in Table 1. Serious games are closely related to gamification [8] since they both enhance learning with the use of game-design thinking [7]. However, as pointed out in [7], gamification uses game-design thinking and puts it into real-life problems, while serious games take real-world problems and put them into the game [7]. In [5] the authors highlight three essential aspects of GBL: pedagogical, technical and game aspects. If all three aspects are addressed, the system can be called a game-based training system, while a system without a game element is just a simulation aimed at training purposes [5].

Table 1. Correlation between gamification, simulation, serious games and games [11].

	Game thinking	Game elements	Virtual world	Game play	Non purposeful
Gamification	✓	✓			
Simulation	✓	✓	✓		
Serious Games	✓	✓	✓	✓	
Game	✓	✓	✓	✓	✓

3 Use of Serious Games for Teaching ERP Concepts

When it comes to simulation games, business simulation games represent an important research domain. A good representative of one is an ERPsim business simulation game [12], based on SAP ERP [13]. This game is aimed at teaching the concepts of Enterprise Resource Planning (ERP) with the use of nine different games [13]. The games are divided into four domains: distribution, manufacturing, logistics and retail. While there is only one version of the Distribution game, other games are available in two or three versions of increasing complexity.

The ERPsim business simulation game was used as a complement to traditional learning approaches within the ERP systems course. The game was used three times, implementing three ERPsim workshops, where every subsequent workshop used more advanced ERPsim games. Following the analysis, we decided to use four of the available games within the ERP systems study course, namely the ERPsim Distribution game, the ERPsim Manufacturing Extended and Advanced game, and the ERPsim Logistic Extended game. The differentiation among the used games can be seen in Table 2. The table Table 2 shows the supported transactions and reports in each of the implemented simulation games. The ERPsim Distribution game is a simulation of the distribution system of a bottled water company [12, 14]. The company operates in a German market, where it sells six different water products in three German regions [12, 14]. Within

the game, participants process the transactions connected to determining prices and marketing expenses and buy products based on forecasted sales via the calculation of requirements. In the ERPsim Manufacturing game, the participants operate a muesli manufacturing company [12, 13]. In addition to the transactions supported in the Distribution game, the participants have to cover the production view, where they can change the product design and release production. In the Advanced version, they have to take care of the logistics domain, with the maintaining of shipping plans as well [15]. On the other hand, the Logistic game only focuses on the logistical domain within the managed Dairy Company [12, 16].

Table 2. Supported transactions and reports within the implemented ERPsim business simulation games.

	Distribution	Manufacturing extended	Logistic extended	Manufacturing advanced
Transactions				
Change Price	✓	✓	✓	✓
Marketing Expenses	✓	✓		✓
Purchasing	✓	✓	✓	✓
Calculate Requirements	✓	✓	✓	✓
Forecast Sales	✓	✓	✓	✓
Release Production		✓		✓
Change Product Design		✓		✓
Stock Transfer			✓	✓
Loan Repayment		✓		✓
Setup Time Reduction		✓		✓
Increase Capacity		✓		✓
Reports				
Sales and Market Data	✓	✓	✓	✓
Stock Levels	✓	✓	✓	✓
Purchase Orders	✓	✓	✓	✓
Financial Statement	✓	✓	✓	✓
Production Cost		✓		✓
Production Schedule		✓		✓

The ERPsim Distribution game is a simulation of the distribution system of a bottled water company [12, 14]. The company operates in a German market, where it sells six different water products in three German regions [12, 14]. Within the game, participants process the transactions connected to determining prices and marketing expenses and buy products based on forecasted sales via the calculation of requirements. In the ERPsim Manufacturing game, the participants operate a muesli manufacturing company [12, 13]. In addition to the transactions supported in the Distribution game, the participants have to cover the production view, where they can change the product design and release production. In the Advanced version, they have to take care of the logistics domain, with the maintaining of shipping plans as well [15]. On the other hand, the Logistic game only focuses on the logistical domain within the managed Dairy Company [12, 16].

The workshops were implemented in week 1, week 5 and week 11 of the semester. In week 1, the introductory workshop was implemented. The outline of the workshop follows the structure from 2018 as presented in [3]. The workshop implemented the Distribution Game, the most basic of the nine games [13]. The workshop in week 5 implemented the Manufacturing Extended game, and the workshop in week 11 implemented the Logistics Extended and Manufacturing Advanced games.

The duration of each workshop was between 2 and 3 h. The explanation of the game at the beginning of the course was followed by a presentation of short instructions, which were necessary for the first round. Subsequently, students formed into groups of 3–4 individuals and played the simulation game. When playing the games, students could focus on creative tasks and on forming appropriate business strategies, since the simulation automates the majority of repetitive and trivial business tasks. After the round ended, students were encouraged to share their opinions and experiences with the ERPsim game. If some additional instructions about used functionalities were required for the next round, they were presented by the instructors and the next round of the simulation game was performed in the same outline.

At the end of each workshop, students completed the survey. Among other things, questions looked into the potentially challenging and risky aspects within the implementation of gamification in higher education and asked for their experiences with the game as well as feedback regarding the implemented workshop.

4 Risks and Challenges in the Implementation of Gamification in Higher Education

A considerable number of studies have explored the use of gamification and serious games in education, as their popularity has increased over the past years [17]. Although many studies reported positive outcomes, among other things in engagement, motivation, and increased participation, negative outcomes have also been observed [17]. This indicates that the use of gamification, or serious games, in higher education is not without its pitfalls and risks. We carried out a literature review, in order to identify the risks and challenges of gamification in higher education. Several studies that reported on the challenges, risks, undesired outcomes, or drawbacks were found. Based on the findings of these studies, we identified three areas in which these risks or challenges can occur.

The first group of challenges relate to *the design of the game or gamification itself*, where several factors were found to be relevant. A game that appears dull to students [18], lacks realism [18, 19], a (back)story [18–21] or AI [19] is less likely to engage. On the other hand, if the game appears too difficult to students, they will be less motivated to engage in it [19, 22]. In other words, if the game appears either too dull or too difficult, it will fail to grab the attention and interest of participants. Secondly, games that fail to increase the level of challenge [18, 20] or lack indications of progression (e.g. levels) [21] will fail to maintain the motivation of participants throughout the game (or course), as the students' abilities are not being challenged [18]. Similarly, a lack of progression (through, for example, levels) will leave students unsure about their progress and success [18–20]. Furthermore, games that lack customization, or offer only one path to the goal, can be less motivating or engaging, as they do not provide the participants with any autonomy during gameplay [20]. The last risk factor identified in this group is a game, that in any way appears manipulative or unfair [20].

The second group of risks and challenges relate to *the introduction and the application of the game in the course*. Looking at more specific details, it was found that when the rules of the game are not clearly presented, and thus, not clearly understood by the participants, their performance can be hindered [19, 22]. Secondly, public and non-anonymous leaderboards were reported as a drawback, as they could decrease motivation due to social comparisons among participants [23, 24]. Additionally, if badges and rewards, that are provided throughout the game are trivial and meaningless to participants, they will fail to motivate [20, 22]. From a broader perspective, a lack of freedom to fail and a lack of overall feedback were identified as risks. If participants are not provided with a safe environment and opportunity to fail and learn from failure, they will not be motivated to explore the subject through the game and experiment with it until they achieve mastery [20, 21, 24]. Closely related to freedom to fail (or lack thereof), is a lack of timely feedback (feedback loop). If participants are not provided with rapid and frequent feedback on their progress and success, their interest and engagement will decrease [20, 21]. Furthermore, if their participation in the game is made mandatory, this can have counterproductive effects on motivation and engagement, as the idea of "mandatory fun" can cause an adverse reaction among participants [23]. Lastly, if the specific course is not well suited for gamification, or if only some game elements without the deeper gameful design are implemented, the game will either fail to grab participants' interest and engagement, or will be short-lived [20].

Third and finally, there are challenges related to *individual differences* among participants. Not considering the characteristics of participants in choosing, designing, or applying the serious game or gamified course can result in its failure. For instance, it has been found that for participants who have a lot of experience with sophisticated games, a high level of gamification is required in order to be engaging or motivating. On the other hand, participants with less game experience might be reluctant to learn through them [20]. Furthermore, if participants are already internally motivated to learn the subject at hand, gamification could act counterproductively, as offering rewards for a task that is already interesting may hurt the motivation to do that task [23]. Lastly, there is some limited evidence that individuals might differ in their preferences for games and types of games based on age [19, 20], gender [19, 20], and personality [20, 22]. Specifically,

one study found that younger participants responded better to games in education, and that females also responded more positively to them [19]. The personality of participants might be relevant as well, with studies finding that different player types have different motivations and learning preferences. Not considering different types when designing the game could result in a failure to motivate and engage certain player types [20, 22]. However, more empirical evidence on individual differences is needed.

As ERPsim was implemented during our research, we were also interested in identifying possible challenges and risks in applying ERPsim in higher education. Although only two studies were found that address our research question, they offered valuable insight into the issue. Furthermore, we were again able to group the stated risks and challenges into the same three groups that apply to gamification and games in general (as described above).

When it comes to the *ERPsim simulation itself*, participants reportedly found it challenging to combine software functionality with theoretical knowledge about business processes and strategies. Furthermore, making a quick decision without fully understanding the implications, as well as some of the unknown factors in the game, posed additional challenges [25, 26]. Lastly, some participants had trouble drawing the line between the simulation and real life when making decisions in the game [25]. As for challenges in *the introduction or the application of ERPsim* in the classroom, some participants struggled with information overload when introduced to the game, and the lack of opportunity to practice outside of the classroom [26]. Furthermore, smaller tasks instead of aggregated assignments were less preferred by some. It was also reported that the instructors had a hard time keeping participants engaged in the simulation, due to the lack of a backstory. Lastly, it was observed that participants could become too focused on the game itself, and less on the learning objectives. Specifically, students started make quiet deals among themselves, in order to meet the goals of the game [25]. Last, several *individual differences* were identified as potential challenges or risks. For instance, the lack of a business background was challenging for some participants, some found it difficult to work in a real-word scenario [26], and not all participants were in favor of game-based learning [25]. Having to work in teams was reported as a challenge as well, with participants having different backgrounds and knowledge, investing different amounts of effort, and experiencing communication issues [25, 26].

Usually, the goal of using serious games or gamification in higher education is to motivate and engage students in the learning process, and to move from extrinsic to intrinsic motivation [24]. These studies indicate that many factors can hinder a successful serious game or gamification. Hence, careful planning and consideration of the possible risks is required before implementing games in the classroom.

5 Addressing the Risks of Overgamification – Student Feedback

With the conducted literature review, we identified the possible risks and challenges that should be considered when implementing gamification within a study course. We conducted three workshops in which we used four different ERPsim business simulation games and while considering available risks and challenges, we addressed the issue of the negative impact of gamification. Table 3 presents the measures taken in order to

address the risks and challenges for overgamification in the ERP Systems course. As presented in Sect. 4, the identified risks and challenges can be assigned to one of three categories. The first one covers the risks and challenges related to the design of the game, or gamification itself; the second group is connected to the introduction and application of the game in the course, and the third group connects the risks and challenges related to the individual differences of participants.

Table 3. Measures taken to address the risks and challenges of overgamification when implementing ERPsim business simulation games.

Risk group 1: Game design and gamification
Main challenges
• Lack of progression [18–20] • Students' mastery level is not being challenged [18] • Game appears manipulative or unfair [20] • Lack of customization, only one path to the goal [20] • Difficulties to combine the software functionality with theoretical knowledge about business processes and strategies [25, 26]
Solutions/Strategies to overcome/Addressed by
• The progression of functionalities is achieved within and between games, with increasing complexity • After each round of a simulation game, participants get feedback in the form of achieved business results • The ratings of the groups in the same simulation can be significantly improved
Risk group 2: Introduction and application of the game
Main challenges
• The rules of the games are not clearly presented or clearly understood [19, 22] • Participation in the game is mandatory [23] • Lack of freedom to fail [20, 21, 24] • Public and non-anonymous leaderboards [23, 24] • Lack of timely feedback [20, 21]
Solutions/Strategies to overcome/Addressed by
• Previous' years feedbacks confirm the appropriateness of the ERP Systems course for implementing gamification [2, 3] • Special attention was paid to presenting the game and its rules to the students • The participants were presented with the fact that the game is a dynamic simulation • Participation in the game was not mandatory, however, bonus points were given to the participants • The participants were not graded according to their success in the game • Since no negative consequences followed a failed game, and experimentation with different strategies was possible, a safe environment to experiment and fail was provided for the participants • The participants were treated as a group and not as individuals • The results are displayed after each round of the simulation game, providing feedback on the successfulness of the chosen strategy
Risk group 3: Individual differences between the participants
Main challenges
• Individuals might differ in their preferences [19, 20, 22]

(*continued*)

Table 3. (*continued*)

Solutions/Strategies to overcome/Addressed by
• The study course is optional, therefore the cooperation in gamification is optional • The feedback confirmed the appropriate level of prior knowledge • The participants have the freedom to form groups and the groups can freely define and change roles within the game • The participants represent a homogeneous audience, which somewhat minimizes potential individual differences

The workshops were implemented considering the measures presented in Table 3. To determine if the risks and challenges of gamification were properly addressed, the observations of the course lecturers were complemented by the feedback collected from the students. Our sample consists of the course participants, which were first year master's degree students in the study program Informatics and Technologies of Communication. Thirty-three percent of our sample is females, and the sample age varies between 20 and 25 years old. Their opinion was gathered following each workshop, using three questionnaires with items, designed specifically for this study. The questionnaire after the first, introductory, workshop followed the same structure as the questionnaire used in previous years [3] in order to ensure compliance and a comparison of the results. Since we wanted to gauge the interest for participating in additional business simulation games, relevant questions were added. In the second questionnaire, questions allowing for the assessment of additional business simulation games were added, but its structure was only slightly adapted. However, the questionnaire after the third workshop differed from the first two. The gathered opinions were aimed at evaluating the implemented extended gamification approach, mainly from the perspective of the challenges and risks of gamification. In total, 24 students were enrolled in the ERP Systems course.

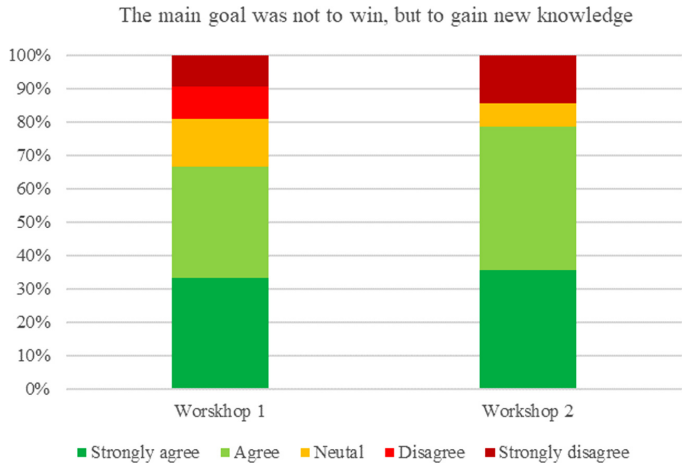

Fig. 1. Frequency of responses on the focus of the game vs. learning objectives.

Students evaluated statements using a 5-point Likert scale, ranking their opinion from 1 ("Strongly disagree") to 5 ("Strongly agree").

The results of the questionnaire after the first workshop confirmed the findings from the previous years [3], and further addressed our research questions regarding the risks of overgamification. Specifically, the results of our study show that the workshops did not put too much focus on the game and distract from the learning objectives, as can be seen in Fig. 1. The majority of students agree and strongly agree that their *main goal was not to win, but to gain new knowledge.*

According to the results, the participants found the provided instructions and directions sufficient, scoring the statement *"The provided instructions and guidelines were satisfactory"* with an average of 4.57 ($SD = 0.51$). The clarity of instructions was additionally corroborated by a mean score of 4.36 ($SD = 0.63$) for the item *"The instructors provided clear instructions and directions for the work"*. Furthermore, almost all of the students agreed that the *information on job aids was enough for the appropriate use of the SAP ERP system and for forming an efficient business strategy*. The frequencies of responses are presented in Fig. 2. However, the mean score of 3.57 ($SD = 0.76$) on item *"I would like more detailed guidance on what strategy to use"* indicated room for improvement when it comes to giving instructions on business strategy in the game.

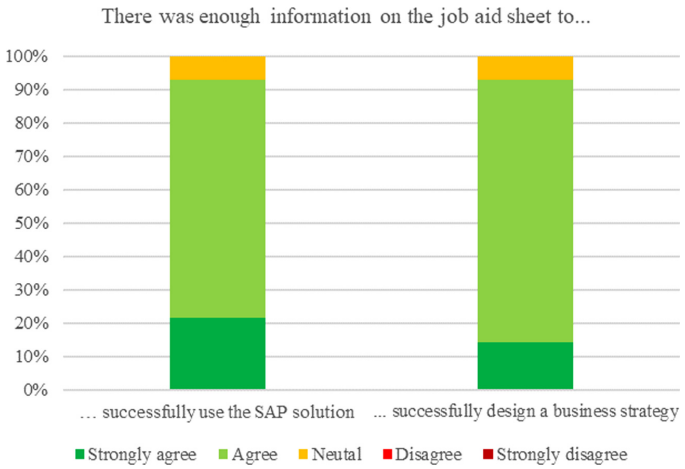

Fig. 2. Frequencies of responses on the provided information.

Furthermore, students positively assessed the sequence of the implemented workshops and used ERPsim games, as indicated by the mean score of 4.64 ($SD = 0.74$) on the item *"Workshops were properly timed in relation to the content of lectures and lab work"*. They found the sequence of the workshops appropriate as well, as indicated by the high average value ($M = 3.87$; $SD = 0.35$) of the item *"The order of workshops carried out was appropriate"*. Teamwork was another identified risk in previous research [25, 26]. With the mean score of 4.64 for both the item *"I am satisfied with my group"* ($SD = 0.74$), as well as *"I am satisfied with the way we worked in our group."* ($SD = 0.52$), we concluded that teamwork was not a major challenge for most students. We

further explored workload division as well as possible communication issues. According to the responses, all of the team members were actively involved in the work and all of the participants positively rated the item, *communication among the team members*. The frequencies of responses after the first and second workshop are presented in Fig. 3.

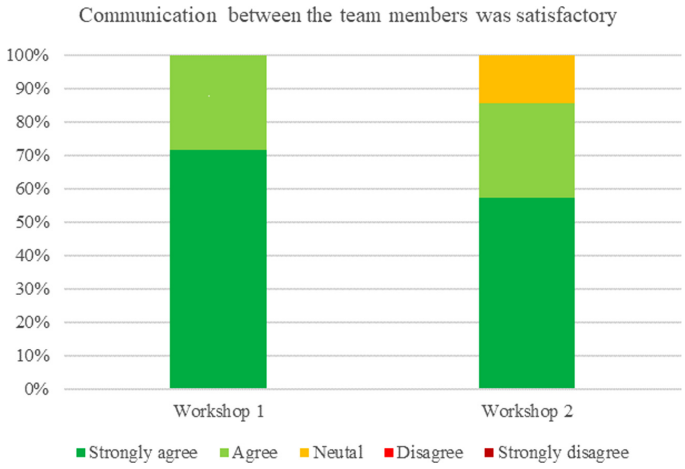

Fig. 3. Frequencies of responses on team communication items.

According to gathered responses, implemented simulation games have an important positive impact on students' future engagement in course lectures. The frequency of responses after the first and second workshop are presented in Fig. 4. More than half of the participants agreed that they *will be more likely to attend the classes because of the used simulation game.*

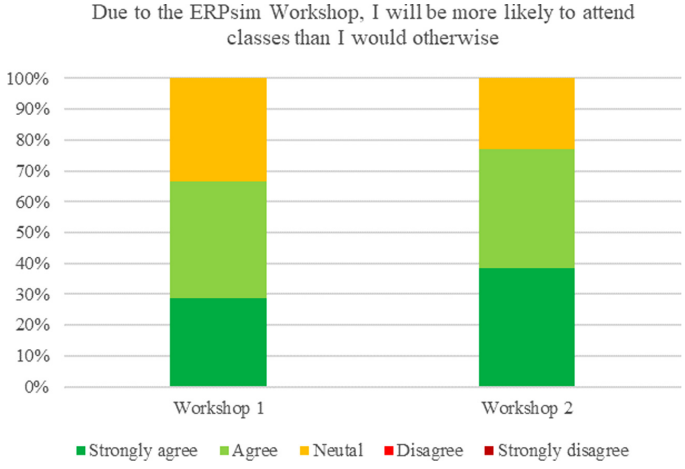

Fig. 4. Frequency of responses on items regarding intent to attend classes.

Lastly, the positive students' acceptance of extended use of gamification can also be seen from the results of the official university students' survey. Table 4 shows the rating in three categories: overall course rating, cooperation with students, and learning outcome. The comparison is done within ratings of the course before gamification was introduced (year 2016), when using gamification as an introduction into the course and when implementing the extended gamification approaches. Students evaluated each aspect using a scale, ranging from −2 to 2. The positive impact of gamification can be seen in all three categories; in fact, an additional improvement in an overall course rating can be seen in the year where an extended gamification approach was implemented and three additional ERPsim units were incorporated into the course.

Table 4. Comparison of the results of an official students' survey.

	Before gamification	Gamification as an introduction	Extended gamification
Overall course rating	1.61	1.88	1.91
Cooperation with students	1.73	1.93	1.92
Learning outcome	1.55	1.87	1.86

6 Conclusion

Gamification is a promising approach in higher education. When implemented properly, it can have a positive effect on many factors, including students' engagement. However, many risks and challenges connected to gamification implementation can be detected in the literature and it is crucial to address them properly in order to avoid possible negative outcomes, including overgamification. The paper presents our findings in implementing three gamification workshops in the ERP Systems study course. Since the gamification approach was an extension of the introductory workshop from the previous years, properly addressing challenges and risks using appropriate strategies and solutions was crucial. The prerequisites for the use of gamification within the course have already been confirmed in previous generations. However, since the set of the used simulation games was extended, special attention was required to provide suitable and sufficient instructions within each of the implemented workshops. The participants were aware that a game is a dynamic simulation and they were not graded according to their success in the game. Since no negative consequences followed the game, they were provided with a safe environment for experimentation. When playing the ERPsim simulation games, students formed groups and the results were displayed in the form of a letter for each company, anonymizing the results. Besides, students could freely form the groups and divide the roles within those groups, resulting in perceived satisfaction with their teams. According to the collected feedback, we successfully addressed the challenges

and risks, since the students' answers were very positive. Also, the appropriateness of the implemented approach was further confirmed with the results of the official student survey. However, as this study was carried out on a small, homogenous sample, no general statements can be made. In future work, we are preparing an updated questionnaire that will systematically cover all of the identified risk groups when implementing gamification. With the gathered results, we could get additional and more precise insight into a domain, allowing us to further research the risks and challenges of overgamification.

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Serious Games Usage in Higher Education, Experiences and Guidelines

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Abstract. Learning methodologies and experiences have changed over the recent years thanks to the incorporation of digital technology in education, among many of this technologies are Serious Games, however the process of designing and incorporating this technologies is not easy and there are very few available tools, this paper focus is to give some guidelines from real experiences and its results in order to improve the incorporation of this new tools.

With modern gadgets and interfaces, now one can initiate learning experiences based on students needs, preferences, and increase the engagement among students, this last period with COVID 19 impacting our institutions and the abrupt incorporation of full online programs and hybrid mode has made us search for new ways to improve the learning experience, young students and millennials are use to playing with games and the results indicates that they are more likely to enjoy learning experiences with them.

There has been use of digital simulation environments since many years ago and gamification is more recently, but new technology has made available new ways of developing experiential learning trough games and Edutainment, gamification and more serious games have been recently developed.

The empirical results lead to the conclusion that games have a very positive impact in the students learning process in higher education and adds a very good component of experiential teaching to students that can simulate complex environments and decision making through these tools and platforms.

Keywords: Edutainment · Entrepreneurship · Serious games · Game learning · Gaming base learning · Startup education · Venture creation game · Battman startup simulator game · Gamification

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1 Introduction

Higher Education is one of the key strategic factors that are helping to sustain and increase development and social mobility (Alexander et al. 2019), especially in emerging countries, and in order to help improving the results and impact with new generations of students, constant innovation is needed. Technology has improved access, affordability, quality, and experiences in Higher Education learning; however, the education industry tends to be slow in the ways of teaching and incorporation of new technology. It is important to incorporate tacit and explicit knowledge that will improve firm's performance (Magnier-Watanabe and Benton 2017, Xu 2013, Bernal and Medina 2015) and this could be achieved better with serious games experiential learning that incorporates both approaches into the learning process.

Since education is one of the key elements to improve productivity for the Knowledge Worker, one of the challenges is how to increase the experiential experience and the impact of learning in this new generation "knowledge Workers" (Drucker 1959; Liberona and Rojas 2017). Knowledge and education are the pillars of competitiveness in the framework of international competition (World Economic forum 2012). Therefore, an important part of the role of education in universities is related to help students to be more prepare and suited to contribute in the professional marketplace, this rises the question of how can we innovate in teaching methods so we can achieve this fundamental goal?, this paper is related to experiences of using serious games technologies to teach entrepreneurial concepts, in particular those related to developing startups or technology skills, In order to give a more experiential aspect to the acquisition of knowledge by students, they engage better and learn more quickly (Beranick-Hericko 2019; Giannakou and Paraskeva 2015).

The research group develop a serious game denominated "venture creation game" in order to review the process of developing a learning game and its effect in the learning experience of higher education students, also we have the case of BattMan Simulator game that stands for Battery Management Semiconductor a game developed in South Korea.

During the last years various technologies has been incorporated to education, such as Anlytics (learning process and outcomes), adaptive learning, mobile learning, artificial intelligence, block chain, gamification and serious games, all of these seems to be long term trends in education according to Educase Horizon project (Alexander et al. 2019) and indicates an expected evolution in the way higher education approaches its mission, as well as a trend toward increased student control over individual learning pathways (Fig. 1).

This paper aims to uncover some of the success factors that enhance learning with serious games by performing a systematic review of prior quality studies and studying real applications cases with more than 3 years of experience. This research has interviewed five professors in different countries that are using serious games in the last year, some of their learning and the opinion of over 375 students that have taking this courses in an aim to give academics some insights on the process and the results.

Producing serious games could be very expensive and time-consuming and could be hard to implement and fulfill the learning outcomes with students.

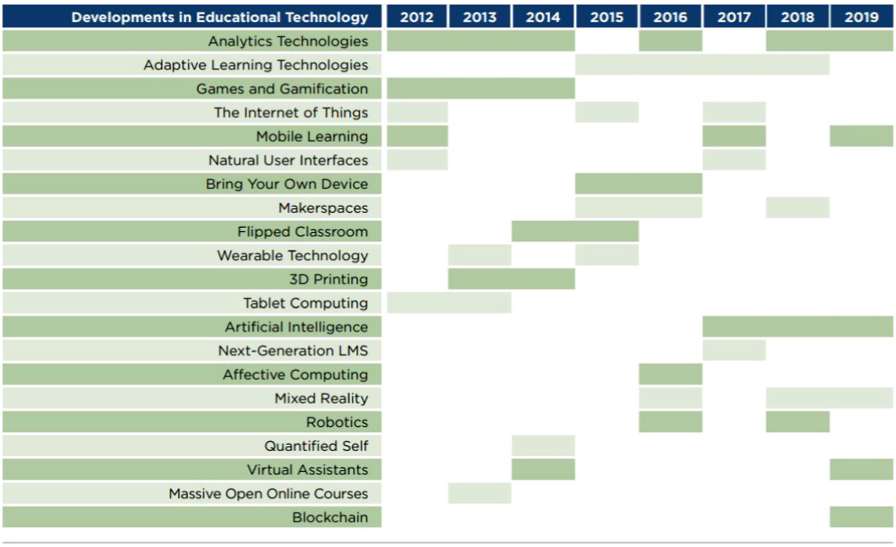

Fig. 1. Development in Education Technology trends. (Report: 2019 Higher Education Edition. Louisville, CO: EDUCAUSE.)

2 About Serious Games

The 21st century is characterized by the incorporation of technologies to many Industries and social life, the improvements of technology leads to constant change. The world is changing rapidly but the way we learn has been very slowly changing, causing a problem in educational systems and teaching technics gap with digital transformation, since a big portion of the education techniques are basically the same for the last 200 years or more, there is a huge disconnection between technology and education and it's only getting wider (Brian Solis 2014).

Online learning has been of wide use over the last two decades, however other alternatives technologies such as serious games have still very little use in Higher Education (Ulicsak and Wright 2010).

"Serious games are games designed in which education (in its various forms) is the primary goal, rather than entertainment." (Gross 2016).

Serious games also sometimes are referred has gamification they are both meant to be entertaining and fun, but experiential learning is its main objective (Sloetjes 2012).

Even though that there no agreed definition of Serious Games basically refers to games that have been designed to learn and have a purpose other than pure entertainment.

The field of edutainment, serious games or learning game design fields, have made big improvements during the past decade, but there they have not reach a very high use in Universities in that period of time (Liberona and Rojas 2017).

If learning games are beneficial why aren't they integrated more in classrooms?

What learning is really happening and achieve in this game's experiences?

There are a few fundamental questions that this research attempts to address such as How has gamification been applied? What policies and strategies could help to successfully incorporate gamification, what are the feedback from students?

This paper also refers to how can learning games be designed or implemented in order to have a deeper and more meaningful impact on the learner.

The answer lies in the difficulty to develop the games and the complexity of its applications, there are only a few companies that are devoted to Serious Games in the world, such as EON Reality (USA), Lamsa (United Arab Emirates), Simcoach Games (USA), Peak-Brainbow (United Kingdom), Costa Edutainment (Italy), Idea Lemon and some startups like Game Lab (Chile), Fingerprint (USA), Digital Dream Labs (USA), Fedot, Centsai (USA).

Moving to the next level will require much more thoughtful and strategic mapping of the learning experiences and outputs in games. It is clear that games can improve the learning experience, but there is much learning to be done from the methodology and for the relevance of content implemented, in the case of business learning there has been a long tradition of market simulation tools, financial models simulators, and digital exercises like entrepreneurial games, but we are at the verge of new experiences. Implementing these experiences will require a big commitment from the Universities in genera and from specialized professors too.

Certainty COVID has been a catalyzer for technology adoption in Higher Education in 2020, but it has net really impacted Serious Games adoption jet, even that the need of more engagement from students is needed.

3 Educational Games (Edutainment)

Educational games, can be traced back to the 1970's where "non digital" games where used in schools for math-related or social science understanding. The digital applications started around 1990's with the first multimedia computers, evolving the term to edutainment, but because of the poor quality and lack of understanding the interest decreased. Never the less, serious games gain attention again during the 21th century with a situational and constructionist approach in games. Research has shown a positive effect of games as educational tools in various skills such as: strategic thinking, planning, communication, collaboration, group decision making, and negotiating skills (Kirriemuir and McFarlane 2004; Squire and Jenkins 2003).

Edutainment, comes from "education" & "entertainment" it is designed to generate motivation, interest and a better understanding throw technology using games, music, internet or television to help both students and teachers in the process of learning. The market of business simulation for education are mainly centered on marketing, finance, strategy and optimization.

Gamification blends game mechanics with traditional eLearning activities and modules. For example using leaderboards, points, and eLearning badges add incentives for students to be more active on their online courses. Gamification and serious games are often grouped together they both motivate online learners and enhance their eLearning experiences (De Freitas and Liarokapis 2011).

If we consider some information about gamification we have to consider that:

- 80% of the learners say that their productivity would increase if the learning approach used in their university/ organization is more game-like
- 82% of the learners are in favor of multiple difficulty levels and explorable content
- 71% of employees are not engaged for disengaged in their work
- 89% of the learners show greater engagement of the LMS application has a point system
- 62% of the learners feel they would be motivated to learn if leaderboards were involved and they had the opportunity to compete with other colleagues
- 90% of the learners recall information if the applying content within a stimulation

Source: https://www.eidesign.net/gamification-in-elearning-facts/

4 Development of Serious Games

Serious games did not come into wide use until the 1990s with multimedia PCs, even though such games were created and used long before. At the time, educational games and other software evolved into "edutainment". However, interest in edutainment soon decreased, partly because of the (poor) quality of the games themselves, and partly because of a growing interest in the Internet (Michael and Chen 2006).

The problems encountered in edutainment are reflected in phrases such as "edutainment, an awkward combination of educational software lightly sprinkled with game like interfaces and cute dialog" (Zyda 2005), or "most existing edutainment products combine the entertainment value of a bad lecture with the educational value of a bad game" (Squire and Jenkins 2003).

With the general renewed interest in serious games, game developers have moved from "skilland-drill interactive learning paradigms towards situational and constructionist approaches" (ELSPA 2006). Games in education is gaining acceptance, but their use is not widespread, and it is a controversial issue (ELSPA 2006; Michael and Chen 2006).

Educational games is also faced with the challenge of providing research evidence of the acclaimed benefits, which currently is "complex and thinly spread", possibly because the study of games and gaming relates to several different disciplines; "as a result of the diversity and complexity of games themselves, and the range of perspectives taken by researchers, there are few hard and fast findings in the literature" (Kirriemuir and McFarlane 2004, p.2).

Despite the "few hard and fast findings", research is showing positive effects of games as educational tools. Games can support development of a number of various skills: strategic thinking, planning, communication, collaboration, group decision making, and negotiating skills (Kirriemuir and McFarlane 2004; Squire and Jenkins 2003; see also Gee, unpublished manuscript). However, "hard facts and evidence" is for future research to provide. There is also a number of concerns to consider in order to realize the full potential of games as educational tools: resources (many schools have computers that are too old for new games, technical support, time for teachers to familiarize themselves with the game, etc.), how to identify the relevance of a game to statutory curricula, difficulty in persuading school stakeholders to the potential benefits of computer games, etc. (ELSPA 2006).

The use of Bloom's taxonomy (Bloom et al. 1956) contributes to the development of games enhancing the results on the learning process.

5 Benefits of Serious Games

- The freedom to fail, games allow mistakes to be made with little consequence
- They are active and experiential
- The freedom to experiment, games allow players to explore and discover new strategies and pieces of information
- Provide feedback faster
- It could have a problem base approach to learning
- Facilitates teamwork and collaboration.
- The freedom to assume different identities: games encourage players to see problems from a different perspective
- The freedom of effort: games allow players to go through periods of intense activity and relative inactivity, so that players can pause and reflect on tasks they have accomplished. To this end, gamification can be broken down into individual elements, each of which bring specific advantages and disadvantages to educational processes (Catalano et al. 2014).
- Retain more information and learning stored in long term memory
- Monitoring of process (Fig. 2)

Fig. 2. Examples of Gamification Techniques applied to teaching courses

Serious Games Application Challenges:

The challenge facing serious games though, is to find a balance between the ludic and skills or knowledge transfer goals so that neither a dominant game mode (taking away from the learning outcomes) nor learning mode (removing the fun element) is present (Giessen 2015).

Examples of serious games in Higher Education related to Startups and Entrepreneurship (Table 1).

Table 1. Serious games related to Entrepreneurship (own ellaboration)

Name	Company	Country	Description
Entrepeneur Simulation	GoVenture, MediaSpark Inc.	Canada	Online Simulation based on the operational phase.
			Include decisions:
			Marketing
			Product Mix
			Finance
			Team construction
Terra NovUP	Terra NovUp	Chile	Board game based on the construction of the business model throw the theory of Alex Osterwalder.
The Start Up Game	Wharton Business School	EE.UU.	Roleplay:
			Investor
			Employee
			Founder
			Focused on:
			Development
			Management
			Raise Capital
			compensation vs equity
CleanStart	Learning Edge, MIT	EE.UU.	Online Simulation.
			Based on the launching and operation of the business
			Includes decisions :
			Product Price
			Team Work
			Raise Capital
Venture Blocks	Venture Blocks	EE.UU.	Online Simulation.
			Based on finding a need and creating a business idea.
BattMan	Kaist University	South Korea	Startup Simulator game-Semiconductor production
			Marketing decisions
			Production decisions
			Investors and Loans
Venture Creation Game	Gamelab	Chile	Startup up role playing Game
			Market Fit
			Finance analysis
			Competitors analysis
			Entrepreneurship experience

6 Alternatives for Game Development

You could develop your game, use and existing one or paid for a company that provides serious games alternatives like Gamelabeducation.com.

a) Adapting an existing game: In the case of using an existing game, the cost tends to be lower, and the experience is good but is not personalize for the class.
b) Developing a game by the University/Professor: This alternative has various options, the two basic ones are to develop the game has part of project with the computer sciences department or engineering students that program it. Other option is to develop with a professional company does know about games and will develop a customize game for you. The cost of developing the game ranges between US$ 60.000 to US$ 300.000 according to the specific requirements and complexity, in any case will require many working hours from the teacher designing the game.
c) Use a serious game service that will provide the platform for you and you will use with a usual price per student that ranges between US$ 5 and US$ 25 dollars per student depending in the complexity of the service.

The time use to develop a game will range between 6 months (if you are customizing) and more than two years, an average (according to the survey) is between12 and 18 months.

The game usually is adapted to different academic level of students, most them can be use in High School, Undergraduate, Senior Undergraduate and master's degree programs.

Results on Classrooms:

The game was use in four different classes, two hundred and fourteen college students and one hundred and seventy-five senior high school students on pre-college workshops were interviewed and participates with the following results (Tables 2, 3, 4 and 5).

Table 2. Have you use Serious Games Before

Have you Participated in serious games before (University)	
No	57%
Somehting similar	17%
Yes	27%

Have you Participated in serious games before (High School)	
No	77%
Somehting similar	11%
Yes	12%

If educating the player should be the primary goal of serious games like Michael and Chen (2006) proposed, the results on the learning process was achieved, the students got better results than just preparing their classes and learned and discusses about reasons and concepts of failure and learning. Class attendance also increased in classes that involved the game simulation (Figs. 3, 4 and 5).

Table 3. What is your preferred method of learning

Which learning method do you prefer	
Reading Papers and Text Books	13%
Presentation Classes &Videos (Regular Teacher Class)	18%
Online courses – E-learning	10%
Serious Games - Simmulators	17%
Workshops	12%
Study Alone	14%
Personal/Private Teacher	2%
Reading Books	2%
Videos - Youtube	14%
Other (please specify)	0%

Which learning method do you prefer	
Reading Papers and Text Books	11%
Presentation Classes &Videos (Regular Teacher Class)	16%
Online courses – E-learning	4%
Serious Games - Simmulators	27%
Workshops	16%
Study Alone	9%
Personal/Private Teacher	2%
Reading Books	2%
Videos - Youtube	13%
Other (please specify)	0%

Table 4. Evaluation of the serious game experience

What is the contribution of the Serious game to learning (University)	
Very Low	0.0%
Little	2.8%
Medium	26.8%
High	32.4%
Very High	38.0%

What is the contribution of the Serious game to learning (High School)	
Very Low	0.0%
Little	3.1%
Medium	19.8%
High	29.2%
Very High	47.9%

Table 5. How was the level of contribution to learning with the serious games

Did the game contibuted to learning about Entrepreneurship	
No contribution at all	0%
Learned some new concepts	33%
It made learning easier and fun	24%
A much better understanding of the concepts	29%
Really helped to clarify and learn entrepreneurship concepts	14%

Did the game contibuted to learning about Entrepreneurship (High School)	
No contribution at all	1%
Learned some new concepts	8%
It made learning easier and fun	34%
A much better understanding of the concepts	35%
Really helped to clarify and learn entrepreneurship concepts	22%

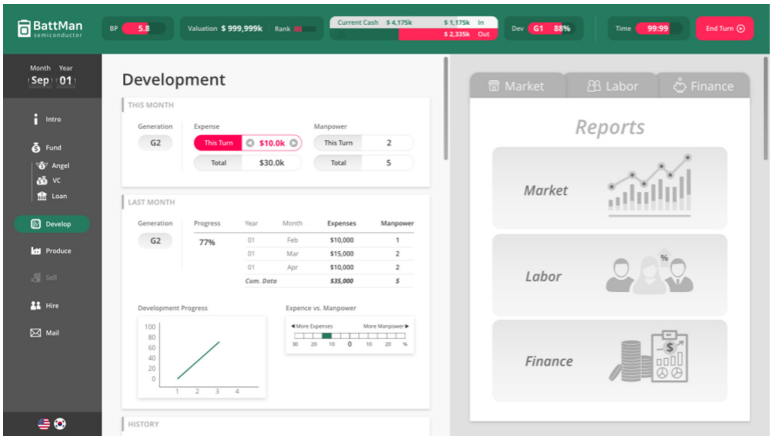

Fig. 3. Game Examples Battman Game (Kaist University Korea)

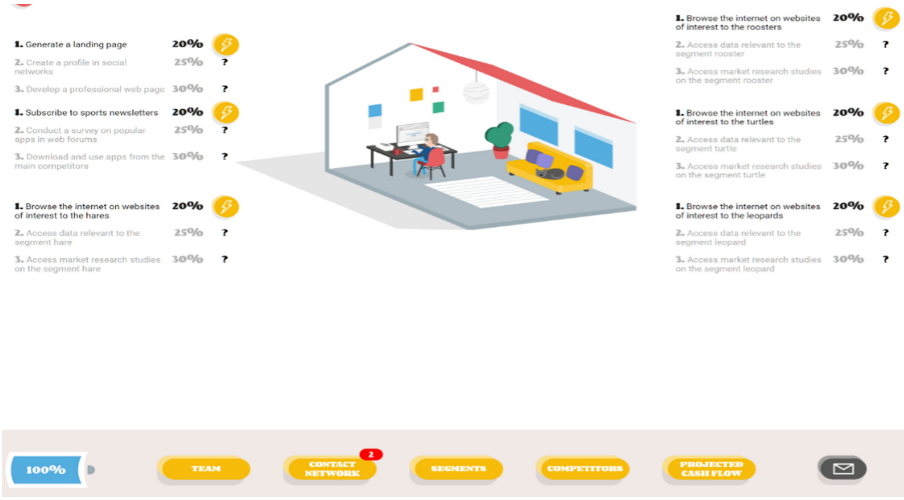

Fig. 4. Venture Creation Game (Universidad Tecnica Federico Santa Maria/Gamelab, Chile)

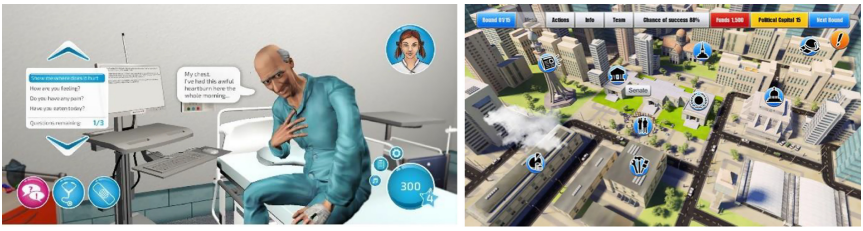

Fig. 5. CareMe (Metropolia University Finland). Leadership capacity (World Bank Institute)

7 Conclusions

Certainly there has been a change in the culture and the way young students learn, all millennials are used to play digital games since very early age, some of them are role playing games such as Oblivion, the Whitcher, Pillars of Eternity, South Park, Fornite, so they are more ready for Serious Games than previous generations, now the challenge is for universities to incorporate this technologies.

The results of the student's engagement, learning and general opinions about the learning games experiences are very positive and are align with most of the studies and benefits considered for implementing the games.

The process of creating a learning game is indeed very complex but there is many alternatives in using games.

The Universities will benefit of developing areas that will help them produce serious games in a serial format, with specialist teams.

Serious Games are an effective way to convey new knowledge in Higher Education, an opportunity is to develop analytics for the game in order to help teacher to obtain more insights on the learning process and dynamics of the game.

The professor that developed serious games also mentioned that they need to develop new games that could incorporate concepts and develop new learning objectives allowing to increase the experience, the problem to do so is related to the lack of available funding to go to the next version. But companies like gamelab education, are incorporating new games, however the cost is one of the issues of the expansion of serious games use.

From a gameplay perspective competition is a big motivation for the engagement of students, awarding points and rewards help to improve the experience of students, also many of them suggested to develop tournaments with winners.

The games should be available in mobile formats too, since many students will like to use their cellular phones, it seems that the level of simulation and graphics on the games will require enhancements since younger students are used to very sophisticated animations an graphics.

Collaboration among teachers will be the next possible steps in terms of serious game usage in universities, games developed by different institutions could be share among them, in this sense, multilanguage games are very advisable.

A new partnership could be develop in the future, gaming companies could tap into the education industry while partnering with Universities and academics in the development of new global serious games that could address many of the learning aspects of formal education and in various levels. Also, the combination of complex simulators with gaming approach and functionality, has great opportunities in the near future in both higher education and gaming markets.

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Learning Practices and Knowledge Transfer

Internal Consistency and Discriminant Validity of the TECO in the Bachelor's Degree Course in Physiotherapy at the "Sapienza" University of Rome: A Cross Sectional Study

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Abstract. The aim of the study was to evaluate the psychometric properties of the Disciplinary section of the TEst of COmpetencies (TECO-D) in students of the Bachelor's degree in Physiotherapy in Italy. The sample was recruited between October and December 2017. To be included in the study, the participants had to be enrolled in the bachelor's degree course of physiotherapy at the "Sapienza" University of Rome and had not to be outside the prescribed time for completion of exams. The test was administered digitally. The internal consistency for the TECO-D score was excellent ($\alpha = 0.86$). The cut-off point for the TECO-D was 186 for the first year of course with a 90% of sensibility and specificity, 204 for the second year of course with a 80% of sensibility and 70% of specificity and 219 the third year of course with a 83% of sensibility and 75% of specificity. The scores showed that the TECO-D is able to assess the students' skills for the three years of the course. This study had a great impact for students, researchers and academics, giving important information to improve quality of education.

Keywords: Test of competences · Progress test · Physiotherapy · Bachelor degree · Students

1 Introduction

Progress testing is a longitudinal testing approach devised by the University of Missouri-Kansas City School of Medicine and the University of Limburg in Maastricht [1–3]. Progress testing refers to the periodic assessment of the entire body of knowledge needed to graduate from medical school. Rather than assessing mastery of a small amount of knowledge, progress exams look for incremental improvement in a student's performance over time. Progress testing is a form of assessment in which groups of learners of different seniority (i.e., different classes in a curriculum) are given the same written test.

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https://doi.org/10.1007/978-3-030-81350-5_13

The test is comprehensive by sampling all relevant disciplines in a curriculum, usually determined by a fixed blueprint. Because of the need for wide sampling, questions are typically of the multiple-choice type. The test is repeated at regular intervals [4]. Used correctly, this approach has a number of advantages, including reduction of student stress [5], early identification of struggling students, [6] and provision of ongoing data to help students and faculty identify and address learning needs [7]. Progress testing has been increasingly used in medical programs across the globe [8].

On this principle, in Italy in 2012, the National Agency for the Evaluation of Universities and Research Institutes (ANVUR) started a project with the aim of testing and monitoring the learning outcomes of Italian undergraduate students through the TEst of COmpetencies (TECO) [9]. This instrument monitors the quality of the educational process in fact TECO results are part of the Italian quality assurance system in the quality process of education. From 2017 TECO test has been adopted in "Sapienza" University of Rome for bachelor degree courses in nursing, physiotherapy and radiology technicians. Since then it showed interesting results and a great potential for improving the educational system in these courses [10–12].

The aim of our study was to evaluate the psychometric properties of the Disciplinary section of the TECO (TECO-D) in students of the Bachelor's degree in Physiotherapy in "Sapienza" University of Rome.

2 Materials and Methods

This study was conducted by a research group from the "Sapienza" University of Rome and from "Rehabilitation & Outcome Measure Assessment" (R.O.M.A.) association. R.O.M.A. association in the last few years has dealt with several systematic reviews and the validation of many outcome measures in Italy [13–26].

2.1 Population and Procedures

The sample was recruited between October and December 2017. To be included in the study, the participants had to be enrolled in the bachelor's degree course in Physiotherapy at the "Sapienza" University of Rome. They were also required to be have completed university exams within set tie period. Participation in the TEst of COmpetencies (TECO) project was voluntary for universities, courses and students, and, at the time of recruitment, the participants were informed about the modalities and objectives of the project. The test was administered digitally in university computer rooms during 170-min sessions [10]. The results of the tests were communicated individually to the participating students and did not affect the evaluation in progress or the final evaluation, while the aggregated data were transmitted to the coordinators of the study courses involved and to the university referents.

2.2 Instruments

Disciplinary section of the TECO (TECO-D) for the physiotherapy bachelor's degree course used in this study was a single file consisting of 100 closed questions with five alternative answers each. It was divided into ten macro areas, as shown in Table 1.

Table 1. Macro areas divided by year of course

Number macro areas	Learning	Year of course	Number questions
1	Biology, Anatomy and Physiology	1	21
2	Physics and Radioprotection	1	2
3	Statistics and Research Methodology	1	4
4	Physiotherapy in skeletal muscle disorders	2	23
5	Health organization and occupational medicine	2	4
6	Physiotherapy in cardio-respiratory and internist pathologies	3	11
7	Psychology and Pedagogy	1	6
8	Pathology and pharmacology	1	8
9	Physiotherapy of neuromuscular disorders	2	12
10	Physiotherapy in childhood	3	9

2.3 Data Collection and Data Analyses

For each year of study, data was collected for each of the main areas of the TECO-D, and, through SPSS-23 software, the data were registered in terms of mean and standard deviation of the score distributions. The internal consistency of the TECO-D was evaluated by Cronbach's alpha, which was considered statistically significant at a cut-off of >0.70. A receiver–operator Curve (ROC) was plotted and the mean (95% confidence Interval [CI]) area under the curve (AUC) was used to estimate a cut-off score for distinguishing the years of course. when the tangent line slope of the ROC (computed using SPSS) is statistically equal to 1 (i.e., AUC = 0.5), then the ROC curve is considered inaccurate for prediction purposes. The predictive ability of a variable was classified with reference to the AUC (Excellent = 0.9–1.0, Good = 0.8–0.9, Fair = 0.7–0.8, Poor = 0.6–0.7, or Non-discriminative = 0.5–0.6.

3 Results

The sample for the study was composed of 404 students of the physiotherapy bachelor's degree course. Of these, 90 (22.3%) were excluded because the students had not completed university exams within set time period. Demographic characteristics of the population are reported in Table 2.

Table 2. Demographic characteristics of the population

	Sample = 314
Age mean (SD)	22.2 (3.4)
Gender male N (%)	250 (79.6)
Year of course N (%)	
First year	103 (32.8)
Second year	110 (35)
Third year	84 (26.8)
Fourth year	17 (5.4)

3.1 Internal Consistency

The internal consistency for the TECO-D score was excellent (Cronbach's alpha = 0.86). The item-total analysis is present in Table 3.

Table 3. Cronbach's alpha if item deleted

No.	Scale mean if item deleted	Scale variance if item deleted	Corrected item-total correlation	Cronbach's alpha if item deleted	Scale mean if item deleted
1	29.48	238.10	0.65	0.48	0.84
2	38.37	328.85	0.44	0.23	0.86
3	37.72	317.53	0.56	0.36	0.85
4	27.53	179.93	0.82	0.70	0.85
5	37.57	316.14	0.56	0.42	0.85
6	35.72	273.58	0.75	0.66	0.83
7	36.82	302.29	0.67	0.47	0.84
8	35.85	277.87	0.79	0.68	0.83
9	35.2	264.56	0.80	0.67	0.82
10	37.17	303.34	0.58	0.41	0.85

3.2 Discriminant Validity

Regarding the discriminant validity, the AUC showed a value of 0.96 (95% CI 0.93–0.98) for the first year of the course (Fig. 1), 0.85 (95% CI 0.81–0.89) for the second year of the course (Fig. 2) and 0.82 (95% CI 0.74–0.90) for the third year of the course (Fig. 3) indicating a moderate capability to discriminate the score of year. The score with the best sensibility and specificity for every year of the course is reported in Table 4.

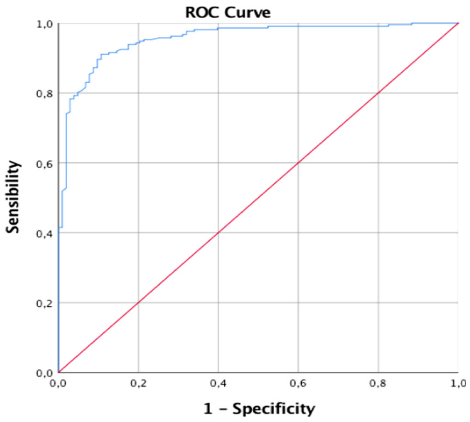

Fig. 1. ROC curve for the first year of the course

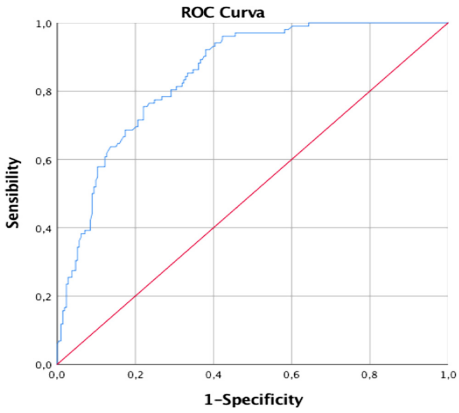

Fig. 2. ROC curve for the second year of the course

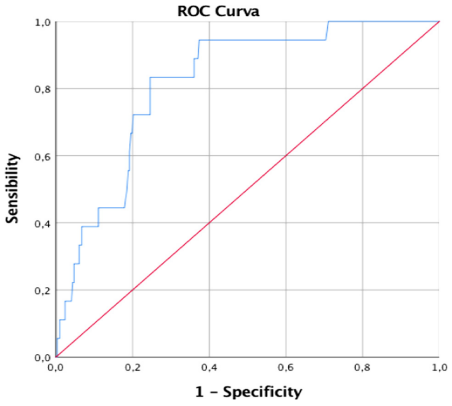

Fig. 3. ROC curve for the third year of the course

Table 4. Cut-off point of TECO-D for Physiotherapy course

Year of course	Cut-off	Sensibility	Specificity
1	186	90%	90%
2	204	80%	70%
3	219	83%	75%

4 Discussion

The aim of our study was to evaluate the psychometric properties of the TECO-D in students of the Bachelor's degree in Physiotherapy at "Sapienza" University of Rome. The progress of individual students can be modelled, giving a sequence of test results, and the effects of rules for progression and remediation can also be modelled [27].

The results of this study, in line with international guidelines, suggesting that the TECO-D is a reliable and valid tool for assessing the skills of students of Bachelor's degree in Physiotherapy. Internal Consistency of the tool was found to have a good degree of Cronbach's alpha (0.86) which means that the questions of the TECO-D are correlated between each other and produce similar scores.

The cut-off points based on Youden's index were provided for practitioners and researchers to use these tests as screening tools. The cut-off point for the TECO-D resulted to be 186 for the first year of course with a 90% of sensibility and specificity, 204 for the second year of course with a 80% of sensibility and 70% of specificity and 219 the third year of course with a 83% of sensibility and 75% of specificity. The scores show that the TECO-D is able to assess the students' skills for the three years of the course.

This study has certain limitation; the current study does not compare the TECO-D with other tools that evaluate the skills of the students in Physiotherapy, this did not allow to evaluate the construct validity. It was not possible to test-retest to evaluate the reliability of the instrument.

This work proposes to evaluate the TECO (TECO-D) instrument in undergraduate physiotherapy students at a university. It has great potential for the future of secondary education. It represents the starting point to provide all students with an equal quality of education and to provide academics with information on teaching areas that need improvement or deepening. This study provides useful information for the recommendation of the TECO-D tool for the academic and scientific world to create degree courses with comparable and reliable teachings. Finally, this study provides useful information in research to investigate, compare and improve specific study courses.

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The Responsiveness and Minimal Detective Change of the Disciplinary TECO in Nursing Students of Sapienza University of Rome: A Cross Sectional Study

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Abstract. The objective of this study is to assess whether Disciplinary-Test of Competences (TECO-D) is able to assess the changes of students in nursing courses. The secondary objective is to evaluate the minimal detective change with TECO-D. The cohort examined in 2017 was divided into three sub-populations: students enrolled in 2017 (I year of course); students enrolled in 2016 (II-year course), students enrolled in 2015 (III year course). In 2018, at the second administration of the test, the students enrolled in 2017 attended the second year of the course, the students enrolled in 2016 attended the third year of the course and the students enrolled in 2015 were undergraduates. The Cronbach's Alpha resulted from administration 2018 showed a value of 0.90. This result is statistically significant. The evaluation of the responsiveness evaluated by t-test for paired samples showed statistically significant data for students enrolled in 2017 (I year of course) and 2016 (II year of course), while data not statistically significant for students enrolled in 2015 (III year of course). The present study has shown that Test of Competences (TECO) is an excellent tool for assessing skills for students in nursing degree courses. These results provide an additional element for Italian universities for assessing competences in nursing degree courses.

Keywords: TECO · Responsiveness · Minimal detective change · University · Learning

1 Introduction

The many different descriptions of progress testing largely converge on the principle of longitudinal, repeated assessment of students' functional knowledge [1–3]. A progress test measures knowledge gain as students' progress through a course of study. Typically,

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tests are administered at regular intervals using multiple-choice questions (MCQs), randomly drawn from a single-item bank [4]. Progress testing also allows for the comparison and evaluation of students' knowledge across established schools [4] and for new medical schools to evaluate whether their students are performing at the level of students who attend more established medical schools. Although they mainly measure knowledge acquisition over time, scores can be norm-referenced to give a cross-sectional measure of an individual's performance relative to that of his or her peers. Progress tests can be used formatively to identify struggling students and for summative assessment. The TECO project (TEst of COmpetence), through the construction of controls that stimulate the university students' skill levels, aims to improve the quality of the training process by activating mechanisms within the academic self-assessment world. TECO is therefore consistent with the most recent European guidelines (Standards and Guidelines for Quality Assurance, 2015), relating to the European Area of Higher Education (European Higher Education Area - EHEA), which promote student centered teaching, accompanied by the analysis of learning outcomes [5, 6].

The TECO is coordinated by the National Agency For The Evaluation Of Universities And Research Institutes (ANVUR) which avails itself of representatives of the academic world that meets in working groups (WG) associated by the Executive Council [5, 6]. Disciplinary-Test of COmpetences (TECO-D) are closely linked to the specific training contents of the course undertaken by the student and can be tackled alone among the courses of a similar nature. The TECO-D tests are administered to the computer, using a platform set up and managed remotely by Consorzio INteruniversitario pEr il Calcolo Automatico dell'Italia (CINECA) [7–10], inside classrooms identified by the universities. The time windows (September-December) are fixed by the ANVUR in collaboration with the CINECA.

In this paper, we report on our early experience with a unique experiment involving the comparison of knowledge acquisition among students in Nursing [7–11].

The objective of this work is to assess whether TECO D is able to assess the changes of students in nursing courses. The secondary objective is to evaluate the minimal detective change with TECO-D.

2 Materials and Methods

2.1 Outcome Measure

The TECO-D uses a bank of 240 MCQs that test knowledge of the students of Nursing. The MCQs are "single best answer" format, with one correct answer and three "distractors" per question. Bank is maintained by systematic review of the items selected for a forthcoming test and problematic items are edited or deleted. In 2 h and a half, students answer 70 questions randomly selected from the item bank. A content template ensures that each test has an appropriate balance of items pertaining to the population. A 12-month blackout rule ensures that students cannot encounter a test item more than once during their course of study.

2.2 Population (Students Cohorts)

In October 2017, students who had been enrolled in the Nursing Course in 2017, 2016 and 2015 at the Sapienza University of Rome received an invitation to participate at TECO. The data of this longitudinal cohort study refer to two TECO-D administrations, one occurred in 2017 and one in 2018 on the same cohort of students. The cohort examined in 2017 was divided into three sub-populations: students enrolled in 2017 (I year of course); students enrolled in 2016 (II year course), students enrolled in 2015 (III year course).

In 2018, at the second administration of the test, the students enrolled in 2017 attended the second year of the course, the students enrolled in 2016 attended the third year of the course and the students enrolled in 2015 were undergraduates.

2.3 TECO-D Administration

The TECO-D was distributed online via CINECA and remained open four month in September and December 2018. Participation was voluntary and students were invited and reminded by email [5, 6]. Figure 1 shows the graphic interface of the CINECA platform for the test delivery.

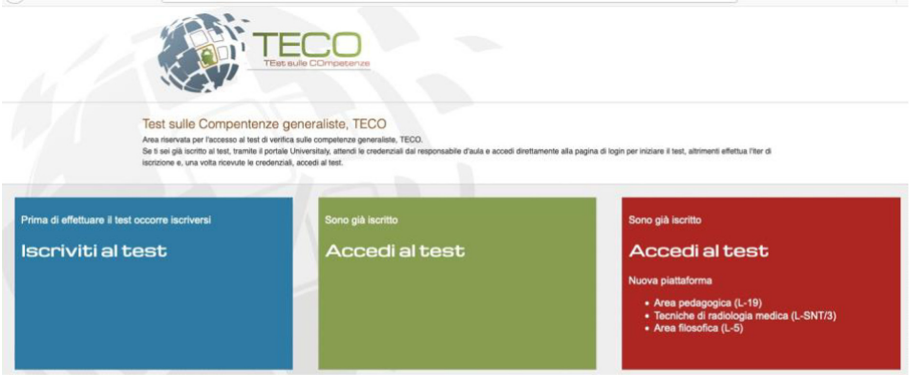

Fig. 1. CINECA platform

2.4 Measurements

The online TECO-D consisted of a series of demographic assessments and two validated questionnaires that measure the students' appeal to learning. The online TECO-D series of demographic assessments and validated questionnaire that measure the students' to learning. The TECO-D is composed by 70 questions divided in 11 macro areas.

2.5 Measurements

A preliminary check of the internal consistency of the TECO-D was assessed using Cronbach's alpha, and the distribution of questionnaire scores was also examined. Next, descriptive measures were generated for the main variables involved in the study. The evaluations of the TECO-D of the year 2018 were compared with the assessments of the year 2017, to assess whether the test is able to measure the changes in skills after 1 year (responsiveness). This data was evaluated through a parameter test for paired samples, with a significant statistic with a $p < 0.05$. Through this test two different student cohorts were compared (2017 and 2018). The error term from the 2 way model (MSE) of the repeated measures ANOVA was used to calculate the Standard Error of Measurement (SEM) (SEM = square root of the mean square error term from the ANOVA), which represents the absolute reliability. A smaller SEM indicates a better absolute reliability of the measure.

The SEM was used to calculate the Minimal Detectable Change (MDC) of each tool with the following formula: MDC = Standard Error of Measurement $\times$ 1.96 $\times$ p2.

The MDC indicates the minimal amount of change that can be interpreted as a real change in acquired competences for a student during the year of course; a smaller MDC indicates a more sensitive measure.

3 Results

3.1 Population

The sample was composed by 494 nursing students. The cohort examined in 2017 was divided into three sub-populations: 239 students enrolled in 2017 (I year of course); 170 students enrolled in 2016 (II year course) and 85 students enrolled in 2015 (III year course). The demographic characteristics of participants were not collected because the test is anonymous.

3.2 Internal Consistency

The Cronbach's Alpha resulted from administration 2018 showed a value of 0.90. This result is statistically significant.

3.3 Responsiveness

The evaluation of the responsiveness evaluated by t-test for paired samples showed statistically significant data for students enrolled in 2017 (I year of course) and 2016 (II year of course), while data not statistically meanings for students enrolled in 2015 (III year of course). The Minimal Detectable Change (MDC) and responsiveness are reported in Table 1, 2, 3.

Table 1. Responsiveness and MDC of students enrolled in 2017

Area	Administration 2017 (mean ± SD)	Administration 2018 (mean ± SD)	Mean difference	SEM	P	MDC
1	3.21 ± 2.1	5.50 ± 2.3	−2.29	0.207	0.00*	0.57
2	1.78 ± 1.6	3.44 ± 2	−1.665	0.16	0.00*	0.44
3	0.69 ± 0.9	1.07 ± 0.9	−0.374	0.084	0.00*	0.23
4	0.61 ± 0.8	1.31 ± 1.1	−0.704	0.083	0.00*	0.23
5	0.58 ± 0.7	1.09 ± 0.9	−0.509	0.08	0.00*	0.23
6	0.39 ± 0.6	0.80 ± 0.8	−0.409	0.067	0.00*	0.18
7	0.49 ± 0.8	1.71 ± 1.2	−1.226	0.095	0.00*	0.26
8	0.99 ± 1.1	2.12 ± 1.4	−1.126	0.118	0.00*	0.32
9	0.70 ± 1.0	1.92 ± 1.4	−1.217	0.113	0.00*	0.31
10	0.46 ± 0.7	0.99 ± 0.9	−0.535	0.073	0.00*	0.20
11	0.86 ± 0.9	1.53 ± 1.1	−0.678	0.098	0.00*	0.27
Total score	10.42 ± 6.8	21.59 ± 7.8	−11.176	0.658	0.00*	1.82

*$p < 0.05$. SD = Standard Deviation

Table 2. Responsiveness and MDC of students enrolled in 2016

Area	Administration 2017 (mean ± SD)	Administration 2018 (mean ± SD)	Mean difference	SEM	P	MDC
1	5.89 ± 1.9	7.31 ± 2.5	−1.42	0.264	0.00*	0.73
2	4.00 ± 1.6	4.78 ± 2.1	−0.781	0.212	0.00*	0.58
3	1.00 ± 0.9	1.43 ± 1.1	−0.432	0.106	0.00*	0.29
4	1.63 ± 1.1	1.89 ± 1.2	−0.26	0.133	0.00*	0.36
5	1.30 ± 1	1.69 ± 1.1	−0.391	0.12	0.00*	0.33
6	0.89 ± 0.9	1.33 ± 1.1	−0.444	0.112	0.00*	0.31
7	1.46 ± 1.2	2.33 ± 1.4	−0.87	0.146	0.00*	0.40
8	1.92 ± 1.5	2.34 ± 1.4	−0.414	0.16	0.00*	0.44
9	1.81 ± 1.4	2.76 ± 1.5	−0.947	0.153	0.00*	0.42
10	0.88 ± 0.9	1.24 ± 1	−0.361	0.099	0.00*	0.27
11	1.71 ± 1.2	1.84 ± 1.1	−0.13	0.127	0.00*	0.35
Total score	22.50 ± 6.8	28.95 ± 9.5	−6.45	0.952	0.00*	2.63

*$p < 0.05$. SD = Standard Deviation

Table 3. Responsiveness and MDC of students enrolled in 2015

Area	Administration 2017 (mean ± SD)	Administration 2018 (mean ± SD)	Mean difference	SEM	p	MDC
1	6.75 ± 2.2	7.66 ± 2.6	−0.916	0.012	0.01*	0.03
2	5.27 ± 1.7	5.06 ± 2	0.205	0.518	0.52	1.43
3	1.54 ± 0.9	1.49 ± 1	0.048	0.717	0.71	1.98
4	1.86 ± 1.1	2.19 ± 1.2	−0.337	0.031	0.03*	0.08
5	1.69 ± 1	1.46 ± 1	0.229	0.157	0.16	0.43
6	1.33 ± 1	1.41 ± 1.1	−0.084	0.598	0.6	1.65
7	1.90 ± 1.3	2.22 ± 1.3	−0.313	0.13	0.13	0.36
8	2.06 ± 1.2	2.45 ± 1.6	−0.386	0.116	0.12	0.32
9	2.53 ± 1.4	2.61 ± 1.4	−0.084	0.727	0.73	2.01
10	1.45 ± 1	1.41 ± 1.1	0.036	0.845	0.84	2.34
11	1.92 ± 1.2	2.01 ± 1.3	−0.096	0.624	0.62	1.72
Total score	27.94 ± 7.9	30.11 ± 9.6	−2.167	0.144	0.14	0.39

*$p < 0.05$. SD = Standard Deviation

4 Discussion

This study was conducted by a research group composed of medical doctors and rehabilitation professionals from the Sapienza University of Rome and from the Rehabilitation & Outcome Measure Assessment (R.O.M.A.) association [12–24]. TECO is a tool developed to evaluate disciplinary competences for students in health care professions. TECO has demonstrated excellent reliability and ability to assess students' skills year by year in the course [10, 11].

The aim of this study was to evaluate, for the first time, the responsiveness, and the MDC of the instrument for nursing students of "Sapienza" University of Rome.

Following the administrations in 2017 and 2018 it was possible to compare the cohorts of students enrolled in 2017, 2016 and 2015 who in 2018 attended the second, third and fourth years, respectively.

The reliability analysis showed statistically significant data, and this confirms again that the instrument has an excellent correlation between the items and that they are all sensitive to change.

As regards the analysis of responsiveness, we can say that for the investigated cohorts the test is able to assess the knowledge acquired between the first and second year and second and third. However, the improvements between the third and fourth years were not significant. The same data can also be seen for all the macro areas present in the TECO test.

Moreover, through the evaluation of the MDC we can affirm that the instrument is more sensitive to the change of competences between the first and third years.

4.1 Limitations of the Study

This study has some limitations mainly consequent to the sample size, in fact the cohort enrolled in 2015 had a reduced number which could have caused the lack of statistically significant results.

4.2 Conclusions

In conclusion, this study provides useful data confirming the test's ability to record a statistically significant improvement in students and reports the minimal detective change value necessary for the test score change to be significant year by year. These results provide an additional element for Italian universities for assessing competences in nursing degree courses and propose this model internationally.

The present study has shown that TECO is an excellent tool for assessing skills for students in nursing degree courses. According to the present study, this data is limited to the evaluation of the first and third years.

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Opinion Mining in the Airline Industry: Learning Social Sentiments and Insights

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Abstract. Due to growing social network traffic through Internet service provider, businesses are creating applications or systems that tap on social data to study user behavior and in turn, enhance the user experience. This paper proposes an airline opinion mining system (AOMS) that mines and analyzes data from social media such as Twitter, Instagram and Facebook. AOMS is developed using Opinion Mining methodology with four modules, which are Problem Areas, Team Performance, High Priority, and Online Feedback. AOMS was evaluated via Unit Testing to resolve all logical and system errors. The prototype of AOMS system is to be further tested via User Acceptance Test (UAT) by studying user experience in a pilot airline industry.

Keywords: Opinion mining · Text mining · Natural language processing

1 Introduction

In today's competitive world, market analysis is essential as every business decision can be executed effectively only if dashboard is provided as insights of a particular topic or products. In a service industry such as an airline provider, level of customer satisfaction towards a product or services is of the utmost importance. Business that runs without understanding the demand in the current market or do not able to quickly understand consumer attitude and react accordingly will lose business opportunities and eventually affect the business in a long run.

Some airline company works with credit card companies to analyze consumer purchases to better understand their passengers and potentially predict services those passengers would enjoy [1]. When it comes to flyers' data, airlines are also pulling consumer details from information provided when passengers sign up for loyalty programs and social media clicks [2]. Airlines claimed that data collected through loyalty programs is more specific and directly linked to passengers. This is useful to offer tailored promotions to passengers and provide more personal consumer service.

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The natural challenge in text or opinion mining would be accuracy of analyzed data as it can be challenging to analyze through text. Moreover, understanding customer spending habit through their lifestyle via social media such as Facebook and Instagram can also be challenging in terms of accessibility and privacy issue. In a study by [3], customer relationship management is important in order to maintain a company's long-term profitability and the researchers claim that 55% of CRM projects fails due to lack of customer focus which will leads to unable to target potential customer and miss business opportunity. Moreover, 75% of all buying decisions have an emotional component, which means customer purchasing behavior can be influenced by their emotions [4] and that companies rarely understand what customers want [5].

Existing CRM modeling techniques do well in describing the "whats" of customer behavior, but fails to understand "whys" [3]. For example, the analysis report can tell that a customer like to travel in the end of every year but unable to tell why customer choose to travel in year-end. In addition, the current CRM modelling techniques fail to identify and take advantages of such opportunities offered by social media which allows companies to listen and engage with their customers. Malthouse [6] also claims that the growth of social media offers companies opportunities to listen to and engage with potential customers and to encourage them to become advocates for their products. The challenge for companies is to identify and take advantage of such opportunities, and to avoid the pitfalls they entail.

Social sentiment analysis provide a better insights of potential customer to a business [7] by understanding an individual lifestyle and needs through text and location data shared in social media rather than analyzing customer with just historical data from loyalty program database. Historical data from internal database does not tell current trend which might lead a company offering products or services that is not what customer needs therefore social media analysis can be used to identify trending topic by finding out what's holding consumer interest and capitalize on the current conversation.

To paper is set to introduce an opinion mining system specific for the airline industry that mines and analyzes data from social media such as Twitter, Instagram and Facebook. Such system is important for the company to complement its existing marketing programs in gaining new customer as well as maintaining strong relationship with existing customer. The company will also be able to understand and provide a customized plan or package for potential passenger. Opinion mining in airline industry has high potential as currently complaints from customers are recorded along with the staff and actions. This is invaluable source of information that can benefit the airline companies.

The remaining of this paper proceeds as follows. Section 2 presents related work on existing Opinion Mining systems. Section 3 presents the Airline Opinion Mining System (AOMS). Section 4 presents its evaluation and Sect. 5 concludes the paper.

2 Related Work

This section reviews three existing opinion mining systems, which are Audiense (https://audiense.com/), Plum (https://www.plum.io/), and Zoomph (https://zoomph.com/). Audiense is a social marketing platform built on three core solutions; social insights, social marketing, and social advertising. The platform is intended to help businesses to connect with their audience and discover, understand, attract, or encourage

them to take action. Audiense can be used to analyze the progress of a Twitter campaign and to identify and understand new followers, as well as key influencers. Users can also monitor the competition and compare their Twitter strategy. Audiense's benchmarking tool can be used to compare the growth of an account to other similar accounts. Users can also automate sending of Twitter DMs to specific target audiences [8].

Audiense provides users with key insights on all their Twitter activity, as well as the behavior of their competition, followers and key influencers. All this information is available via the Twitter Dashboard. Users can discover and understand their Twitter community by uncovering information such as where their followers are from, what industries they work for and how they behave on Twitter. Find new customers by searching for new followers using a range of predefined criteria, such as number of daily Tweets and ration of friends to followers.

Audiense can be used to tailor content to suit desired audiences by utilizing the Twitter Analytics report to measure the performance of existing content and understand an audience's behavior. Discover what content works for an audience and monitor how competition and similar accounts manage their community. The app also shows users the best time to send a Tweet out to their desired audience by analyzing the timelines of their followers.

Next, Plum is a Software as a Service (SaaS) platform for pre-employment assessment that makes it possible to quantify company culture and attitude. The solution assesses candidates from different aspects, including attitude, behavior, problem solving abilities and social intelligence. It significantly reduces the time required to go through resumes and interviewing candidates, while also decreasing the amount of time required to train [9]. The short role analysis survey allows recruiters to select the most important traits required for each job, while software's intelligent algorithm calculates an overall score of each applicant based on those traits. Candidates can take the pre-employment assessment test through Plum or an existing application tracking system. Hiring managers complete the Employer Survey, which allows teams to determine the real-world needs of roles, instead of relying solely on skills and qualifications.

Plum's Problem Solving assessment evaluates candidates' capacity for logical thinking and their ability to solve new problems, using questions which require candidates to identify relationships and patterns. The test is designed to estimate each candidate's ability to acquire new knowledge and solve work-related problems. The Personality Inventory test assesses 10 character qualities; assertiveness, compassion, openness, politeness, enthusiasm, self-regard, stability, orderliness, intellections, and industriousness; designed to provide a comprehensive analysis of the most important temperament, traits, and dispositions of candidates. The test was developed with a forced-choice methodology, preventing candidates from increasing scores for all traits by falsely reporting their character traits.

Plum's Social Intelligence test evaluates candidates' individual differences in understanding social cues and their ability to anticipate the impact that different actions may have on the feelings and impressions of others. In the assessment, work situations are presented, and candidates are asked to select the most and least effective courses of action that could be taken in response to the problem from several different options. Scores for the three sections are calculated in percentiles and color-coded, with darker

colors representing more exceptional scores. Users can create and apply thresholds and filters to identify optimal candidates, and results are accompanied by short descriptions of the significance of the score. Candidates can then be shortlisted and interviewed using the provided structured behavioral interview questions.

Finally, Zoomph is an audience insights and engagement platform for marketers looking to understand their consumers on a human level. Zoomph enables marketers to easily track, analyze, and leverage data from various owned and social media channels. Zoomph combines real-time social data with our database of 260 million buyer profiles to provide rich, human insights on your consumers. The analytic tools or data integrations to track multiple consumer segments, identify lookalike audiences on social, and target ads [10].

Zoomph is most well-known as a platform that ties together all social media content from today's most popular social channels (Facebook, Instagram, Twitter), collects and ranks social media content and then streams it to an integrated interface where event attendees can absorb topics, trends, and real-time conversations. When utilized for meetings and events, clients using Zoomph often deploy the platform out of a kiosk or large monitor which displays real-time social media content generated by the attendees. On the back-end, event planners use "feeds" to collect and filter content based on their unique specifications. For example, user can assign one feed to only show the Twitter content that is tied to the event hashtag. Yet another can be tailored to display responses to social media surveys that you create for your event. Zoomph then allows users to display the content from all three modules; integrated and updated in real time-based on the content you choose from your searches. At the same time, Zoomph offers leader boards that update in real-time to promote engagement and gamification of any event.

3 Methodology

This paper is set to learn social sentiment and insights in the airline industry based on an opinion mining methodology. The main objective in this system is to capture complaints related to specific problem are from social media as well to monitor team performance in terms of response rate of each member in social media. According to [11], social media generate a large volume of content such as customer reviews, online articles, and tweets. Thus, opinion mining and sentiment analysis are frequently used for such analysis because they emphasize the extraction of sentiment polarity and user opinions such as positive, negative, and neural sentiment. Basically, opinion mining uses a set of computational techniques to extract, classify, understand, and assess the opinions expressed in various online news sources, social media comments, and other user-generated content.

Another related task, emotion detection, concerns the classification of text into several classes of emotion, usually the basic ones, as described by [12]. Therefore, opinion mining that involves sentiment analysis can be defined as a series of processes used to identify and extract positive or negative sentiments from the text and use this piece of information for decision-making. In order to extract the sentiments, texts are preprocessed to remove noisy elements and be normalized by treating special slang, or repeated punctuation signs [12]. Based on [13], sentiment analysis manipulates people's

emotions by identify their negative or positive posts into social media. Figure 1 shows the overall framework for the proposed AOMS.

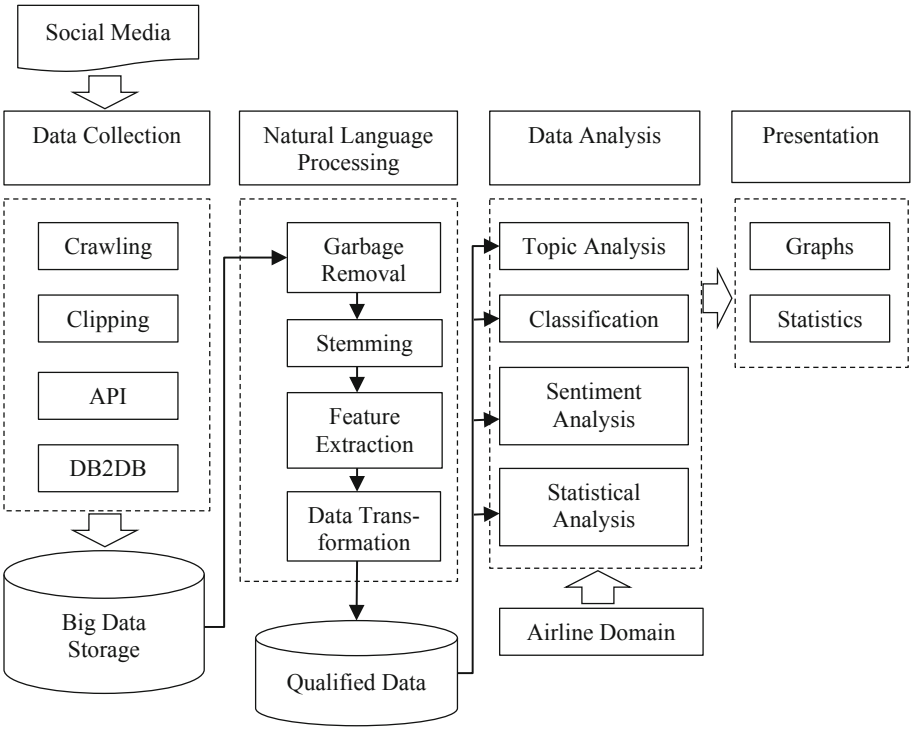

Fig. 1. Overall framework for AOMS.

Based on Fig. 1, a social media behavior opinion methodology should have the process that involve computational techniques to aggregate, process, extract, analyzed and present the result of text based analysis in social media content. The methodology used in this paper contains the following steps.

- Collect data from targeted social media channels such as Facebook or Twitters
- Clean the collected data using various natural language processing techniques
- Apply sentiment analysis to the qualified dataset
- Visualize and present the results in graphical or tabular forms

3.1 Data Collection

This project sourced data from social networking sites such as Facebook and Twitter using open access API and gather the data for analysis purpose. Basically, unstructured text generated by users are sometimes filled with too much of noisy data such as advertisements and meaningless online emoticons that impact the behavioral analysis results as shown in Fig. 2.

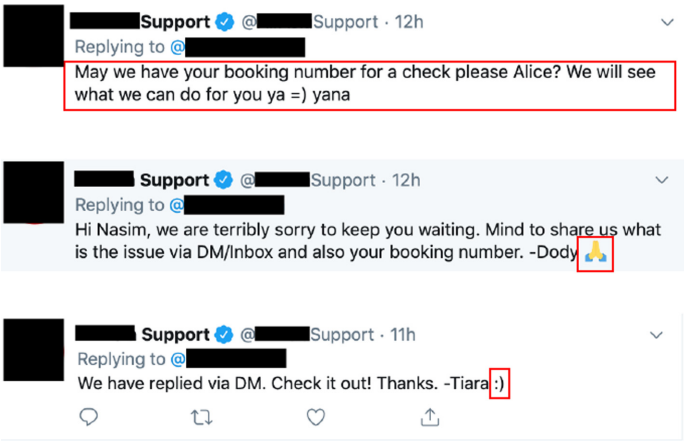

Fig. 2. Excerpt of actual tweet messages from an airline social networking sites.

Due to this, filtering and removing are required through research. Therefore, raw data should be pre-processed in order to generate accurate and meaningful information analysis. Figure 3 shows an excerpt of raw data from social networking site of an airline system which identity has been crossed out.

[{"created_at":"Thu Aug 01 04:05:24 +0000 2019","id":
1156779279645831169,"id_str":"1156779279645831169","full_text":"@AishathIbrahim Hi, may we know how can we assist
you today? Please share with us your concern and booking number via Direct Message for further assistance. Thank
you- Amel","truncated":false,"display_text_range":[16,172],"entities":{"hashtags":[],"symbols":[],"user_mentions":
[{"screen_name":"AishathIbrahim","name":"Aishath Naaringu\ud83c\udf88","id":
494954817,"id_str":"494954817","indices":[0,15]}],"urls":[{"url":"\u003ca href=\"http:\/\/www.salesforce.com\"
rel=\"nofollow\"\u003eSalesforce - Social Studio\u003c\/a\u003e","in_reply_to_status_id":
1156769517361483778,"in_reply_to_status_id_str":"1156769517361483770","in_reply_to_user_id":
494954817,"in_reply_to_user_id_str":"494954817","in_reply_to_screen_name":"AishathIbrahim","user":{"id":
179379726,"id_str":"179379726","name":"_____ Support","screen_name":"_____Support","location":"ASEAN and
Beyond","description":"We're here to help you with your @_____flight concerns and to pre-book add-ons! We're
live 24\/7 in English and Bahasa Melayu. \n#_____Support \ud83d\ude0a\ud83d\ude4f","url":"https:\/\/t.co\/
PZOLSnup19", "entities":{"url":{"urls":[{"url":"https:\/\/t.co\/PZOLSnup19,"expanded_url":"http:\/\/
support._____.com","display_url":"supports_____scom","indices":[0,231]}],"description":{"urls":
[]}},"protected":false,"followers_count":247821,"friends_count":10483,"listed_count":545,"created_at":"Tue Aug 17
04:07:15 +0000 2010","favourites_count":

Fig. 3. Excerpt of raw data from an airline social networking sites.

AOMS used the JavaScript Object Notation (JSON), which is a lightweight format for storing and transporting data tweets data. Raw text feature will extract tweets using Twitter API and the result will showed in JSON file. Problem Areas uses Search Tweet API whereas Team Performance uses Get User_Timeline API to extract tweets related to a topic. The result responded from Twitter API will contains all tweets that meets the parameter specify by the researchers which means all text in JSON file is raw and no data cleaning process is done yet. Raw text feature is developed to show raw or original text extract from source to user.

3.2 Natural Language Processing

In the second phase, a series of Natural Language Processing (NLP) tasks are carried out. NLP is a technique to manipulates, understand, interprets and presents natural language text for linguistics analysis. In this phase, NLP is responsible for pre-processing

activities, parsing sentences, removing disabled letters, extracting features and tagging specific characters. In addition, sentiment dictionary and stop words can be generated to improve accuracy. Following [12], this phase contains the following steps:

- Repeated punctuation sign normalization. This step detects repetitions of punctuation signs (“.”, “!” and “?”).
- Emoticon replacement. This step match the content of the tweets against an annotated list of emoticons. The emoticons found are replaced with their polarity whether “positive” or “negative”. “Neutral” polarities are deleted.
- Lower casing and tokenization. In this step, lower cased data will be split into tokens, based on spaces and punctuation signs.
- Slang replacement. This step involves is to include the semantics of the expressions frequently used in Social Media.
- Word normalization. In this stage, the tokens are compared to entries in Rogets Thesaurus to obtain a word match. Repetitive letters will be reduced until a match is found in the dictionary.
- User and topic labelling. All tweet person marks such as “@” are replaced with “person” and topics which the tweet refers to such as “#” are replaced with “topic”.

3.3 Data Analysis

This phase focuses on application of various analytics to generate result and insight of each user traits in social media. The output of the natural language processing tasks on the raw data will extract the count of keywords defined in the program such as:

- “change” that relates to changing flight details or changing passenger details
- “refund” that related to refund issues such as refund airport tax or booking
- “delay” that relates to flight delay
- “error” that relates to website error or mobile application error faced by passenger during booking process or any other related processes, and
- “luggage” that relates to all baggage issues such as lost or damaged baggage

Next, sentiment analysis is utilized to evaluate personality traits and soft skills of each users account. For instance, sentiment analysis results categories to provide a detailed relation about a person character that are Openness to Experience, Conscientiousness, Extraversion, Agreeableness and Neuroticism. In this research, a sentiment lexicon was used. Sentiment lexicon is a dictionary of sentimental words that people often used in their expression to enhance the opinion mining results within tweets data.

3.4 Presentation

The last stage is present behavior traits using visualized outputs such as matrix, graphs, and tables. However, this is the main stage of providing clear understanding stage of results rather than complex and technical analysis results, so that end-users are able to comprehend the meaning and use for decision making. In AOMS, the Generate Graph

feature will convert pre-processed text into graphical form to support data visualization. Problem Areas pre-processed text is demonstrated using vertical bar chart (Fig. 4) whereas Team Performance pre-process text is showed in horizontal bar chart (Fig. 5).

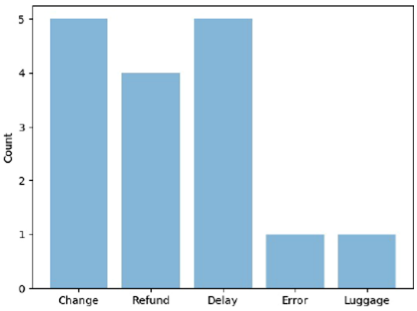

Fig. 4. Graph for problem areas.

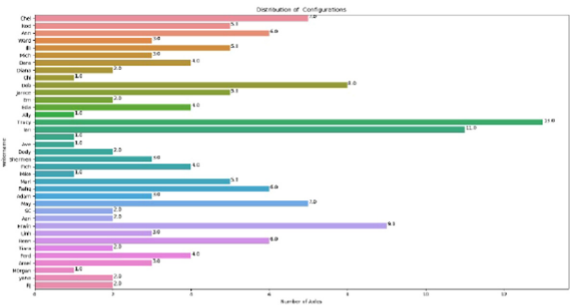

Fig. 5. Graph for team performance.

The moment when generate graph feature is activated, the system will extract tweets using Twitter API and perform data cleaning process before plotting a graph. This feature allow user to view what are the common problem areas within airline industry as well as how is the team performing on social media in terms of response rate.

4 Prototype of Airline Opinion Mining System (AOMS)

The main interface of the proposed Airline Opinion Mining System (AOMS) is the login page, which will be prompted upon opening the AOMS system. The system will check if the respective user exists in Firebase authentication feature which use to store all account information for each user. Email and password will be the key to access into the system main menu and any unauthorized users will not be allowed to access the system. An error message will display if email address or password entered is incorrect.

Since AOMS is an internal system used by an airline company, normal users are not allowed to register an account and only admin account is allowed to create new account for users. To register an account in AOMS, admin required to enter email address,

password, and confirm password and click on "Register" button to create a new account which a new record will be generated in Firebase. Validation is done upon entering all required field by admin such as the system will check if the email entered is in the correct format as well as check if password is in alphanumeric form. Moreover, one email address is only for one account in AOMS which means user is not allowed to register multiple account with the same email address.

As shown on Fig. 6, the main menu of AOMS consists of four modules, which are Problem Areas, Team Performance, High Priority, and Online Feedback. Problem Areas will contain information related to common problems faced by passenger whereas Team Performance will contain information related to individual performance in terms of response rate to tweets posted on Twitter.

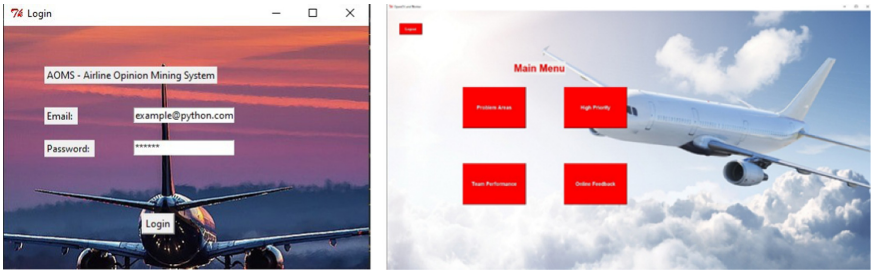

Fig. 6. Main interface of AOMS and its main menu.

High Priority feature will show the highest score value for both problem areas and team performance in a week and the result will be updated in daily basis. High Priority value is determined by retrieving past 7 days data from Firebase starting from system date and then placed into an algorithm to calculate the highest count value before displayed on screen. Both Problem Areas and Team Performance will have its own compiled JSON file, which when the final result is displayed separately on screen. Figure 7 shows the high priority output for the week.

Fig. 7. High priority output for the week is displayed in AOMS.

The result of highest Problem Area will help an airline company to identify what are the problems that is occurring repetitively and identify the root cause of it before the

problem get deteriorate. However, result of highest staff performance of the week will encourage and motivate staff to work harder in order to achieve a goal by giving out rewards to best staff performance as return. This can be seen in Fig. 8.

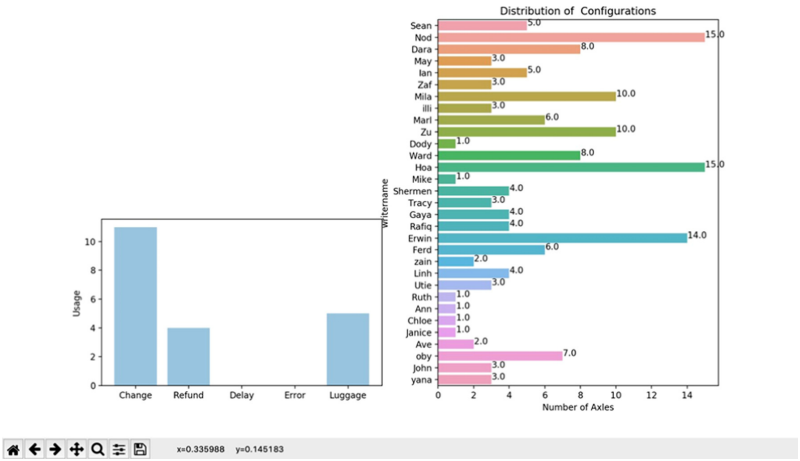

Fig. 8. Graph generated based on the real-time tweet into AOMS.

Online Feedback feature allows users to view historical data stored in Firebase. Both Problem Areas and Team Performance data is stored according to tweet date in JSON format. In order to view past data, users can select specific date from drop-down list and click on "Generate" button to view data in graphical format. AOMS will retrieve data from Firebase based on input date value provided by user and plot graph according to pre-process data that was retrieved from Firebase.

5 Conclusions

By successfully developing the Airline Opinion Mining Systems (AOMS), data analytics executives or other related executive will be able to achieve their goal and task using sentiment analysis tool. In additional, airline companies will able to have a better understanding of customer and closer to achieve what is important in customer goals. As social media information has been growing exponentially, businesses tend to encounter hassle of searching relevant information from an immense volume of data to form a personalized preferences of an individual. The information searching process consumes a large amount of time which poses a challenge and constraint to businesses which might lead to miss out of business opportunity. Thus, the proposed application targets to reduce time and effort required for businesses to analyses social media accounts and generate a dashboard as the results.

The tangible benefits will include the ability to save cost on traditional advertisement, to increase profit by maximizing sales through understanding customer preferences, as well as to save time on marketing because social media can reach out to people faster

than any marketing technique. Opinion mining also allows the airline companies to gain new potential customers hence increase sales and to quantify data and present in a dashboard to quickly identify areas that need improvements. Lastly, companies will be able to predict and forecast current trend and come out with products or services that align with current trend.

However, the key success to learning social sentiments and insights in any domain including the airline industry is the availability of data. Finding and solving customers' problems can be done effectively by taking social media dataset into consideration rather than the traditional way of gathering feedback given by each passenger verbally or by filling up a feedback form. Data obtained from social media are generally open access as compared to feedback forms. Active response by the customer service department to tweet messages or Facebook comments will create a highly useful chain of information that can be later mined for sentiments and insights.

In summary, after the unit testing and user acceptance testing have been performed, it is found that the proposed AOMS system is ready to deploy as all logical and system error has been resolved. Therefore, it is concluded that the system is giving expected results to users in terms of functional and non-functional requirements. The final AOMS system is further tested with user acceptance test by selecting experience user who work in this field. The researchers will target 3 different users who specialized in data analytics or business intelligence field to test the system and provide feedback. The result from user acceptance test has proven that AOMS system will provide insightful data to airline companies and further enhancement on AOMS system will be considered by adding more graphs to show more about airline industry from social media data. Facebook and chatbot text is suggested to extract as well to make comparison and increase reliability of the data.

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Evaluation of Knowledge Management in University Research

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Abstract. This paper describes the development of a set of indicators to measure knowledge management in the process research mission to the University; which attempt to demonstrate continuous improvement. From the exploratory method is able to determine the theoretical foundations and case studies to have a view of the applicability of knowledge management in the evaluation of research in the University, with emphasis on establishing the state of maturity of this process. The target population was selected to evaluate the indicators and is composed by a group of active members of the academic community, including teachers, Researchers, students, members of seed research and administrative staff Who are Involved in the area of research. Obtained results describe the external and the internal facilitators, achieved by indicators and measurement as a basis for evaluating creating a model of knowledge management processes for storage, processing and transfer of knowledge in research at the university. Importantly, do not need a large investment in resources (technology, infrastructure, etc.), for the implementation of the indicators, due to the existence of established techniques in the research**.**

Keywords: Agents facilitators · Indicators · Academics · Maturity · Research · Knowledge management model

1 Introduction

Development of indicators to assess knowledge management research at the university, is the basis for implementing a management model. The problem to address is the escape of knowledge of universities, through the migration of teachers to new institutions within and outside the country. This leads universities to generate legal to retain human capital mechanisms, but in practice does not allow to have the knowledge of the person, which has been developed in the research processes along its productive life.

In research facilitators they addressed to determine the set of indicators to be set. The science and technology system implemented by Minciencias (is the public entity that leads, guides and coordinates the national policy of Science, Technology and Innovation (CTI), and the National System of Science, Technology and Innovation (SNCTI) to

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generate and integrate knowledge to social, economic, cultural and territory of Colombia) has few paths to public and private institutions to establish criteria for measuring the development of research processes. Universities have implemented hybrid systems among posed by Minciencias and international benchmarks, thus facilitating the flight of human capital.

The need to generate indicators is created to identify the elements that are part of research system as facilitators to generate and transmit knowledge in the different layers of the system. The variables to consider are internal and external facilitators system, the target population, the processes of storage, processing and transfer of knowledge in research and measurement indicators.

2 Background Knowledge Management

The main theoretical foundations and case studies to have a vision of the applicability of knowledge management in the evaluation of research at the University, are described below.

2.1 Knowledge

According to the Royal Spanish Academy cited by [1] knowledge is defined as "action and effect of knowing where knowing is defined as ascertained by the exercise of intellectual faculties nature, qualities and relations of things" [1].

This definition conforms to man and depending on the level of intelligence or interest possessing likewise generate response to the unknown, however when de fi need knowledge from the organizational point of view, the concept varies. According to the authors Stewart Thomas, Michael Porter & Prahalad cited by [1], defined knowledge as "information that has value for it, i.e. information that can generate actions associated to meet market demands and support new opportunities through the exploitation of the core competencies of the Organization" [1].

2.2 Knowledge Management

Knowledge management is "Leverage existing resources and experiences in the organization, so that your staff can find, select and apply best practices, rather than reinventing the wheel every time" [2].

Moreover, [3] defines: "Knowledge management is the process by which an organization facilitates the transmission of information and skills to their employees, in a systematic and efficient manner. It is important to clarify that the information and skills need not be exclusively within the company, but may be generated out of it". This approach allows to identify not only within organizations can be found knowledge also outside it, why, external.

Another definition of knowledge management is that proposed by Piccoli, cited by [4], which defines it as: "The process by which organizations create, store and use their collective knowledge. This process includes three stages: organizational learning process by which information is acquired; the production of knowledge, the process of transforming and integrating information into usable knowledge; and the distribution of knowledge, the process of dissemination of knowledge through the organization" [4]. This definition allows contemplate that knowledge management before use, it must be processed and transform then distributed and used within the organization.

2.3 Objectives and Benefits of Knowledge Management

One of the priority tasks of management knowledge is the definition of the objectives to be achieved, and often vary depending on the strategy of each organization. Three of the main objectives sought are: The process improvement, innovation and development of new products and services and improved customer relations (…). In definitive, a good knowledge management provides new management tools, facilitates the task of motivation, promotes innovation and development of new products and services and helps improve connectivity and customer relationships [5].

The main benefit provided by knowledge management for entrepreneurs is, without any doubt, the creation of value and it can be included in four groups the contribution of knowledge management in a company, (…) which are the promotion of R & D and orientation towards innovation, knowledge and information of markets and clients, the valuation of people and the promotion of the corporate culture and the alignment of the processes and synergies with the business strategy [5].

2.4 Elements that Interact with the Knowledge

The definition of knowledge also allows referring to various elements with which it is associated.

The Data: As mentioned [6], "The data are more or less isolated from reality elements abstracted from mental models of an individual or group of representation". (…) likewise cited by Davenport & Prusak [6], define as abstracted elements actually the same for the purpose of identifying made discretely. "That is to say data by themselves do not provide any explanation of the events they describe. Therefore, have to be interpreted, for people to have meaning and to generate profit" (p. 40).

Information: It is generated from selected, organized and processed data according to pre-established criteria. The basic methods for converting data into information and, at the same time give them meaning are categorization, contextualization, analysis and synthesis [6].

Intelligence: While the term is used in the social sciences as a capacity possessing and developing individuals to intervene advantageously about reality through the use of their knowledge; in the business or organizational sphere, the notion of intelligence refers to the capacity they possess to develop processes for the processing and use of information and knowledge that facilitate effective decision-making, generating competitive advantages [7], p. 51.

2.5 Intangible Assets in Knowledge Management

Intangible assets are due in knowledge, skills, values and attitudes of people. These intangible assets are called Intellectual Capital. Intangible assets capacity generated in the organization, when resources begin to work together, [8], p. 36.

Intellectual Capital: According to [9], defined as: "The combination of immaterial or intangible assets being included staff knowledge, ability to learn and adapt, relationships with customers and suppliers, brands, product names, internal processes and the ability of R & D, etc., an organization which, although not reflected in traditional financial statements, generate or generate future value and on which It may support a sustained competitive advantage".

Human Capital: "Produced with knowledge and personal experience, it is comprised of knowledge (explicit or tacit) useful for business people and having the same equipment as well as its ability to regenerate; that is, their ability to learn [6], p. 41. As can be evidenced this capital is the basis for generating the other two intellectual capital assets.

Structural Capital: It is self-knowledge of the organization, which is latent in their process of innovation and technological upgrading. "It's the knowledge generated in the field and formalizes the structure and culture of the organization" [10]. What is the structural capital of an organization being its information systems and communication, organizational culture, patents, work processes, among others, this capital is measured in terms of efficiency [6, 11].

Relational Capital: Links the results of the above components in the relationship with users/customers and other stakeholders of the organization, to meet the most varied demands and information needs. Power organizational learning, decision making in organizations and has an impact on society [12]. This capital allows to establish relations of the organization with its environment.

2.6 Case Studies of Knowledge Management in Organizations

University of the Basque Country/EHU [7], applies the search for a model knowledge management to guide research the application of scientific knowledge and technical, in collaboration with businesses and public administrations (…) (p. 13). The object is to diagnose the current situation of the management of the research process - development-transfer scientific knowledge - skill in the UPV/EHU, and then, on the basis of said diagnosis, formulate a new model to enhance the strengths and remove the weaknesses of the current model ([7] p. 17).

Another space are meetings with various universities in the South American region, made in Argentina, covering topics such as Knowledge Management: composition and measurement of intellectual capital at the university. It is envisaged that the University must be prepared to teach, to research, to management and to perform extension as quoted Stiglitz [13]. To this point four key aspects for economy based on knowledge and learning are:

- In education as a key process provided it is geared towards "learning to learn" and to influence knowledge as a factor of development.
- In developing a process of social appropriation of knowledge to society, individuals or organizations appropriating it as "public good' in a project to build and interrelatedness that meets the demands mentioned above.
- The ability to generate dynamic alternative social learning as a key element to strengthen the powers of persons, entities or regions.
- In Knowledge Management integrated into the corporate strategy to guide changes and processes that make sustainable development.

"The University is a sector highly qualified and sensitive to launch the process that allows to use excellent tools such as Intellectual Capital and Knowledge Management. It is true that there are no parameters in most cases, but it is understood that you can start with a few indicators to go comparing them periodically. Because it is essential to work to deepen the process of identity that tell who we are, who we are and how we are" taken from [13] (p. 17).

In Perú, an implementation model of knowledge management aimed at generating benefits to public universities in Peru it was applied. The project proposed by [6], covered:

- Identification map existing knowledge (who knows what?).
- Identification of the needs of skills development by individuals and teams.
- Identification of flows to allow the transmission of tacit and explicit knowledge.
- Identify and manage knowledge market.
- Analyze knowledge transfer systems from the point of view of the needs of people.
- Check and adapt policies evaluation and recognition of targets.

One of the major problems identified in this project had to do with the need to adapt the concept of university to how the processes of learning and innovation are organized and put in place in institutions of higher education [6]. Should be encouraged, within the University, a culture of planning that allows use in permanently and continuously (…) by planning tools such as plans strategic, internal rules, training processes, etc., as well as use strategic thinking actions that allow winning vision, develop skills (emotional intelligence to create alternatives, creativity and long-term thinking, methodologies and learning processes) and values to accompany the development of action plans.

In Colombia a group of researchers Department of History and Management of the Technological University of Bolivar, made up of teacher's program of industrial engineering and business administration, made a model of knowledge management with the company "Compañia Colombiana de Clinker S.A., (Colclinker). "The end result is a cycle of creation of organizational knowledge and a tool to develop the tacit explicit knowledge within an organization" [14], p. 1.

The knowledge management model applied at the Pedagogical University, seeks to improve the dynamics of the processes of creation and dissemination of knowledge through research. Conversion of tacit to explicit and explicit to tacit (the knowledge of researchers investigator) to achieve efficiency and collective use of their results in the search process and transfer of knowledge through solutions liaison with the productive world and research [15], p. 58.

The model takes into account: Development and implementation of institutional investigative policies (…), appropriation of financial and human resources for knowledge creation (…), generation of research culture, based on pedagogy; that is to say, researchers are part of teaching and teachers are researchers, develop motivation for internal and external customers, through the shared (…) knowledge [15], p. 58, among others. The model is a proposal and did not reach its implementation phase, and does not show the necessary resources to carry out the above processes or have indicators to measure their efficiency and effectiveness.

3 Analysis of Facilitators and Indicators

3.1 Facilitators or Facilitators Agents

According to [16], facilitators are the elements that will allow boosting the actions of the organization, therefore these agents help to establish the policy of university research, and evaluation of this process, through indicators that will facilitate the identification, development and retention of knowledge.

Facilitators associated to a particular node with the purpose of providing a defined area of knowledge and in them we can bring together the various indicators that provide us with the decision on the proposals for achieving the strategy [16]. Considering the direct impact on the organization, we can classify facilitators in:

Facilitators node organizational structure

- Modernization and continuous improvement
- Research productivity
- Sstructural line research area

Facilitators human talent node structure

- Disclosure culture
- Researchers skills node

Technological Facilitators

- Technology integration
- Communications
- Technical innovation

Each activity must be related to the facilitators required to perform each process; human talent agents, agents and other technological processes with specific characteristics. The articulation of these elements produces the expected results, however the respective controls by means of indicators to assess the results to be evaluated and if necessary, create action plans to raise the level of commitment and participation apply active of all those involved in improving the quality of research at the University.

3.2 Indicators

An indicator is "a measure that reflects a very specific situation and to be located on the scale numerical allows you to set an order of the observations made and knowing the distance between each other" [17], p. 3 further is understood as "the systematic process of measuring and valuing the knowledge of the organization in relation to its economic performance, social, intellectual production and fulfillment of its objectives strategic" [16], p. 191.

Based on the above, the baseline indicators are taking as initial parameters, indicators determined by Minciencias in the research area, enabling the annual evaluation of universities and thus have a standard measurement, which will reveal the current state of the research area of the University and later comparison. In addition, the criteria considered for the development of indicators, are those established by the National Accreditation Council on the issue of accreditation in Colombia and, in a broader perspective, in relation to compliance with the social function of higher education and to achieving high levels of quality by institutions and academic programs at that level, asserts CNA quoted by [16]. These indicators are framed facilitators.

External Facilitators. They are related with its social, cultural and institutional environment, providing the elements for the regulation or management of activities in the education sector, and providing indicators that facilitate the accountability component of higher education to society ([16], p. 195).

Social Environment. It refers to social improvement to the contribution of the development of the region and its environment through the participation of their talent.

Culture Knowledge. Refers to the sense of belonging but difficult by geographical location, there is little flexibility and control over the researchs (Tables 1, 2 and 3).

Table 1. Social environment indicators guide. Source: [16].

Denomination	Objective	Form of building
Social projects being conducted by the institution through research	Assess the relevance of social projects to meet local needs, national and international	Number of social projects being conducted by the institution through research
Number of social projects being conducted by the institution by institution its research	Verify the social projects being conducted by the through program its investigation	Number of social projects being conducted by the through its teaching, extension

Table 2. Culture knowledge indicator guide. Source: [16]

Denomination	Objective	Form of building
They organize working groups or projects periodically	Assess the organization and development of working groups	Qualitative assessment
The organization encourages and facilitates the process of sharing knowledge	Assess whether the organization facilitates the process of sharing knowledge	Qualitative assessment
There are mechanisms for recognition of performance excellence	Assess whether there are mechanisms to recognize excellence in performance	Qualitative assessment

Self-appraisal. Is the study and continuous measurement, conducted by educational institutions or organizations or academic programs, based on the criteria, characteristics, variables and indicators defined by an agency or institution or state accreditation recognized by it. The educational institution should take the lead in this process and encourage the broad participation of community academic.

Internal Facilitators. They are specific to each institution, and must serve it to define its policies and actions.

Table 3. Self-assessment indicators guide. Source: [16]

Denomination	Objective	Form of building
Existence and application criteria and guidelines defined to advance self-evaluation processes by researchers	Verify the existence and implementation of self-assessment and self-regulation processes of the research process	Qualitative evaluation
Existence and application criteria and guidelines defined to advance self-evaluation processes by researchers at the College	Verify the existence and implementation of self-evaluation processes by researchers at the University	Qualitative evaluation

Technology: The use of new information technology and communications will provide the University be present in a timely manner and respond to the requirements of the different fronts of their university work (Table 4).

Table 4. Technology indicator guide. Source: [16].

Denomination	Objective	Form of building
Existence of a technological platform that guarantees connectivity, interactivity and access to information systems, support and resources	Assess the availability of a technology platform	Qualitative assessment
Availability of information portal	Assess availability of an information portal	Qualitative assessment
Availability of a knowledge portal	Assess the availability of a knowledge portal	Qualitative assessment
Percentage of researchers used computer resources	Evaluate the percentage of researchers uses computing resources	Total researchers who uses resources University/Total equipment available in University * 100

Processes: Process indicators relate to the completeness, flexibility and interdisciplinary research area (Table 5).

People: In research it is seen to people, as a primary for intellectual production of a university organization factor. This indicator allows the evaluation of knowledge management, because of the ease you have for comparison with other universities and research organizations. Therefore, they are divided into two indicators in people and research production (Table 6 and 7).

Table 5. Process indicator guide. Source: [16].

Denomination	Objective	Form of building
Quality research	Identified the level of recognition to the quality research institution	Total research groups of excellence (type A) * and consolidated (type B)/Total research groups recognized by the institution. Minciencias classification, entity responsible for promoting research in Colombia
Project management research	Identify the capacity of groups renowned for their quality, to manage research projects with external entities	Total research projects obtained fi nancing with different entities to the institution/Total projects approved by the research groups of excellence and consolidated

(*continued*)

Table 5. (*continued*)

Denomination	Objective	Form of building
Resource management capacity to research	Identify institutional capacity management resources for research	Total resources for research achieved with different entities to the institution/Total resources for research
Research disclosure	Note investigation results in the context of the international scientific community	Total publications international journals indexed per year
Technology production and scientific contribution of research	Dimensioning the scientific and technological research to society	Total patents (or equivalent level) national and international obtained in latest five year

Table 6. People indicator guide. Source: [16].

Denomination	Objective	Form of building
Research effort of teachers	Identify the ability to design and/or development of research by teachers of the institution	Total approved research projects (internal and external) running in the period of 1 year/Total full-time faculty)
Recognition of the research work	Establish quality research work based on distinctions obtained	Total national and international awards won in the year
Doctorate teacher quality	Grade training of the Ph.D. teachers	Total teachers template with Doctor title/Total teachers
Teaching quality in master's degree	Grade training of the Master teachers	Total teachers template with Master title/Total teachers

Table 7. Productivity research indicator guide. Source: [16].

Denomination	Form of building
Research groups registered and recognized by Minciencias	# Research groups recognized
Teachers with research assignment	# of teachers with research work assignment
External research resources	Million pesos assigned to th e University to research support
Research projects	# developing research projects

(*continued*)

Table 7. (*continued*)

Denomination	Form of building
Research hotbeds	# research hotbeds
Participation of research hotbeds	# of research projects submitted in calls/total hotbeds

4 Research Indicators Model

The research indicators defined in the model are:

Indicator: Research groups recognized by Minciencias

Name: Minciencias research groups recognized
Objective: Determining recognition of research groups and permanence group
Theme relationship: Number of research groups recognized
Responsible: Vice Chancellor Research - deans or equivalent
Measurement: Number

Indicator: Teachers with research work assignment

Name: Teachers with research work assignment
Objective: To determine the participation of teachers who perform research
Theme relationship: # of teachers with research work assignment.
Responsible: Vice Chancellor Research - deans or equivalent
Measurement: Number

Indicator: External Resources Research

Name: External Resources Research
Objective: To determine the management of teachers or research groups for their projects.
Theme relationship: Millions of pesos allocated to the University to support research.
Responsible: Vice Chancellor for Research - Deanatura or their equivalents.
Measurement: Number

Indicator: Research Projects Development

Name: Research Projects
Objective: To determine the consolidation of interest groups and knowledge generation
Theme relationship: # of Development Research Projects
Responsible: Vice Chancellor for Research or equivalent
Measurement: Number

Indicator: Research Hotbeds

Name: Research Hotbeds
Objective: To determine the research training programs.
Thematic relationship: # of hotbeds of Responsible Research: Research Vice Chancellor or equivalent
Measurement: Number

Indicator: published in national refereed journals Articles

Name: published in national magazines Objective items: To determine the publications resulting from research conducted and knowledge generation nationwide
Theme relationship: Number of articles published in journals indexed by researcher
Responsible: Director Research Group
Measurement: Number

Indicator: published in international journals Articles homologated

Name: Articles published in international journals
Objective: To determine the publications resulting from research conducted and the generation of knowledge at international level
Theme relationship: Number of articles published in journals indexed by researcher
Responsible: Director Research Group
Measurement: Number

Indicator: Management master's thesis and/or Ph.D.

Name: E-thesis
Objective: To determine the contribution of researchers to research trainees
Theme relationship: Number of Master's thesis and/or doctorate completed and approved
Responsible: Researchers
Measurement: Number

Indicator: Patents registered

Name: Patents
Objective: To determine the contribution of researchers on innovation and development of new technologies
Theme relationship: Number of registered patent research group
Responsible: Researchers and director of research groups
Measurement: Number

Indicator: Digital Books

Name: Books
Objective: To determine the contribution of researchers in the development and publication of new knowledge thematic relationship: Number of books published by research group
Responsible: Researchers and director of research groups
Measurement: Number

Indicator: Software developed

Name: Software
Objective: To determine the development of new tools for managing information and knowledge
Theme relationship: Number of software developed and documented by research group
Responsible: Researchers and director of research groups
Measurement: Number

5 General Analysis Indicators of Missionary Research Process

As a corollary of the above indicators is reflected growth significantly low research products as Minciencias (is the public entity that leads, guides and coordinates the national policy of Science, Technology and Innovation (CTI), and the National System of Science, Technology and Innovation (SNCTI) to generate and integrate knowledge to social, economic, cultural and territory of Colombia). Low participation in research groups has meant that there is a greater commitment to the dissemination of new knowledge and the consolidation of the research as the most determined of the administration to inject resources for new research projects support.

5.1 Measurement Indicators

Management indicators become vital signs of the organization, the results of indicators allow a glimpse of the evolution of processes, allowing to know their contribution to knowledge management model. In turn it enables stratify indicators on intellectual capital (human capital, structural capital and relational capital), showing the degree of maturity.

The contribution of these indicators, you can see over time the evolution of the respective indicator, assessing whether is significant its result compared to previous periods also allows averaging the indicator and establish their effectiveness, efficiency or effectiveness as appropriate, with the purpose of establish improvement actions. This model was initially composed of the element of intellectual capital, which is to be measured (Human, Structural and Relational), then the facilitator is added, with indicators and periodicity to be evaluated in the field of intersection indicator and period type value (Table 8).

Table 8. Measuring indicators (results). Source: The authors.

Measuring Intellectual Capital Indicators Item						
Facilitator one			**Indicators Year…n**	**Year 1 Average**	**Year 2**	**Year 3**
	Indicator 1	Value one	Value two	Value 3	Value n	Prom. Ind. 1
	Indicator 3	Value one	Value two	Value 3	Value n	Prom. Ind…n
Facilitator two	Indicator 1	Value one	Value two	Value 3	Value n	Prom. Ind. 1
	Indicator 3	Value one	Value two	Value 3	Value n	Prom. Ind…n
Facilitator … n	Indicator 1	Value one	Value two	Value 3	Value n	Prom. Ind. 1
	Indicator 3	Value one	Value two	Value 3	Value n	Prom. Ind…n

5.2 Target Population

For the evaluation of the indicators, a sample population of 81 people, between researcher's teachers, students of the methodology subject of research program systems engineering, members of seed research and officials from the office of Investigation was conducted in the University of Amazonia in southern Colombia [17]. He understood as a research professor, teaching everyone that contains at least one research project registered and endorsed at the Vice Presidency of Research at the University.

Indicator area in Fig. 1, teachers sometimes know and use them to 36%, while the students and members of seedbed often know and use it with a value of 40% and 40.9% respectively, while officials always know and use with a value of 35.7%. A general academic community level - administrative know and use indicators knowledge management (Table 9).

Table 9. Measurement results (indicators). Source: The authors.

Population	Size	Sample	Percentage
Researchers teachers	115	25	0.217
Students methodology	235	22	0.107
Research (course) members of seedbeds	129	20	0.155
Administrative officials	19	14	0.737
Total	**738**	**81**	

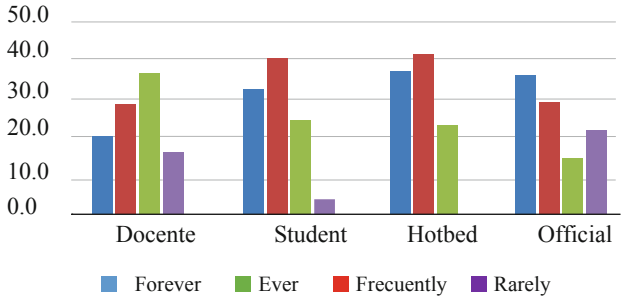

Fig. 1. Percentage of knowledge and use of indicators for knowledge management. Source: The authors.

6 Conclusions

The project management knowledge in the research process at the university, its goal is to improve procedures optimizing the information and generate a new, enabling greater productivity in this area; tasked indicators will regularly evaluate the proposed goals and control the system.

Despite differences in some groups of the academic community (teacher's researchers, students, and staff member's seedlings), it can be said that the model generally has a favorable opinion. Of course you have to make several improvements to the model, especially in the areas of technology, content and personnel, and standardize so that it is more profitable these resources and to generate a high value on knowledge.

For that end, it will be necessary to raise communication strategies, awareness and training for the entire University community, which to publicize in more detail and to be made aware of the importance of the model, for both areas in particular to the University as a whole. Similarly, these strategies will be required for improvements that occur in time.

Continue to work the model for the entire University, stipulated by the process map which includes macro-strategic, mission processes, and support. This will improve the standard of academic-administrative quality to integrate with the integrated quality management system that implements Universities, making the inclusion of performance indicators in the different processes.

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Innovation in ICT Course Provision: Meeting Stakeholders' Needs

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Abstract. ICT companies face problems in recruiting a workforce with ICT skills to meet an increasing demand driven by business growth and innovation. Typical degree courses offered by universities have failed to keep up with this demand, with the number of graduates failing to provide a sufficient supply of suitably-qualified employees. There is also often a mismatch between the degrees offered and the requirements of companies in the ICT industry. There is a need to develop new approaches to address these challenges with sustainable effect. This paper presents three case studies from three different countries. These case studies describe approaches taken by universities, government and industry in developing ICT courses using co-creation method. We consider the role of the different stakeholders and identify areas of commonality and challenges for the future.

Keywords: ICT courses · Co-creation · Digital skills

1 Introduction

In recent decades the role of higher education institutions has changed dramatically. Generation and communication of knowledge is no longer seen as the sole preserve of the university, while at the same time knowledge-based innovation has become integral to the success of business and of regional and national economies [11]. A number of different stakeholders are involved in the relationship which seeks to both support and drive this knowledge-based economy. Important among these are the universities which both conduct research and deliver courses; businesses which require knowledge and an increasingly highly skilled workforce to innovate and develop; and governments which can support and legislate to provide greater impact. There is currently considerable interest in the development of these roles and relationships, particularly in the area of course development and delivery.

A further central component in this (although seemingly not always at the forefront of course development models) is the learner. They are the basic

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resource that must provide the necessary skills for industry; they are the raw material at the heart of a course and the potential co-creators of knowledge through their own skills and life experiences. They are also individuals with competing demands who need to maintain a successful work-life balance [2]. Any model which ignores this dimension is unlikely to succeed.

This paper uses a case study approach to investigate different models for course development which incorporate various stakeholder perspectives. We present three separate cases from different countries and consider which stakeholders are primarily involved and how each seeks to address the needs and motivations of the different groups. We compare and contrast these models on the dimensions of stakeholder involvement; their support for students' work-life balance; and the extent to which they are successful as a useful model of course provision. Initial conclusions are presented based on these findings.

2 Background

In a knowledge-driven society, companies internationally have an increasing demand for employees equipped to contribute to continued economic performance and growth through on-going innovation. However, a continuing shortage of suitable workers and mismatch of skills is seen as directly damaging economic growth and societal well-being [4,6]. This is despite the fact that many countries are now producing more graduates than ever before. For example, Davenport et al. [8] comment on the UK context in which there is a huge shortfall in the predicted industry requirements for skilled workers in the digital sector, while at the same time noting surprisingly high rates of unemployment amongst graduates of computer sciences. The obvious question is, why are such discrepancies arising? In order to address these concerns and to better meet existing needs, new models for course provision are being introduced.

Successful innovation in the area of course development, as in other areas, does not come from the university alone. Etzkowitz introduced a "Triple Helix" framework which views innovation as being increasingly based on the interaction of government, industry and academia [10]. This is not just a dialogue between three interested parties but an increasingly intertwined relationship resulting in an interactive model of knowledge transfer innovation. In the context of course development, such a model would suggest that in order to find creative solutions to problems such as the skills shortage the different stakeholders should be contributing to new approaches. In considering new models of course provision it may therefore be instructional to consider the extent to which the different stakeholders have been involved and how this has influenced the model and its operation.

In some cases, a new approach may be strongly dictated by one of the stakeholders with less input from or consideration of others. For example, a study by Zheng and Hu [21] considered initiatives in Singapore and Taiwan to increase national skills capacity as part of a "catch-up" industrialisation programme. As

part of this, highly orchestrated government-led initiatives created new education institutions committed to teaching programmes that could provide the necessary skilled workforce. On many measures, the up-skilling initiative was seen as hugely successful. However, the authors report that there was a high level of attrition after the workers had been recruited. The authors point to what they refer as the "missing link": that is, the failure of the government-driven approach to meet industry requirements at the company level. As this example suggests, it seems likely that a model in which one stakeholder predominates will not be completely successful.

The triple helix model identifies three important actors but fails to take account of one central group of stakeholders - the learners. Meeting a skills gap is not just about creating an efficient production process that can offer the right range of skills for industry. It is increasingly acknowledged that students have a valuable role to play in the co-creation of content and mutual investment in curriculum [9,20]. Further, in purely practical terms the mode of delivery must make courses accessible to learners. There can be many constraints on learners (in terms of finance, time, location, learning support, family support and so on) which render good courses unsuitable or inaccessible. It is therefore also necessary to consider the perspective of learners and the approaches to course development, provision and support which can promote participation and contribution [2,3].

3 Methodology

This paper adopts a case study approach to investigation of emergent approaches for innovative course provision. Case studies examine specific instances and can provide unique understanding of real examples in real situations [7]. They are set within organisational and institutional context and provide description with analysis. They can contribute to knowledge via analytic rather than statistical generalisability, that is, in their ability to contribute to the compass and expansion of theory [1].

Three separate approaches to innovative course provision from three separate countries are presented. Each approach is targeted at different situations and in different contexts. However, each is motivated by a desire to meet the skills gap and with consideration for learner participation and contribution. The questions we seek to answer are:

- to what extent are the different stakeholders involveds;
- in what ways do the models seek to involve the learners' perspective and support a sustainable work-life balance;
- how successful are the models (so far) in providing a sustainable model to meet stakeholders' needs;
- what recommendations are suggested by the experience in these case studies.

We describe each approach under consideration, followed by a discussion comparing and contrasting the individual approaches.

4 Case Studies in Innovation

4.1 ICT Courses in Finland

In Finland, as in many countries worldwide, there is a noted lack of applicants with suitable digital skills [15] with ICT companies facing problems in recruiting in many areas [17]. Typically, traditional degree courses were found not to be solving the problem as the curricula offered were failing to meet the needs of industry. One response to this has been a national scheme to introduce innovative Masters level programmes at Universities of Applied Sciences [16]. Developed in close cooperation with industry these courses are intended for students who have at least three years' work experience. They complete their degree in 18 to 36 months, studying alongside their job.

The programme has proved successful with both students and companies, with 13,000 graduates in 2015 [16]. However, ICT graduates form only a part of this number and the skills gap continues to be a problem [15]. Seinajoki University of Applied Science has engaged in the programme and runs a variety of successful Masters courses. However, they have also sought other means by which to address the on-going skills shortage. In particular, they have introduced a new ICT education programme (offered at both Masters and undergraduate level). The initiative is based on the principle of co-creation of knowledge.

Taken from management studies, co-creation brings together different interested parties to produce better results [13]. In education, the focus shifts away from the idea that the university is the sole creator and disseminator of knowledge. Companies and students become partners in the creators of knowledge [20]. The initiative was taken forward on a regional basis, by identifying and working with local industrial partners to co-create Bachelor/Master level provision. The first step in this process was a joint business meeting to form an initial idea of needs in ICT areas, with key local companies invited to contribute. Following this a web survey on ICT competencies was conducted amongst regional companies. Of the 49 respondents, 12 were identified to participate in a series of "co-creation workshops" in which business and academia collaborated on the needs and requirements of a curriculum. Company's immediate needs must be balanced with the requirement to provide a sound theoretical basis and understanding. The workshop provided a meeting point where ideas could be discussed face to face. Following the workshop, on-going discussion and development continued online.

The co-creation workshop was not just a talking shop: it was carefully structured to encourage meaningful collaboration, bringing together drivers from industry ("we need to have...") with the curriculum perspective and pedagogic knowledge of the academic members ("students need to know..") [3]. A further feature is the on-going nature of the collaboration, giving industry joint ownership in steering and developing the courses. A number of companies were willing to contribute to teaching, either through guest lectures or by contributing a whole module. Connections to places of work were also offered (such as locating teaching and project work in a company).

4.1.1 Involvement of University, Industry and Government

In this case study, government were not involved as part of the proposed solution. The initiative worked through close cooperation of specific academic and industrial partners. It was achieved on a regional basis, allowing specific needs in a particular locale to be addressed. As a result, the companies involved were able to see themselves as meaningful contributors to the creation of the syllabus and the running of the course. Their feedback indicated that they were happy with the curriculum, feeling that it met their needs. The on-going collaboration ensures that developments of changing requirements can be incorporated through a process of continuing dialogue [3].

4.1.2 Involvement of Learners

Students were not involved in the initial development of the course. However, a further central motivation of the approach was to consider students' work-life balance and to see how they could be involved in co-creation of knowledge at a module level. One example of how this was achieved was in the use of novel technology to support distance seminars [2]. Given that the course involved several separate centres over 100 km apart, students previously taking a traditional version of the course needed to do a great deal of travelling. Practical approaches such as this were shown to make a large difference to students and their ability to juggle life, work and study.

The students on this Master course brought a good deal of experience and knowledge to their study. Technology was used to support an approach in which sharing of individual experience was a central part of knowledge creation. The management of the software was again very important, as was the teachers' role in ensuring that the sharing process happened in an organised and structured way and that the contribution to the learning objectives of the module were clear [2].

4.2 Degree Apprenticeships in the UK

In the UK the digital skills shortage is being addressed at government level as one of the key objectives in its Degree Apprenticeships scheme (Graduate Apprenticeships in Scotland). For many years, employers have been expressing dissatisfaction, both at the number of qualified applicants and at the skills of graduate applicants [18]. The government has consulted groups of employers representing sector areas (known as trailblazers) to develop standards for different degrees, both at undergraduate and Masters level. In computing, the Digital Technologies standard applies, which has variant specialities covering Software Engineering, Security, Data Science etc. [14].

Individual universities work with industry to develop degrees accredited against the appropriate standard. There is considerable flexibility in how the standard is interpreted allowing each specific degree to be tailored and shaped by the joint discussions between university and industrial partner(s). A degree may be "closed" (available only to the intended partner companies) or "open" (other companies may negotiate to send students).

Students are identified by the companies from their existing workforce or recruited as degree apprentices to meet both the requirements of the company and the degree. The company commits to paying the degree apprentices at least a minimum wage (most pay more) and to allow them at least 20% of their contracted hours for study. Each degree standard carries an agreed level of tuition funding and this is paid to the university provider by the industrial partners for each degree apprentice.

The mode of delivery is decided by agreement between the university and the company (day release or block teaching, distance learning, blended learning, combinations of different methods for specific modules). An undergraduate degree should take between 3 and 5 years to complete. With only a guaranteed 20% of time off the job students obviously do not have as much time as traditional students to devote to their studies and in order to fit a degree into the required time the focus of Degree Apprenticeships is on work-based learning. Specifics of this for each individual student is agreed in tripartite discussions between the student, the university tutor and their work-place manager. This allows learning tasks and assessments to be based around the work that the degree apprentice is engaged in.

When a specific degree is accredited it will state the modes of assessment that apply, and this is another aspect discussed between university and industrial partner(s). There may be some formal examination and coursework which is quite structured and fixed in nature. But there may also be tasks which are defined by learning objectives that can be met in different ways by individual students depending on the opportunities afforded by their working role. The nature of the exact task for each student would again be decided in the required tripartite meetings.

Degree Apprenticeships are as yet relatively new, having gained approval for delivery in 2015. Many universities are now embarking on their first one, either with curricula currently under development or with a first cohort now underway. Whether the intended outcomes of the scheme will be met is yet to be evaluated, however, initial indications are that they are increasing in popularity amongst universities (with more providers registering), in industry (with many companies now looking for suitable academic partners) and with students.

4.2.1 Involvement of University, Industry and Government

The government is key in this initiative, providing the necessary structure and financial incentives that make the scheme attractive to employers and degree apprentices. In addition to the intended benefits to industry of providing more graduates with better-focused skills the Degree Apprenticeship scheme offers companies direct financial incentive. This is because they would in any case have to pay an "Apprenticeship Levy" but can off-set that cost against the funding for the degree apprenticeships.

Industry have been involved as trailblazers in creating the standards and are also central in the development of every degree proposal against the standard. Companies therefore have a considerable degree of ownership of the curriculum.

However, it is a partnership with the academic provider so universities discuss with the industrial collaborators to create a strong syllabus which will ensure that students obtain a robust theoretical grounding and full range of transferable skills as opposed to just being trained for a particular role.

4.2.2 Involvement of Learners

Degree apprentices are involved as an equal contributor in tripartite meetings. They are encouraged to take responsibility for their own learning and to negotiate learning and assessment activities with their manager and tutor. There has not been time for any evaluation to take place on this so it will be interesting to see how far in practice students feel they are able to shape their learning. Despite the flexibility in negotiating work-based learning activities, students must work within the structure of the degree. The general content and timetable is set for the cohort as a whole. A single degree is likely to bring together apprentices from a number of different areas (either from within a single company or from many different companies). Thus a class could represent a diverse range of knowledge and skills. In theory, that could support student-led learning drawing on shared experiences of the group. However, in practice this would depend entirely on the how the curriculum is conceived and delivered.

4.3 Industry-Driven Development in Slovakia

In Slovakia, the digital skills shortage has been noted as a key problem in all industries for many years. Employers have been expressing dissatisfaction, firstly at the number of qualified applicants and secondly at the skills of graduate applicants who lack hands-on experience with problem solving in IT projects.

Over the years, the Faculty of Management Science and Informatics at the University of Zilina has been repeatedly commended as one of the best ICT faculties in Slovakia and recognized for producing graduates who are immediately employable. Despite this fact, traditional ICT degree courses were found not to be following the ICT trends as the curricula offered were too traditional and therefore failing to meet the changing needs of industry. At the same time, universities are able to produce a limited number of graduates. In the Zilina Faculty of Management Science and Informatics, only around 100 ICT professionals graduate with a Masters level degree every year. Unfortunately, the annual demand of local companies is several times bigger. The university is not able to multiply the number of graduates as well as change curricula significantly (as it would require a new accreditation process), therefore, ICT companies have decided to cope with this problem individually.

One solution widely used by local ICT companies is an internal ICT course tailored to their own needs. This model was already tested by two local companies in Zilina. The ICT course composition and duration were very similar in both companies. Participants of this course were recruited as potential workforce. They were assessed according to essential criteria such as: level of knowledge in programming, potential fit with the company culture, internal drive and motivation to pursue an ICT job. The course was completely free for participants and

they even got two substantial benefits: hardware and salary during the whole program.

There was extensive coursework and constant examination. Those who failed were excluded from the program. The approach centred on work-based learning with minimum lectures and maximum self-study and practical learning during actual software development.

The intended outcomes of this course were met. However, companies faced several challenges: course composition, course material (subcontracted to university), number of applications, quality of applicants, budget, value of the participant to the company compared to time and money invested. Therefore, they decided to search for a new model in cooperation with the university. Individual companies were not willing to invest the amount of time and money needed to train skilled workers. They agreed to cooperate within an ICT cluster and develop meaningful courses in cooperation with the university. They are now working on a new ICT course under the supervision of the Zilina ICT cluster and using co-creation methods for the course development.

4.3.1 Involvement of University, Industry and Government

In this case study, government were not involved as part of the proposed solution. The course was created in close cooperation between university and industrial partners. It was a regional initiative, allowing specific needs of individual companies to be addressed. As a result, the university involved was able to see itself as a meaningful contributor to the creation of the syllabus of the course. On the other hand, strong company involvement in the curriculum development met their specific needs. The on-going collaboration within the ICT cluster ensures that development of new course under the changing requirements can be developed through a process of continuing dialogue between industry and university.

4.3.2 Involvement of Learners

Participants were not involved in the initial development of the course, however, they were encouraged to take responsibility for their own learning. Participants evaluated this type of course as extremely helpful and the best students from the course (mostly all who passed) are working in the companies that trained them. A single course has brought together participants from a number of different areas. Thus, participants represented a diverse range of knowledge and skills. In practice, the curriculum was conceived and delivered by practitioners who were extremely motivated to get the best out of participants.

5 Discussion

The skills gap is acknowledged as major problem worldwide. Projected figures indicate that in many areas the gap is huge. The European Commission calculates the demand for workers with ICT skills to be growing by about 4% annually, which may lead to a shortfall of 900,000 qualified workers vacancies in

2020 [12]. This is a significant problem which creates a substantial challenges for policymakers at all levels [5].

Given the scale of the problem and diversity of needs, it is likely that a variety of different solutions will be needed to tackle the problem in different ways and at many levels. The three case studies reported here give an indication of the diversity of approaches currently being adopted. They also give an indication of some of the aspects which are important considerations for the success or failure of such a scheme. Each of the schemes involves stakeholders in different ways. The UK Degree Apprenticeships are top down in conception (that is, initiated at government level) but are implemented at a local level by collaboration between academia and industry. There is flexibility but only to a certain degree because the basic specifications are fixed. The ICT training approach in Seinajoki is a regional initiative instigated by the university. Again, it sees industry involvement as central and the co-creation principle works well in ensuring industry's needs are met and in engendering shared ownership and responsibility. In Slovakia, industry were the initial movers, taking the training situation into their own hands to meet their skills shortages. However, the investment for companies to do this in time and money proved a major disincentive and the model now adopted is a collaboration between a group of businesses and academia.

Although different in nature, the schemes have all found (although not in all cases the original approach) that co-creation with industry is a key factor. While tailored individual solutions are attractive, the resources required make it infeasible. All three approaches involve the delivery of central, core material while allowing scope for individual student and company directions through large components of workplace learning. Universities are well-placed to develop a curriculum which provides students with a broad range of knowledge and skills needed not just to serve a company in the short time but to become innovators in the field. While industry has sometimes complained about the "abstract" and theoretical nature of university teaching there appears to be a growing awareness that a balance of that is needed in order for their own growth and development.

Another feature to come of the case studies is the need for courses to be flexible and adaptable to meet changing needs in industry and new research from universities. It remains to be seen whether the fixed syllabus of Degree Apprenticeships will allow sufficient flexibility for this to work successfully.

Although the three studies all involve students to some degree it is clear that they are not being involved in the inception and development of the initiatives as much as they might be. We suggest that this is an area that should be considered for the future. With shortages of recruits for many STEM degrees, the student voice on contents and modes of study would be a valuable input. There is some degree of student perspective incorporated currently at an individual module level (with work-based learning and technology-supported distance learning). However, the design of such schemes often does not involve student voice to any significant degree. This may lead to problems further on. For example, there are anecdotal indications that the workload on Degree Apprentices is in some cases stressful and unsustainable.

One of the main motivations for each of these schemes is to bridge the skills gap. Indications are that they are proving attractive but that these are just initial steps [19]. However, there are also other possible benefits that can be gained by a move from more traditional methods of course provision. Schemes which are more accessible (such as the Seinajoki ICT training) are likely to attract students from a more diverse background. Similarly, a Degree Apprenticeship model (with it's emphasis on practice and employment and with funding to the students) is likely to increase access to Higher Education for students from low-participation groups. Initial studies are starting to indicate that this is indeed happening [19].

6 Conclusion

Although it is early days, the schemes presented in our case studies are all informally reporting success in terms of attractiveness to industry, recruitment of students and placement of graduates in industry. However, there are still many challenges to be faced. These include limited places due to funding, a lack of flexibility in curricula, lack of student voice, student workload and successful management of workplace learning to meet learning objectives, both as a challenge in the workplace and in universities. This together with the fact that demand continues to increase means that more work and more initiatives with high capacity are needed. As the current schemes begin to mature, further research is needed to evaluate their strengths and weaknesses in order to inform future work. It is likely that a range of different schemes will be needed to cover different situations and needs, but co-creation as a basic principle may well be beneficial in all cases.

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