JOURNAL OF e-LEARNING AND KNOWLEDGE SOCIETY

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VOLUME 17 | ISSUE NO. 1 | JULY 2021

REGULAR ISSUE

PEER REVIEWED
RESEARCH PAPERS

**AN INTERNATIONAL AND OPEN ACCESS JOURNAL
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ISSN (online) 1971 - 8829 | ISSN (paper) 1826 - 6223

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The Journal is issued online three times per year.

ANVUR Ranking: A-Class for Sector 10, 11-D1 and 11-D2

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Registration at the Rome Court in the pipeline

ISSN (online) 1971 - 8829
ISSN (paper) 1826 - 6223

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AND KNOWLEDGE SOCIETY

www.je-lks.org

ISSN (online) 1971 - 8829
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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 1-9

The extent of South African schools' preparedness to counteract 4IR challenges: learners' perspectives

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(submitted: 20/5/2020; accepted: 14/3/2021; published: 18/5/2021)

Abstract

The aim of this paper was to explore learners' perspectives on how their schools are preparing them to prosper in the Fourth Industrial Revolution (4IR) era which is powered by Artificial Intelligence (AI). Taking cognisance of the learners' perspectives on how South African schools are preparing them is essential for enabling the education fraternity to ascertain its level of effectiveness and efficiency hence improving its state of readiness to face the challenges of the 4IR. Therefore, the exploration of the level of preparedness, in line with 4IR challenges, can assist educational policy makers and planners to be more proactive and craft mechanisms to ameliorate the obstacles and discrepancies inhibiting the acquisition of the 21st century educational competences and skills. Employing a qualitative paradigm, semi-structured focus group interviews were used to solicit data from a sample of 30 grade 10 and 11 learners. Findings reveal that computer technology was irregularly and insignificantly used indicating that South African schools are highly ineffective in dispensing grade-appropriate skills thus producing ill-prepared learners to prosper in the 4IRworld of work.

KEYWORDS: Artificial Intelligence, Fourth Industrial Revolution, level of preparedness, Technology Acceptance Model

DOI
https://doi.org/10.20368/1971-8829/1135265

CITE AS
Sikhakhane, M., Govender, S., & Maphalala, M.C. (2021). The extent of South African schools' preparedness to counteract 4IR challenges: learners' perspectives. *Journal of e-Learning and Knowledge Society*, *17*(1), 1-9.
https://doi.org/10.20368/1971-8829/1135265

1. Introduction

Preparedness for the future is crucial in all education systems if the young generation is to prosper in this era characterised by fusion of disruptive technologies. Schools in South Africa need to equip learners with critical computational thinking skills for them to function effectively in the 21st century. If all South African schools are to take advantage of the advent of the Fourth Industrial Revolution (4IR) they need to be contingent on their abilities to transform the education system to equip the millennial generation with new skillsets such as deep learning and promoting other 'soft' skills (techUK, 2018) in their schools simultaneously ensuring that teachers, across the curricula, are up-skilled in regard to digital-wiseness; encouraged and supported to engage in lifelong learning.

Despite extensive research on 4IR challenges and work requirements (Human Sciences Research Council, 2018) current literature insignificantly highlights the unpreparedness of the South African education system in facing the said challenges hence a glaring manifestation of a gap necessitated this evaluative study. Congruently, in a dialogue conference (10 - 12 December 2018) on Disruptive Technologies and Public Policy in the age of the 4IR, Gastrow (2018) asserted that the 4IR national policy framework's purpose was to harness the power of the 4IR towards the achievement of South Africa's developmental aspirations, which in a way focuses on how to prosper with such a global phenomenon (4IR) that is powered by ever-changing digital technology without putting to the fore the findings pertaining to the extent of preparedness of South African education system to counteract such

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challenges. Furthermore, having explained what 4IR was, a range of challenges and requirements such as pedagogical adaptation, and increased funding for and investment in resources and infrastructure for technological advancement were identified in adapting to the 4IR (Kayembe & Nel, 2019), 'ignoring' baseline assessment(s) of the situation on the ground that could inform more meaningful direction to materialise. Such conspicuous discrepancies strongly motivated this study to ascertain levels of efficiency and effectiveness of teaching and learning processes in light of the 4IR requirements within the South African context.

Subsequently, the purpose of this study has been, therefore, to explore learners' perspectives on how schools are preparing them for the 4IR, the findings of which can contribute to a better understanding of the shortcomings of the educational dispensations thus allowing stakeholders (policymakers, educational planners and teachers) to take necessary measures towards improving the quality and use of digital technologies within the South African schooling systems. Particularly views of learners with regard to computer literacy levels, availability of computer resources in their schools, and stakeholder support was examined taking cognisance of the advent of the 4IR world of work and challenges. The aim was to ascertain levels of preparedness of our secondary schools in creating conducive learning conditions for the millennial generation to prosper in the 4IR.

2. Background

The impetus for digital technological change in education is so powerful that new perspectives on teacher training (Department of Basic Education, 2019; Mihaescu & Andron, 2019), more especially in relation to the pedagogical curriculum, has to be adopted in quest for a new and responsive skills sets, which are considered vital to adapt to the world of constant change. When emphasizing inclusion of coding alone in the South African education system, Retief (2019) asserted that it would not sufficiently and constructively prepare South African learners to face the 4IR challenges. Regarding effective learner-preparation Retief (2019) further revealed that South African schools were, indisputably, producing school-leavers ill-equipped to operate effectively and efficiently in a digital world.

Nevertheless, making reference to the realities of the 4IR, Butler-Adam (2018) stressed that virtually all workplaces required adaptable people whose jobs are reimagined and aligned alongside digital technological developments. Therefore, subsequent to the above postulation, in concurrence with Alvin Toffler (1970) as cited in the South African News Centre (N.D) that the illiterate people of the 4IR era would be those individuals who cannot learn, unlearn and relearn. With regard to the foregoing assertion the attitude of life-long learning needs to be inculcated in our schooling systems as knowledge is constantly changing exponentially. Therefore, our schools should prepare learners for the changing technologies in the digital world and understand how (De Angelis et al., 2019) they can acquire new and relevant skills, which they should employ in solving challenging problems creatively and collaboratively in accordance with 4IR requirements.

Given the aforementioned enlightenment, Mihaescu and Andron (2019) further stressed that teachers are forced by the rising volume of information and by the changes to adapt and question paradigm shifts such as deeper digital educational knowledge and learner collaboration as well as learner feedback for better joined learning pathways and sharing of knowledge. In addition:"The fourth industrial revolution represents entirely new ways in which technology becomes embedded within societies and even our human bodies. Featuring technologies such as artificial intelligence (AI)…the 4IR is poised to change the face of the world economy in the 21st Century" (techUK, 2018, p. 2).

Similarly, the Adendorff et al. (2018) asserted that the 4IR represents fundamental disruptions in the way we live, work and relate to each other resulting in change, inevitably, occurring in either desirable or undesirable ways. Nevertheless, in this regard, techUK(2018) postulated that only the nature of those jobs changes, which somehow purports that jobs are not going to be completely new but modified, hence education is instrumental in preparing tomorrow's workforce accordingly. Similarly, McNully (2018) posited that the growth of digital technologies and the extent to which we rely on them in the workplaces dictates that learners need to acquire meaningful technological skills. Accordingly, to accomplish this benchmark in South Africa we need to see a fundamental shift in education moving towards sharing a common goal and working together with all the relevant stakeholders in driving technological innovations in schools.

Taking cognisance of the aforementioned paradigm shifts in the job market, in its submission to the Education Select Committee of June 2018, techUK posited that up-skilling of current employees is fundamental since about 63% of jobs in the United Kingdom then required above-basic level digital skills hence the need for home-based strategies. Given the fact that such assumptions could be translated into reality, where will our South African secondary school graduates stand, given the current 'rudimentary' and 'archaic' systems through which they are being taught, especially in previously disadvantaged rural schools. These schools are characterised by having scarce or sometimes even no computer technologies in place; no broadband facilities available in most public schools; hence current research reveals that learners cannot even carry out the simplest computer operation, as revealed by Retief's (2019) study in the face of the 4IR. Given the fact that as a developing country which is still dependant on labour intensive extractive industries (McNully, 2018), South Africa is at risk of not amply taking advantage of the rapid advancement of the new digital technologies hence producing graduates whose skills are not grade-appropriate to face challenges of the 4IR. Regarding the foregoing enlightenment it is conspicuous that teachers today are faced with a plethora of challenges, however they have enormous benefits of enhanced interconnections powered by internet.

As knowledge and skillsets are changing exponentially there is dire need for critical foresight to ameliorate the challenges that inevitably come with the 4IR. Emphasizing the importance of lifelong learning by the current workforce in light of the looming changes coming with the 4IR, techUK (2018) expressed that the knowledge and skills of the future would be dependent on meaningful on-going training and up-skilling which is almost similar to Sarayreh, Khudair and Barakat's (2013) assertion, as cited by Amino, Bosire and Role (2014), that for meaningful continuity and growth, schooling organisations should remain self-organising-criticality and adaptively relevant to the scheme of things in their operational environment.

Therefore, in order to prosper in the 4IR there is need to engage current workers, in the teaching fraternity, in meaningful on-the-job up-skilling programmes because what could be relevant knowledge and skills today could be regarded obsolete in a decade or two (Siemens, 2004; 2005) as knowledge transforms exponentially. Particularly, in the context of national e-education policies, the South African White Paper 7 (Department of Education, 2004), global education super-highway is constantly revolutionising that is being driven by the changing nature of work and new global partnerships alongside the realities of the information age. Subsequently, in this policy the Department of Basic Education (DBE) proved to articulate well the way forward in terms of implementation of e-education and e-learning policies. However, its intentions did not come to fruition as e-education directorates 'failed' to induct implementers (teachers) due to lack of 'appropriate' knowledge themselves about the policy intents as they perceived themselves as mere 'conduits' to these policies (Vandeyar, 2015). Nonetheless, the then Minister of the Department of Basic Education, Doctor Naledi Pandor, was quoted, in the White Paper 7 of 2004 confidently positing that the e-education policy's goal was that all South African learners were supposed to be ICT capable by the year 2013 (Department of Education, 2004). Contrastingly, learners lacked the necessary computer competence to meaningfully use computer tools for authentic instruction and ultimate learner academic performance by the year 2015, which is a painful revelation (Mathevula, 2015) after two years of the set target.

It is therefore clear that there is need for more to be done to ensure schools, partners in education and employers meaningfully collaborate on preparing the future workforce for the 4IR requirements. For example, SchoolNet South Africa is a dedicated partner in South African education system whose core business is to provide teacher professional development in line with effective digital learning thus improving the existing pedagogies so as to promote higher order thinking skills and encourage spirit of enquiry among learners (Department of Basic Education, 2019), although its coverage is still negligible, especially in previously disadvantaged schools.

A coordinated effort is essential because it can yield positive outcomes only with transformational leadership envisaged, unconditionally, for pursuance of a practical curriculum in which digital technology is enforced across the curriculum. In concurrence techUK (2018) emphasised the importance of empowering local schools, learning-providers and other partners in education to ensure that students are workplace-ready. This approach can be adopted and modified to suit domestic challenges in light of 4IR requirements. Hence it is crucial to come up with domestic paradigm shifts in terms of e-Education and e-Learning policy formulations. For example, all eThekwini municipal libraries have internet facilities accessible by all community dwellers such as adults and school-going children, for 'free', as a crucial inroad towards catching up with the 4IR digital requirements and challenges.

As a government it is incumbent upon us that rote/recall learning and examinations are avoided for a transformational education system that promotes and rewards application and adaptability of knowledge and skills in light of 4IR challenges. Collectively, the aforementioned studies indicate that there is a need for the South African Department of Basic Education to take seriously research and task independent education commissions that should investigate the current education dispensation strategies from Early Childhood Development (ECD) to lifelong learning so as to ensure learners gain grade-appropriate knowledge and skills that allows the young generation to prosper in the 21st century.

3. Theoretical Framework

This study is grounded in the Technology Acceptance Model founded by Davis (1989), which puts to the fore that the attitude of learners is seen to be playing a pivotal role in determining the level of usage of digital technology (Gokcearslan, 2017) hence the adoption of the following model whose cascading relationship is illustrated as follows:

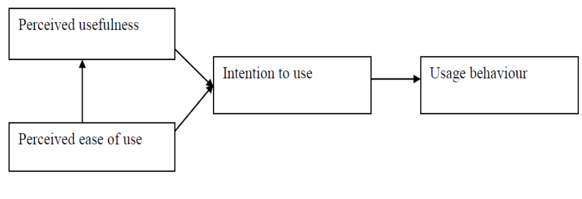

Figure 1 - Adopted: Technology Acceptance Model (Davis, 1989).

Perceived ease of use affects perceived usefulness, which cascadingly affects the intention to use technology and the learners' ultimate usage behaviour (Gokcearslan, 2017). The rationale for adopting this framework was based on the fact that for learners to effectively use technologies, which blur the lines between physical, digital and biological spheres (McNulty, 2018), they need to be exposed to schooling system that is technologically savvy that effectively integrates the usage of new and emerging technologies. In light of 4IR requirements, powered by AI learners need to perceive and comfortably use computer technologies that are constantly changing with passage of time.

4. Methodology

The qualitative paradigm was employed in this study as it promoted detailed and a deeper understanding of participants' perceptions, feelings and experiences pertaining to the phenomenon under study (Kumar, 2014; Denzin & Lincolin, 2018). This paradigm was specifically selected because of its advantages grounded in the assumption of social interpretations by individuals (Bertram & Christiansen, 2016; Bricki & Green, 2018), which presumably allowed the researchers to yield usable detailed information about learners' perceptions and experiences on how they were getting prepared, in their school, to face the realities of the 4IR.

Making use of semi-structured focus group interviews, a case study design was used to promote deeper exploration of learners' perspectives about how conducive their schools were in dispensing grade appropriate knowledge and skills; hence semi-structured focus group interviews for learners, involved an interpretative and naturalistic approach to its subject matter (Denzin & Lincoln, 2018), were employed. The researchers strongly believed that through the adoption of case study participants' perspectives towards phenomenon under study could be optimally captured.

4.1 Participants, sampling and setting

The targeted population were secondary school learners from Durban North West circuit of Pinetown district in KwaZulu Natal, South Africa. More specifically learners from KwaMashu Central and Mafukhuzela Ghandi Clusters constituted the specific population. Deliberately, (Bertram & Christiansen 2016; Edmonds & Kennedy, 2017) using purposive sampling procedures three schools were selected by virtue of having and assumedly using computer technologies for teaching and learning. Two schools were from KwaMashu central and one from Mafukhuzela Gandhi; these schools constituted communities of different socio-economic backgrounds, which allowed the researchers to draw comparisons in terms of learners' perspectives and their learning experiences. The involvement of learners from diverse backgrounds was intended to increase the generalisability of the study. In order to elicit pertinent information about the phenomenon under study the researchers purposively sampled 30 learners from the 3 schools having computers, i.e., 10 learners (five from grade 10 & five from grade 11) from each school; hence the sample constituted 3 schools and 30 learners.

4.2 Description of Data Collection Procedures and Analysis

Semi-structured focus group interviews were employed, which constituted the instrument for data collection in this study to explore learners' perspectives on how prepared their schools are in dispensing education that allows them to prosper in the 4IR. The underlying assumption was that these interviews would allow learners to provide more and in-depth explorative information about their views concerning use of computer technologies to enhance learning across the curricula.

Due processes and procedures were followed to attain ethical clearance from the institution. Permission to conduct research was sought and obtained from the Department of Basic Education.

Procedurally, the sampled schools were visited prior to data collection to seek for permission and explain the purpose of the study. Consent forms were issued to participants and concerned parents, to accord their children's consent to participate in the study, for completion and signing prior to the actual interview process. Interviews were then carried out on agreed dates with the sampled participants. Each interview session was voice-recorded, taking a duration ranging from 40 to 60 minutes, and then transcribed verbatim to allow its systematic analysis of data thereafter. The researcher provided prompts whenever it was necessary so as to assist the participants to generate accurate responses. Participants validation of their verbatim statements was carried out once the final transcriptions for analysis was available.

Thematic analysis technique was used taking cognisance of the theoretical framework under in which the study is grounded and research question to extract salient themes from both transcribed data. The researcher employed a constantly comparative method of data analysis, that is, subjected sought data analysis to comparison of relationships between concepts and categories noted from rural and urban wards. As advised by De Vos et al. (2011) differences and similarities were clustered until no new categories emerged, eliminating duplication as much as possible. Surfaced themes were presented in continuous form for final reporting. Moreover, the inductive thematic approach, which allows the data to determine the themes, was employed. This technique was chosen because it promotes coding of the collected data without trying to fit it into a pre-existing coding frame or the researchers' analytic preconceptions thus striving to meet the trustworthiness criteria of the research findings. Furthermore, data analysis was conducted in a precise, consistent, rigorous and exhaustive manner so as to promote credibility of the research outcome.

5. Findings and discussions

The findings of this study are presented and discussed in accordance with the learners' perspectives on how they learnt and benefited from their secondary schooling systems; particularly views of learners with regard to computer technology literacy levels, availability of computers resources in their schools and multi-stakeholder support was examined specifically considering the skillsets demanded to prosper in the 4IR challenges.

The analytic process of the semi-structured focus group interviews takes the following pattern: each learner is coded according to the school, followed by the grade and lastly a letter of the alphabet such as Learner B10B or A11C; hence the school is identified by the first letter and the participant learner by the immediately following letter, i.e., learner B10B means the school is B, and the learner in school B is B and doing grade 10. The tendency of learner pseudonymity was consistently followed to uphold ethical requirements thus ensuring anonymity and confidentiality of the participants.

The themes extracted with regard to level of preparedness of South African secondary schools to face the challenges of 4IR are as follows: *1. Access and frequency of computer technology usage by learners;2. Learner challenges, stakeholder support provided, and recommendations,* which are succinctly integrated in the findings and discussions.

The majority of the participants acknowledged that their schools had computer resources, which when used effectively and equitably across the curricula can enhance meaningful learning, especially in subjects regarded 'most difficult'. Technology use promotes authentic learning (Lombardi, 2007; Edutopia, 2014) as most teachers and learners consider learning-by-doing the most effective way to learn which results in construction of learners' own permanent knowledge. Generally, learners viewed computer technology usage as essentially relevant (Llomack, 2008) and promotes experiential learning (OECD, 2015), resonating Llomack's postulation, as it facilitates hands-on and collaboration in accordance with 4IR job market requirements which constantly change alongside technological changes across the world.

However, more specifically, frequency of computer usage in the sampled schools was solely dependent on level of accessibility to computers in the schools and the local municipal libraries, and/or, the number of assignments given especially in 'hard' subjects where learners perceive that computers can ameliorate in making their research easier. In corroboration: *"I use it approximately five times per month to Google things that I find very hard to do like finding formulas for physical sciences that we sometimes do not get from teachers. I use this tool because I think it makes my research easier." [Learner C10C].*

In congruent with the conceptual framework of this study learners perceived that computer tools can be used easily hence making their research easier to carry out. However, the findings surprisingly reveal that learners infrequently and irregularly access computers due to scarcity of computer resources; scarcity of which is exacerbated by rampant theft wreaking havoc in the delineated area of study. In this regard: *"We are not able to do everything we want to do because of the computer shortages; the lab was vandalised last year, so they stole laptops; I don't know; so many computers. From school, am not even sure we've permission to go to the computer lab; it's only CAT (Communication & Application Technology) learners who've the permission; in the municipal library you've to wait for a couple of hours before you even get the computer. When you book for the computer the time is limited, like 30 minutes; so you can't really do what you want to do because in 30 minutes there's nothing you can do." [Learner C11C].*

The above enlightenment unequivocally indicates phenomenal challenges entailing that our secondary schools are ill-prepared to dispense grade-appropriate education which could allow our millennial generation to prosper in the 4IR. This is similar to Retief's (2019) findings that our schools are "producing school-leavers who are ill-equipped to operate effectively in a digital world" (4IR), although learners have the intention to use technology but due to the limited accessibility and availability their intention is hindered.

Nevertheless, concurring with Zupanec et al. (2013) learner B10C posited that use of computer tools promotes computer assisted learning (CAL) which combines simulations and visualisations that helps abstract concepts to be perceived in a more realistic perspective hence promoting better understanding of the subject content. Learner B10C stressed: *"Well, it is important because it allows things that are in 'motion', like learning about the heart in Life Sciences…it is easier to see how it pumps; you can see it pumping; so I can say it has improved my knowledge. However, the major issue is lack access sir." [Learner B10C].*

In concurrence with the foregoing statements and making reference to technologically enhanced learning about the heart in Life Sciences subject learner C10C corroborated: *"The computer is a good tool to make you see those things; you may see the heart, the muscles. 'Ok these are the muscles. Are standing like this.' You see it's a very important tool…; it's much easier to use the internet, and when you are looking at the teacher, sometimes you just say 'OK, what's she talking about?'; there're some Apps that you can download to learn like Mindset and stuff; they teach you more; they teach you most of it." [Learner C10C]*

Learner C10A concurred that: *"Sometimes when the teacher is explaining things they use words that are not even written down on the book…bombastic* *words…complicated words you can't even understand…hard to pronounce. Even in Life Sciences you can even bite your tongue."* Thus, from what learners expressed it becomes evident that computer usage enhances learner academic performance as computers are presumed to stir some form of motivation inspiring them to learn more, consequently increasing their intention to use technology as was alluded to by Gokcearslan (2017) within the selected theoretical framework.

Nonetheless, learners expressed regret over the shortage of computer resources, which is a major challenge in their schools hence limited access cascading into superficial use of computer tools for learning. Furthermore, in this regard learner B11B expressed: *"I've used a computer in the Internet café. In my school I've never touched a computer but I was doing CAT so we didn't have computers; they were stolen so I'd once touched the computer."* Learners further lamented that they come from poor families meaning that learners who only enjoy access to computers in their schools are those doing CAT (Communication & Application Technology) subject and the few whose parents afford to buy them; and/or, live near municipal libraries where they queue to use the few available computers. In light of the aforementioned phenomena (lack of access and computer theft) learner A10E posited: *"Per month I can say maybe I use a computer twice just to find information. Twice or thrice because when the teacher is teaching I don't understand him/her quietly; I just go and use internet. I've email address but I hardly use it yeah." [Learner A10E]*

In this regard learner C11D substantiated: *"When given an assignment of Agriculture to research we don't have computers so I decided to go on a library to research the assignment. In order for me to go there I've to take a taxi. There're people who are doing CAT but me am not doing CAT so computers in the school are only for CAT."* Basically the major challenges highlighted by the generality of the sampled participants are that of lack of computer resources, accessibility to the scarce school computers, long awaiting queues in the municipal libraries and lack of bus fares due to financial constraints. Such scenarios further entrench the digital gap amongst learners and teachers hence application of 4IR Learning Management Systems (LMS) e-learning facilities such as Moodle and ATutor becomes virtually impossible. Nevertheless, in an ideal digitalised environment, learners "have options to choose how and where they want to acquire their…education" (Reid, 2019, p. 14) hence LMS could be regarded as ideal "game changer of traditional teaching and learning" towards more learner-centred strategies.

Participant learners also highlighted lack of stakeholder support, except for a minority of well-to-do parents', as one of the major challenges. *"I get support from my parents who're bought me the laptop and some data every month. I also learn from my peers who teach me from here and there some things that I don't know. I think we don't get enough support from the School Governing Board (SBG) because some computers at the CAT lab are not working; we've to share; so that is a problem. When a teacher gives a practical, you've to share a computer with someone or have to wait for the person to finish then that's when you've to use the computer." [Learner B10A*]. In concurrence learner C11C also highlighted: *"Support from the DBE! Uuh, I've never heard of any support or the principal announcing that 'here are some computers for everyone to use from the DBE'; so I think we've no support from most of the stakeholders whatsoever."* Similar to the observation of (Retief, 2019) lack of support prevalent in our schools translates into production of graduates ill-equipped to operate effectively in this digital world.

The aforementioned enlightenments point to the fact that learners basically do not have any tangible support from the DBE, in the schools studied, which is in sharp contrast with the White Paper 7 of 2004's vision that by the year 2013 all learners in both general education and training (GET) and further education and training (FET) band should be computer literate (Department of Education, 2004). Nonetheless, John Seely Brown (n.d.) cited by Boholano (2017, p. 21) expressed that "today's digital kids think of ICT as something akin to oxygen…they breathe and it's how they live", of which their lives come into demise in the absence of technology that pervades the current teaching and learning processes.

To worsen the situation learners revealed that even their teachers, who should support them in terms of guidance, virtually know 'nothing' about benefits of the computer usage for teaching and learning, which is an evidence of lack of teacher support in terms of in-service or on-the-job-training about computer integration. Because teachers are not meaningfully supported learner C10C, in concurrence with other participants' statements, indicated that they received no meaningful support from their teachers due to the teachers' own incompetence and lack of digital knowledge. The learner succinctly posited: *"They always (teachers) tell us to download previous exam papers. You know, they're always telling us what to do, you know; but they're just telling us, doing nothing showing that they're confused themselves" [Learner C10C].* Therefore, this phenomenon indicates that our schools, besides being ill-equipped with 21st century digital technological tools, they are manned by digitally incompliant human capital hence not prepared to dispense quality education that is in tandem with challenges and requirements of the 4IR. This is in contrast to Boholano's (2017, p. 21) observation that "educational systems must be outfitted with a prerequisite of ICT resources, both hardware and software, and curriculum must be designed to promote a collaborative learner-centred environment to which students will relate and respond."

In light of the foregoing highlighted challenges participant learners suggested that meaningful support be accorded to them in line with e-Education policy intents. Subsequently: *"The DBE should walk its talk. Not only supply computers for CAT students yet the department expects all of us to perform well in these challenging times of the 4IR; plus before supplying computers they should put security measures in place otherwise all computers they supply will be stolen before we've even used them to be computer literate; so I suggest that in future security levels be improved because our labs are being vandalised everyday by community people." [Learner B11A].*

One of the participating learner seemed to indicate that the problem of theft lay with them (learners) as they divulge inside information that the school had received so many computers hence concurrently posited: *"Well we know that they (learners) do it anyway, so I suggest that in future the security levels should be increased at school so that they'll not just come in and steal the computers." [Learner C11C].*

The above narratives indicate that schools do not have, and/or scarce, computers due to rampant theft hence the suggestion for tight security requirements. Therefore, given this overwhelming computer shortages coupled with serious computer illiterate levels on the part of both the learners and their teachers, the study not surprisingly revealed that computers were insignificantly and irregularly used; hence further to that conclude the level of ill-preparedness of South African schools to dispense grade-appropriate education that can allow the 21st generation to prosper in the 4IR era. However, the findings cannot be generalized to reflect the level of preparedness nationally but could be taken as the true and transferable picture of how schools in the area studied are unprepared to face challenges of the 4IR.

6. Conclusion

The study revealed that learners had very little access to digital technologies in their schools due to scarcity of computers caused by rampant theft thus resulting in them being disengaged and unresponsive hence 'poor' performance. In this regard, because these schools lacked computer resources that could be used across the curricula in line with the challenges and requirements of the 4IR, the study concludes that the sampled schools are not adequately prepared to dispense education that is practically oriented and responsive for current the learners to prosper in the 4IR.

The study also found out that, due to different learner-family economic backgrounds, some learners are more privileged than others in terms of ownership of computer resources, accessibility, and affordability hence disparities in computer literacy, which inevitably increases the digital divide among them. This kind of a scenario makes it very difficult for the teachers, in case of the area studied, to give online assignments that have to be done beyond the school boundaries. Therefore, despite the fact that teachers have to cope with the new requirements and adopt a new role of their teaching behaviour (Abdelrazeq et al. 2016), they are forced to stick to traditional teacher-centred instructional strategies asynchronous to 4IR challenges and world of work.

Conclusively, the state of readiness of the schools leaves much to be desired. In light of the aforementioned findings the study recommends that Department of Basic Education embarks on comprehensive computerisation and digitalisation of all schools so as to try and fulfil the goal(s) of the White Paper 7 of 2004 on e-Education national policy; promoting equity and equality across provinces thus allowing teaching and learning process to benefit from use of LMS facilities that allow both learners and teachers to interact and collaborate defying distance and time constraints.

The study only employed qualitative paradigm purposively selecting three schools from which 30 learners constituted the complement of the research sample. In this regard the study findings cannot be generalised to portray wholesale picture of the population across the country. Despite the foregoing enlightenment the study managed to collect sufficient data through in-depth semi-structured focus group interviews with learners and systemically analysed it thus making the findings valid, dependable and transferable.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 10-17

The use of online learning environments in higher education as a response to the confinement caused by COVID-19

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(submitted: 24/7/2020; accepted:19/3/2021; published: 31/5/2021)

Abstract

In Colombia, a developing country, higher education has a gross coverage rate of about 40% (supply concerning the entire population). However, although this value is low, ten years ago this rate barely exceeded 20%. The increase in coverage is largely due to a policy that has promoted training by cycles. This model allows education by levels with the granting of professional degrees at each stage, which allows for rapid employment. Even so, places are limited, particularly for medium and low economic levels (which concentrate the majority of the population), and access to them in public universities (those with state-funded enrolment) is very restricted. Access to education is a major concern for institutions and the state, in particular for vulnerable social groups, and has been further depressed by the security and control measures implemented to slow down the spread of the COVID-19 virus. In a short time, and with limited resources, institutions have had to adapt their models to guarantee continuity and quality in academic processes. In this context, digital platforms have come to play a fundamental role by allowing access while reducing social interaction. However, the use of these platforms implies the development of specific learning environments adapted to academic, economic, and social conditions. This paper explores the design, development, and impact of some of these learning environments in the process of technological training of students from low economic strata in the most important public university in the Colombian capital. The initial results of this study show that the distance learning model adopted as a response to social isolation does affect students' academic performance. Besides, the results also show that there are effects on the students' interaction schemes and their motivational levels towards their training process.

KEYWORDS: Cycle-oriented Training, COVID-19, Learning Environments, Online Learning.

DOI
https://doi.org/10.20368/1971-8829/1135309

CITE AS
Martínez, F., Jacinto, E., & Montiel, H. (2021). The use of online learning environments in higher education as a response to the confinement caused by COVID-19. *Journal of e-Learning and Knowledge Society*, *17*(1), 10-17.
https://doi.org/10.20368/1971-8829/1135309

1. Introduction

One of the key factors for the development of a country is the level of education of its individuals. In Colombian society, it is widely accepted that the economic development of the new generations, and their family groups, is strongly linked to the level of education. In particular, higher education is considered to be a path of development since it makes it possible for people to work at a professional level. However, access to higher education institutions is limited, partly because of the majority of the population from lower economic strata, unable to finance studies in private institutions, and partly because of the low coverage offered by state-funded institutions.

Among the national policies aimed at increasing coverage in higher education, there are programs aimed at funding private institutions for young people with high academic performance, as well as the implementation of minimum quality standards for educational institutions, both public and private. One of the policies that have had the greatest impact in the last 10 years in increasing the coverage rate has been the ones oriented to support propaedeutic formation by cycles (Perez, Mena, Hoyos, & Perez, 2010). It is a cycle-oriented training in which a traditional undergraduate program is structured along with two or

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three training cycles, each one a prerequisite for the next one, with its own rules for admission and graduation, as well as a professional degree at the end of each cycle. Based on this strategy, academic programs were designed mainly in technical areas such as engineering, in which the traditional five-year programs were divided into two or three cycles, granting professional qualifications at the end of each cycle. These cycles were designed in such a way that the training in technical and technological tools was prioritized in the first levels, allowing a fast labor linkage of the young people, and impacting more quickly the economic development of their families (Arias, Ruiz, & Henao, 2012).

Among the first programs with this structure are the engineering programs offered by the Technological Faculty of the Universidad Distrital Francisco José de Caldas, the most important public university in the Colombian capital (Jirón, 2014). This characteristic is important because many of the city's low-income students attend this institution, and because the model it uses has an impact on other institutions in the city and the country. The campus of this faculty was built 25 years ago in Ciudad Bolivar, one of the poorest areas of the city. Among its policies, it decided to focus its training programs on areas identified as priorities for the city, which create real needs in the labor market. Also, it designed its admission scheme that considers not only academic results but also prioritizes the young people of the area. This is a social development project that has been consolidated over the years due to the high quality of its graduates, its social commitment to highly vulnerable populations, and its training paradigm. However, in recent months the restrictions imposed by the national government aimed at slowing the spread of the COVID-19 virus have created new conditions of inequality that add to the social ones.

Institutional policies prioritize the need for equitable access to quality education for the city's poorest young people. To guarantee this principle, the Universidad Distrital complemented its programs of food support and psychological follow-up with others of access and communication, made visible in the distribution of digital tablets with wireless connectivity for its most needy students. These programs sought to reduce the impact of not having access to the resources of the university campus, and the inability of young people to acquire computer resources. However, access to education has several additional aspects that involve the adaptation of content and processes to this new training strategy, and the development of new distance learning skills by students (Halimi, Salzmann, Jamkojian, & Gillet, 2018; Huang, 2020; Jotikabukkana & Sornlertlamvanich, 2019).

These new structures achieve their objective of distance ordered by restrictions. However, on the other hand, they also bring many new positive elements to the training process, with verifiable results in the short, medium, and long term (Ospina & Galvis, 2017). Properly oriented online training promotes discovery learning, with less distraction, and greater motivation and interaction among students, and between students and teachers (Y. Wang, 2019). With great savings in travel time, and less distraction for students due to grouping restrictions, there is greater dedication, and dialogue and interaction is promoted throughout the training and evaluation process (J.-H. Kim, Park, Cho, & Kim, 2012).

It is, therefore, necessary to develop the strategies for students to generate their learning outcomes in coherence with the new social conditions, which according to institutional and national projections will extend throughout the year (Raga & Raga, 2018). It is expected that some of these strategies will be maintained even after health emergencies have been overcome. These strategies must be formulated and structured based on the objectives of the training process, and the integration of technologies and tools not traditionally used in classroom training schemes (Choi & Cho, 2018; Zhao, 2020). Online education becomes a fundamental tool for these strategies since it allows access to resources and teaching activities in coherence with current interaction restrictions (Bright, 2012). This also occurs at a time when technological evolution places in the hands of individuals low-cost ubiquitous computing that enables access to specialized digital platforms (social and digital inclusion) (Cho & Kim, 2016; Sánchez & De Los Ríos, 2015; Wood, 2006).

The new national policies in education promote the development of learning outcomes that can be evidenced in the professional development of graduates. It is a labor approach that favors social and economic development. In this sense, skills strengthened by distance training such as communication and collaborative work should be reinforced in these digital platforms (Arooj, Farooq, Umer, Rasool, & Wang, 2020; Y. Kim, Cho, & Chong, 2014). The electronics, control, and instrumentation area of the Technology in Electricity program of the Universidad Distrital structured a set of digital platforms as specific training tools to support some of the program's courses. These platforms were conformed with an active learning model with the support of PBL (Project Based Learning) (Jacinto, Martínez, & Martínez, 2016; D. Kim & Kim, 2014; Martínez, Montiel, & Jacinto, 2016; Zhu et al., 2020). Each of these tools allows students to actively analyze basic concepts, work on projects structured in groups, and design their solutions based on the proposals of the teachers (Kang, Oh, & Woo, 2009; Liu, Huang, & Wosinski, 2016).

This study w as conducted on three courses of the technology cycle at different stages of the training process. The objective of this study is to evaluate the impact of the distance learning scheme strengthened with technological tools in aspects such as educational performance, critical discussion, project development, and collaborative work (Laberge & Lin, 2015; Matsumoto & Kashima, 2012; C. Wang et al., 2017). Additional elements of the study consider the capacity of democratization of knowledge of our institution under the new conditions of isolation and the robust against possible reductions in equity and quality (Awofeso & Bamidele, 2016; Hayes & Johnson, 2019; Kargutkar & Chitre, 2020).

2. Materials and Methods

The following null hypotheses were tested in the study:

- H_1: There is no significant effect of the distance learning scheme on students' academic skills.
- H_2: There is no significant effect of the distance learning scheme on student interaction.
- H_3: There is no significant effect of the distance learning scheme on student motivation.

This study retrieves information recorded in the years 2018 and 2019 during a process of monitoring the performance of students in the electronics area of the Technology in Electricity program. This follow-up is carried out as part of the improvement plans promoted by the Colombian government. These data allow us to form control information, and therefore structure quasi-experimental research. The data matrix was completed with an additional level, corresponding to tests applied during 2020 to students at equivalent academic levels but with a distance training model supported by digital platforms. The data contains information related to motivation levels, performance, and results of collaborative work.

The sample in the control group consists of a total of 40 students in two groups. The sample in the test group consists of 37 students in three groups. The students are mostly male (86.5%), but this study does not consider gender incidences on the parameters. Table 1 shows the characteristics of the students in the study concerning the parameters that define the population.

Academic population	Ages	Academic Program	Duration of the Academic Program	Course	Training type
Undergraduate students	From 16 to 25 years old	Technology in Electricity	Three years	Dynamic Systems Analysis, Digital Circuits, and Deep Learning	Propaedeutic cycles

Table 1 - Typology of students involved in the study.

This measurement instrument was designed to consider both the students' social environment and their emotional response to the dynamics of the training process. At the emotional level, we included indicators related to the open expression of ideas, communication with classmates and lecturers, the dedication shown in the development of the projects, the questions asked during the sessions, and the attendance at the online sessions. Regarding the social environment, indicators such as students' initiative to collaborate, level of participation during synchronous activities, integrated presentation of proposed projects, and familiarity of social interaction were considered. The performance evaluation focused on assessing the level of apprehension of the course concepts. The data were structured in a matrix, for which a code was generated for each group of students:

- Control group 1: PEC1 MLC1 CLC1
- Control group 2: PEC2 MLC1 CLC1
- Experimental group 1: PEE1 MLE1 CLE1
- Experimental group 2: PEE2 MLE2 CLE2
- Experimental group 3: PEE3 MLE3 CLE3

Where:

- PEC1 = Performance evaluation control group 1
- PEC2 = Performance evaluation control group 2
- PEE1 = Performance evaluation experimental group 1
- PEE2 = Performance evaluation experimental group 2
- PEE3 = Performance evaluation experimental group 3

- MLC1 = Motivational level weighting control group 1
- MLC2 = Motivational level weighting control group 2
- MLE1 = Motivational level weighting experimental group 1
- MLE2 = Motivational level weighting experimental group 2
- MLE3 = Motivational level weighting experimental group 3
- CLC1 = Collaborative level weighting control group 1
- CLC2 = Collaborative level weighting control group 2
- CLE1 = Collaborative level weighting experimental group 1
- CLE2 = Collaborative level weighting experimental group 2
- CLE3 = Collaborative level weighting experimental group 3

The distance learning courses were implemented using four digital tools. Google Classroom and Google Meet were the platforms for the synchronous meeting between students and teachers. They were used to set up meetings and record the progress of the courses. They were also used to provide feedback to students. The material of the courses was developed in Python on Google Colab, there were designed interactive worksheets with live code and rich text, the material with which the students interacted during and after the sessions. The teaching-learning process was developed synchronously with face-to-face classes by the lecturer on the conference platform. Students had to attend in a similar way as in the face-to-face classes. During these sessions, three basic training strategies were developed: direct work, consisting of the instructor's lectures where the central concepts were explained and exemplified, cooperative work developed from laboratory exercises proposed by the instructor for the students to solve by simulation in groups of two, and autonomous work where the student had to develop autonomously the reading of texts, online lectures, and research in the style of a flipped classroom. Each of these moments had its methodological processes and forms of interaction, for instance, during the lectures, examples are made and exercises are proposed to the students to be presented to the rest of their classmates, all laboratories were supported online to the teacher and other students, and autonomous progress controls were carried out through forums and joint assessments. Finally, all the course material is made available to students through a public repository in GitLab, this resource is continuously updated according to the dynamics of the sessions (Fig. 1).

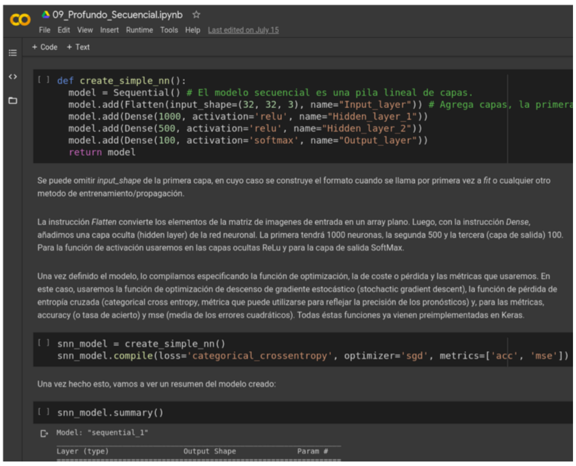

Figure 1 - Interactive electronic platform used during the study.

The PEXX groups were used to establish differences in performance, the MLXX groups were used to apply the assessment of changes in motivational level, and the CLXX groups were used to assess the elements of social interaction. The groups marked XXCX correspond to the control groups evaluated during 2019, while the groups marked XXEX correspond to the students evaluated under distance learning due to confinement. The performance evaluation considers purely academic aspects reflected in the intermediate and end-of-course academic assessments. The students' answers to the survey questions correspond to the input used to evaluate the emotional and social aspects.

The study with the experimental group was developed for over 16 weeks. In the courses of Analysis of Dynamic Systems and Digital Circuits, an intensity of six hours per week was developed, distributed in sessions of two hours every two days. In the case of the Deep Learning course, an hourly intensity of four hours per week was implemented, in two weekly sessions of two hours each. This intensity of work is the same applied to the students of the control groups, but with a traditional classroom training strategy. When we talk about traditional training strategy, we refer to the training model that was being developed with students in the classroom before the confinement forced by COVID-19, the readings corresponding to this dynamic that make up the control group were carried out during the year 2019. In both cases (control and experimental students) the students were continuously motivated to dedicate more time and work to the course on their own. A similar academic performance test was used to evaluate all students. To prove the null hypothesis, we applied statistical analysis to the data, we performed covariance analysis with a significance level of 0.05.

3. Results

3.1 Hypothesis H_1

According to the results, hypothesis H_1 is rejected. Although it is necessary to repeat the tests on a larger number of groups, the results of this study show that if there is an effect on students' skills and academic performance attributable to the variable parameter, the training scheme (classroom or distance). This effect indicates that the latter modality (distance learning) has a positive impact on students' academic performance ($F_{(2.28)} = 2.21$, $p < 0.05$, $\eta^2 = 0.19$, $R^2 = 0.71$).

Initially, these results can be explained by a bigger dedication in the time and effort of the students to the courses, parameters also consulted in the student survey (Fig. 2).

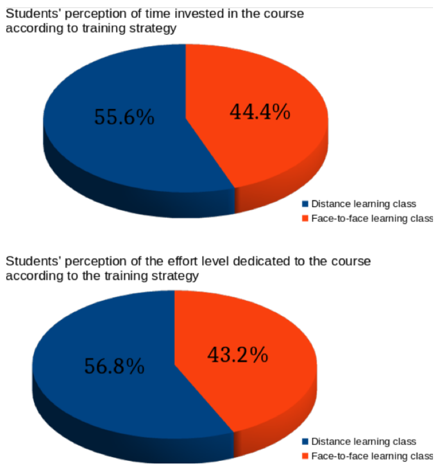

Figure 2 - Students' perception of dedication to academic courses before (face-to-face classes) and after confinement (distance learning classes).

3.2 Hypothesis H_2

Again, the results show that the hypothesis is rejected ($F_{(2.28)} = 14.52$, $p < 0.05$, $\eta^2 = 0.28$, $R^2 = 0.71$). There is a strong indication that the distance learning strategy considerably reduces student interaction, which has had an impact on competencies related to teamwork, assignment of responsibilities in the development of joint activities, and communication of ideas (Fig. 3).

The results show that the distance learning scheme has a statistically significant effect on interaction patterns for this student population used to high levels of social interaction.

3.3 Hypothesis H_3

In this last case, the hypothesis is also rejected. The results reveal that there is an interaction effect of the distance learning scheme on student motivation in

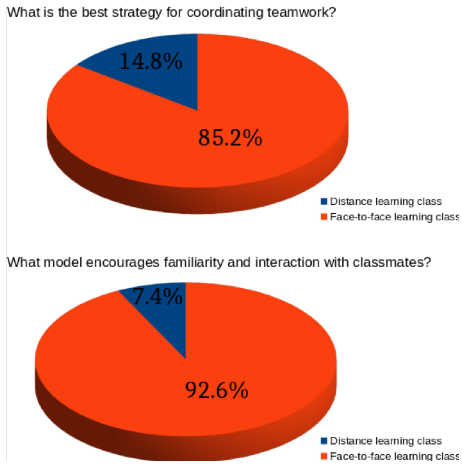

Figure 3 - Students' perception of interaction with classmates before (face-to-face classes) and after confinement (distance classes).

terms of dedication to the courses ($F_{(2.28)} = 3.44$, $p < 0.05$, $\eta^2 = 0.22$, $R^2 = 0.71$). The data show a markedly greater effort in the courses, with a greater number of hours dedicated and a greater interest in the contents. This may be a consequence of the increased availability of time due to confinement, and/or greater willingness to study given the lower number of external elements that distract the student.

Table 2 summarizes the statistics measured for each hypothesis.

Hypothesis	$E_{(2.28)}$	η^2	R^2
H_1	2.21	0.19	0.71
H_2	14.52	0.28	0.71
H_3	3.44	0.22	0.71

Table 2 - Statistics summary ($p < 0.05$).

4. Discussion and Conclusions

Colombian universities have implemented in a very short time distance education strategies on digital platforms for their students to allow the operation of their training processes in line with national policies of social confinement and distance as a result of the spread of the COVID-19 virus. The Universidad Distrital Francisco José de Caldas, a public university in the Colombian capital, also implemented these measures during the first academic semester of 2020. The design of the training tools fell mainly on the professors in charge of each course.

Our study focused on the analysis of the impact of the use of online learning environments on undergraduate students from the poorest economic strata in the city, characterized by a dynamic and very close social behavior, with a history of daily work with high social contact, and with only previous experience in traditional classroom training.

The study showed that social isolation, and the obligation to continue educational processes through the use of online environments on digital platforms, had a significant effect on the dynamics of students, both academically and socially and emotionally. These results are valid for the social group studied, and in the specific academic areas of the group.

In terms of academic performance, there was a slight increase in the group's capacities compared to the control group, in terms of reasoning, appropriation of concepts, creativity, and critical thinking. These results are in line with those reported by similar studies such as the one by Moreira (2017). However, an unreported negative impact was observed in terms of collaborative work and communication skills. It remains to be determined whether the causes of these negative effects lie in the pedagogical tools used, in the profile of the group of students, or in the way in which the change in training strategy was developed.

The evaluation of the students' perception also showed some negative results at the social and emotional level. Based on the data, it can be concluded that the transition from a model of classroom training to a model of distance learning took place abruptly, breaking basic patterns of social interaction, which, while increasing parameters such as dedication and interest, from the student's perspective, reduces his or her capacity for action because they do not have spaces, resources and social support that were very familiar and basic to them. Our findings in this sense coincide with others reported in studies such as Krystle (2016).

The most important results, however, relate to the ability of these digital tools to create a favorable study environment away from distractions, which seems to promote student interest, dedication, and critical thinking about the course content and the teaching processes designed in it. Although students show less interaction, from the teacher's point of view, there is more active participation and a higher level of student interest and dedication.

According to these perceptions, we can conclude that these pedagogical strategies allow a high level of training, critical development, and conceptual appropriation even higher than that observed in the traditional classroom strategy. The university even increases its social role by increasing access to training processes. However, given the abrupt form of the process, there were negative elements at the social and communicative level that affected the overall performance of students. It is necessary to create alternative strategies to support these skills and to shape a true model of integral formation.

Acknowledgements

This work was supported by the Universidad Distrital Francisco José de Caldas, in part through CIDC, and partly by the Facultad Tecnológica. The views expressed in this paper are not necessarily endorsed by Universidad Distrital. The authors thank the research group ARMOS for the evaluation carried out on prototypes of ideas and strategies.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 18-28

The effect of a Training Program based on Open Educational Resources on the Teachers Online Professional Development and their Attitudes towards it of AL-Dakhliya Governorate in Sultanate of Oman

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(submitted: 11/6/2020; accepted: 24/4/2021; published: 31/5/2021)

Abstract

This study aimed at investigating the effect of a training program based on OER on the professional development of AlDakhlia Governorate teachers. The study also investigated the teachers' attitudes towards this form of training using an experimental research method. The training program was prepared as an interactive lecture presentation for 3 days of training; one session per day for 2 hours. The educational content was available on the SHMS platform and then the experiment was implemented on 40 teachers, where 20 teachers were in the experimental group and the other 20 teachers were in the control group with professional years of experience ranged between 5 and 10 years. The results showed the significant role of the OER platforms in teachers' professional development in the form of an increase e in the level of knowledge and teaching skills. Also, the participated teachers' positive attitudes towards the online professional development indicated that these OER environments are rich in knowledge and cooperative activities. Generally speaking, these OER platforms encourage teachers to keep up with their professional development and self-learning throughout their career life.

KEYWORDS: OER, Online Professional Development, Open Educational Resources, MOOCs, Lifelong Learning.

DOI
https://doi.org/10.20368/1971-8829/1135283

CITE AS
Shemy, N., & Al-Habsi, M. (2021). The effect of a Training Program based on Open Educational Resources on the Teachers Online Professional Development and their Attitudes towards it of AL-Dakhliya Governorate in Sultanate of Oman. *Journal of e-Learning and Knowledge Society*, *17*(1), 18-28.
https://doi.org/10.20368/1971-8829/1135283

1. Introduction

The appearance of the open education movement forces the transformation of education worldwide. Therefore, it is necessary to shift to the Open Educational Resources since it is an existing educational resource that is free, open and easy to use and to level up the teacher competencies and professional developments. The researchers believe that the results of combining free OER such as MOOCs with professional development training programs will open a wider gate to high-quality instruction and learning process. Since the teachers are a vital component of any educational system, it forces the specialists and experts in any educational institution to focus on continuous professional development, which will be achieved easily and professionally by utilizing technology.

From the world of OER, MOOCs are probably one of the most important sources, because they offer plenty of developing courses and activities that can be modified and shared by the teachers. Many educational platforms have been established since 2002 which offer a variety of tools and essential professional development courses, such as Coursera, EDx, Udemy, Edraak, Edlal, and SHMS.

Cronin and MacLaren (2018) as cited in (UNESCO, 2012) defined OER as any "teaching, learning and research materials in any medium, digital or otherwise, that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions". These resources include textbooks, course materials, videos, tests, activities, multimedia and simulations and scientific experiments (Itmizi & Al-Salmi, 2019). The researchers believe that Open Educational MOOCs will help teachers to gain the appropriate skills and competencies for high-quality development and life-long learning because MOOCs are highly modified by specialists and allow teachers to choose what skills to obtain depending on their own needs, and offer the training courses in a very different and modern style parallel to open education

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trend, which is confirmed by many studies confirmed (Mahony, 2016; Bass, Admiraal & Berg, 2019; Al-Mubarak, 2019). However, Stracke et al. (2019) stated that the concept MOOCs need to have the four elements that make up the abbreviation, which are massive, open, online and course; therefore, not all MOOCs are categorized under this term if they do not achieve these four elements. They added that MOOCs can be perceived as OER product, but from the perspective of Open Education, MOOCs are considered innovative enablers of Open Education which shows a new method of changing education.

Open Educational Resources Network SHMS is a Saudi program aimed to offer rich educational contents and courses to support education, provide greater educational opportunities for Arab teachers, students, and faculties (Alkhasawneh, 2020). It is considered a national platform that offers safe and supportive knowledge for anyone who seeks it. On the other hand, the researchers believe that professional development for teachers through online training courses that implement technology tools to develop the educational process will achieve the proper delivery of the content in a motivating form as the training materials include drawings, pictures, videos, simulations, and chat windows, which encourage teachers to follow up and continue their professional development further.

The researchers assure that the online professional development will not only uplift the teacher's performance but will also open a new knowledge channel in which teachers can obtain continuous skill development which will reflect the quality of the whole educational process, not ignoring the reflection on the students learning as well.

The concern here is about the best form of a training program, based on an open educational resource that can overcome the variety of teachers' needs and maintain the continuous development of the teacher self-regulation skills so they can be a part of the creating, sharing, providing and modifying these resources.

1.1 Research problem

The researchers could specify the problem of this study in the one-way of the traditional method of professional development programs, established by the educational technology section, where it is not suitable anymore to achieve the main purposes and results of any professional development. This is becauseit does not include the modern tools of interaction and sharing required by any training program nor does it overcome the workload of the teachers or the geographical distance barriers. Thus, this study tries to answer the following main question:

What is the effect of a training program based on OER on the online professional development of teachers and their attitudes towards it?

Sub questions emerged from the main question as follows:

1. What is the suitable theoretical framework behind the teacher online professional development?
2. What are the requirements of the teacher online professional development?
3. What is the effect of a training program in SHMS platform on the teacher online professional development?
4. What is the effect of an online program at SHMS platform on the teachers' attitudes towards the online professional development?

1.2 Research objectives

The study objectives are:

1. To emphasize a proper theoretical framework of the teacher online professional development.
2. To identify the essential requirements of the teacher online professional development.
3. To investigate the effect of SHMS in the teachers' online professional development.
4. To investigate the effect of an online training program on the teachers' attitudes towards online professional development.

1.3 Research significance

1. This study could reframe the training programs in the educational technology sections in the Sultanate of Oman Governorates.
2. This study could present proper solutions to many training obstacles in the Ministry of Education.
3. This study could encourage the main training centre and training institutions in adopting new open training methods.
4. This study could alter the view of the educational systems about the Open Educational Resources and encourage them to step forward in benefitting from them.
5. This study could grab the stakeholder's attention to improve the existing national platforms for more development and implementation in education.

1.4 Research delimitations

This study is delimitated to:

- Effect of a training program on SHMS platform on teachers online professional development.
- Professional development training courses on the SHMS platform only.
- Teachers from AlDakhlia Governorate.
- Second semester of 2020/2021.

1.5 Research methodology

This study is based on an experimental method to investigate the effect of the training program on online professional development and teacher's attitudes towards it.

1.6 Research variables

First: independent variable, represented by the online training program on SHMS platform,
Second: dependent variables, represented by:

- Online professional development,
- Teachers' attitudes towards OER online training.

2. Materials and Method

2.1 Open Educational MOOC (SHAMS)

Despite the significant role of MOOCs in offering synchronous and asynchronous online distance learning, they still face challenges in Arab countries. The major obstacle is the language, so many Arab countries established some regional MOOCs to overcome this barrier. For example, Edraak and Rawaq were the initial Jordanian and Saudi platform, respectively. Other Arab MOOCs were established recently, like Omani Edlal, Oman academy, and the Saudi SHMS platform. SHMS is a Saudi network considered as OER offering educational materials and sponsored by the National Center of e-learning and distance learning in Saudi Arabia (Al-Raghbi, 2019). All educational materials published in SHMS have been licensed under Creative Commons license, which provides very intensive lessons, lectures, libraries and scientific experiments. It is considered to be a safe and reliable knowledge source for all students, teachers, faculties and even parents, as well as anyone who seeks knowledge without any registration, or certificates.
In this study, the researchers specifically pick SHMS platform for several reasons, as noticed from the official website:

- It is a complete OER platform, where any student, teacher or faculty can use its content without registration, which is frankly mentioned on the website.
  - Its mother language is Arabic.
  - It is sponsored by the National Center for e-learning, which ensures high quality of content and resources.
  - Various universities and institutions are participating in SHMS.

The researchers noticed that the students highly participated in the platform as well as the teachers who create the content and collaborate with others for further improvements. Therefore, the researchers believe it is a rich environment with plenty of educational tools for raising up professional development and lifelong learning as (Al-Shamrani, 2019) agreed and proved.
SHMS started with 13 from 25 universities in Saudi Arabia with 61 permanent academic staff with 35,000 published educational materials. Now, there are 15 participating universities, 1,786 academic staff, and 180,000 published educational materials according to the sixth report issued in 2018 (National Center for e-Learning, 2018). This study relies and is based on the principles of the connectivism theory by Siemens and Downes, because it takes into account the use of technology and networks in learning and then connects the main principles and knowledge of the learner to form the learning paradigm in which precision and knowledge updating is the key factor of the whole learning activity. This enables the learner to decide and choose what he/she wants to learn, which is typically applicable to MOOCs, where the learner learns through various channels like courses, email, blogs, forums, discussion groups, and web search (Al-Hadi, 2010). As Al-Raghbi (2019) mentioned in her study, the connectivism theory ensured that the learning has to have a final goal to be achieved by learners through developing the performance of specific skills as well as self-assessing skills and mastering access to modern knowledge resources. The researchers believe that constructivism theory also emphasizes the learning or training through MOOCs as the learners build up their knowledge since they are free and responsible for their time and learning mechanism, and also MOOCs ensure social and collaborative learning (Al-Zahrani, 2018).
To the researcher's knowledge till now, no previous Arabic studies investigated the implementation of SHMS educational materials for professional developments, which drives the researchers to do this study in the first place.

2.2 Teacher professional development

Teacher professional development is a critical factor in improving the quality of education. Therefore, constant professional development programs are needed to ensure that all teachers can meet the needs of the 21st century, to introduce teachers to the latest updates in the field of education, to provide teachers with sufficient knowledge about the education techniques and various education strategies, and to train teachers on learning and self-evaluation methods (Castaño-Muñoz et al., 2018). Laurillard (2016), also demonstrated the importance of professional development to develop teachers' instructional skills, thinking skills, and innovation.
Basically, teachers' professional development has to be classified as high-quality professional development, which is different from conventional and widely practised form of professional development, to ensure the greatest effect in improving teaching practices and therefore students' outcomes, and this can be achieved when combined with in-service training features, resulted from multiple empirical research papers. Researchers who studied high-quality professional development like (Desimone & Park, 2017; Song et al., 2018; Hassan, 2019) ensured that the combination of three professional development features enhances powerful and high-quality professional development practices, and these are: 1) content-focused learning, 2) active learning, and 3) collaborative learning. The content-focused learning concept is all about focusing on supplying teachers with knowledge and skills through learning activities, which required higher-level

of thinking skills (Desimone & Park, 2017). This form of practices enables teachers to understand and explore new instructional methods and approaches which definitely led to essential development in teaching practices (Musset, 2010). Engaging teachers in active learning by observing expert teachers, offering curriculum materials transforming opportunity, planning for classroom implementation, leading discussions among groups, presenting and engaging in written works (Niemi et al., 2016), will reflect directly in the teacher ability to criticize ideas and resources and upgrade the teachers own learning construction and skills, thus changing their teaching practices (Song et al., 2018). The third feature is collaborative learning, which represents in its simplest form a group of teachers encouraged to actively share and support their learning process during in-service training (Barrera-Pedemonte, 2016). In the researchers' opinion, the importance of collaboration lies on the opportunity in exchanging experiences and sharing thoughts and ideas or even assessments of other colleagues' work (Brown et al., 2016).

Previous studies emphasized the obstacles of the professional development programs like Hassan (2019) and Desimone and Park (2017), who agreed that training centres cannot train the numerous numbers of teachers, either because they lack big training halls for the training or because they lack sufficient numbers of trainers, corresponding to the huge numbers of teachers, as well as the lack of training programs that represent the actual need for the teacher. Other reasons demonstrated by (Zidan, 2018) argued that traditional training has shortcomings in material and human capabilities, and some training programs take place only once during the semester or sometimes once a year, which results in the reduction opportunities to join the training program. Furthermore, the geographical distance from the training center may reduce the teacher's desire to attend the training program and that is exactly what the researchers usually deal with while waiting for some teachers to arrive to the training center to start the program.

It might be concluded that OER illustrated as MOOCs combine all the three high-quality features, as educational resources involved active, constructive, collaborative, and content-focused resources. Moreover, recent perspectives have focused on the quality of distance education of MOOCs which is an important elements of success MOOCs since the gap between the designers' perspectives and the learners' preference for interaction might inhibit the success of MOOCs (Stracke et al., 2018). Stracke et al. (2019) added that MOOCs can go beyond OER in terms of its contribution to education quality through transforming online education through peer education and building education communities. Therefore, the researchers believe that utilization of an online professional development program is a powerful alternative solution to overcome obstacles rather than keeping on training teachers conventionally. In the researchers' own belief, when teachers are able to learn new ways of instruction methods and cope with the rapid developments of pedagogical approaches, students construct learning reflected directly and positively in return.

2.2.1 Online professional development

Why do we need online professional development? To answer this, we must first pay attention to the idea that professional development is a constant process of training, learning and support activities, which could be taking place in either work-based settings (conventional) or network-based settings (online), aimed mainly to develop professional knowledge, skills and attitudes to educate students more effectively (Karlovac, 2016). Hence, education and training are highly affected by technology, along with the wide availability of computers, internet and mobile devices. The implementation of technology overcomes lots of obstacles. Song et al. (2018) pointed to a surprising finding of their study about teacher professional development over 47 countries. They found that teachers who have participated in professional development activities were very low. Miyazaki (2015) hinted at some of the online benefits that overcome obstacles, such as the following:

- Serving massive numbers of teachers at once through the internet, in different locations.
- Open and available to anyone continuingly.
- Courses are easily accessible and cost-effective.
- Offering a new method of learning with unique features.

Brown et al. (2010) also pointed out other reasons:

- Providing self-directed professional development.
- Observing expert experiences and improving collaborative skills.

The researchers agree with Abdul Wahab (2017) and Al-Gahni (2017), in that OER in training is a modern and advanced method of training, offering knowledge and educational materials in a very accessible manner anytime, anywhere, which overcomes any financial and epidemiological troubles in the world, like facing COVID-19 virus nowadays. Many researchers investigated the utility of MOOCs for professional development around the world (e.g., Al-Harthy, 2016 & Koutsodimou & Jimoyiannis, 2015), demonstrated the utility of MOOCs in Greece and Saudi Arabia, and confirmed a high rate of interaction in completing training courses of all the teachers who participated.

To the researcher's knowledge, no prior studies have examined the effect of a training program on SHMS platform in relation to online teacher professional development and examined the perception of teachers towards OER.

2.3 Research tools

1- *Cognitive test (Self-designed) mainly to measure the achievement of the trainee regarding the topic of the training course.*

According to the training program objectives and the educational content, a cognitive test was prepared as follows:

- Test purpose: measuring the cognitive aspect of some skills of technology (e.g. applying YouTube videos as instructional strategies, download YouTube videos directly from the web, remove ads from videos, using google chrome in their teaching as a technological tool) of the targeted teachers who are participated in the training program.
- Formulation of test questions: 20 multiple choice questions were prepared and formulated according to the program objectives and suited the academic level of the teachers as well as their professional experiences.
- Test instructions: the researchers prepared a set of instructions for the test so that all the participators will follow the test clearly. The following general considerations were taken place:
  - Simple, clear, and direct instructions are established.
  - Clarify the right way of answering the test questions.
  - The test time is not affected by the instruction reading time at the beginning of the test.

After the researchers determined the questions, they transformed it into an online exam using Google forms because it is the most suitable form of any test in any online environment and it is easy to design and distribute to participants in the study either by email or WhatsApp application.

The researchers wrote the test instructions in the first scene of the test so that all participants could follow easily. Each question consists of 4 options to choose from as the right answer.

- Initial test examination: the test was first applied to a test sample of teachers; the sample size was 10 teachers.

This is basically done to:

- Determine the test time.
- Calculate test validity.
- Measure the test reliability.

The initial experiment has achieved its goals which includes:

- Determining the test time: by recording the time of the first teacher to complete the test and the time spent by the last teacher to complete the test by the following formula:

$$\text{Test time} = \frac{\text{first teacher finished time} + \text{last finished}}{2}$$

$$\text{Test time} = \frac{45 + 30}{2} = 38 \text{ minutes}$$

- Calculating test validity**:** the test is considered valid if it meets and achieves the purpose goals, the researchers determined the frequency of the test sentences and then proposed it to 4 specialists who confirmed the test validity before implementation. They advised to change some questions and delete some other questions, so 20 questions only were left to implement. Then, the researchers calculated the intrinsic validity of the test by calculating the square root of the coefficient of the test validity and found that the intrinsic validity coefficient (0.87) is considered an acceptable ratio which indicates that this test is valid.
- Measure the test reliability**:** the reliability coefficient of this test was calculated using the Kuder-Richardson formula through v 23.0 SPSS statistical analysis program. The test reliability coefficient reached (0.85) and that demonstrates that the test is stable enough and ready for implementation.

2- *Teachers' Attitudes towards OER training program scale (self-designed).*

After the teachers have been trained by OER resource, the researchers designed this scale as follows:

- Scale purpose**:** this scale is designed to measure the teachers' attitudes towards the training program based on OER platform and whether they accepted the idea or not to demonstrate the extent of their impact on them and if they made a positive or a negative attitude towards using these resources in their instruction methods at schools. The researchers designed this scale in the form of a questionnaire integrating both positive and negative sentences.
- Formulating scale sentences**:** the researchers drafted the scale sentences according to the teachers' characteristics, and the technological skills level they have, and their point of view on the environment they trained in**.** The scale consists of 30 sentences reflecting the target objectives. The researchers measured the validity and stability of this scale to confirm its sincerity as follows:
- Calculate scale validity: the researchers proposed the scale to 4 educational technology experts who confirmed the validity of it with some phrases modified. Then, after modifying the scale, the researchers calculated the intrinsic validity of it by calculating the square root of the validity coefficient and found that the intrinsic validity coefficient is (0.85) which is an acceptable ratio of validity.
- Measure the scale reliability**:** to calculate the reliability factor, the researchers calculated the reliability parameter of the scale using the method of analysis of variance using the Kuder-Richardson formula through v 23.0 SPSS statistical analysis program. The test reliability coefficient reached (0.91) which indicates a fair enough degree of acceptance for stability, indicating that the scale is suitable for implementation. Since the training is in an online environment, the researchers transformed the attitude scale into an online scale by Google Forms.

2.4 Research sample and experimental design

1- Research community and sample

- Community: consists of AlDakhlia teachers at all levels of education, teaching any subject, male and female teachers with professional experiences between 1-10 years.
- Research sample: the researchers determined the sample randomly, through the training center database by sending the teachers a survey in their e-mails requesting them to attend the training program and be a part of the experiment. Once the study sample replies to the survey, 40 male and female teachers were intentionally chosen. Those selected had participated in Intel for teachers' program to avoid OER ignorance because, at intel program, the participants usually are given a brief background on OER.

The researchers separated them into experimental group and control group as follows:

- Randomly selected 10 male teachers and 10 female teachers as the experimental group with professional experiences between 5 and10 years.
- Randomly selected 10 male teachers and 10 female teachers as the control group with professional experiences between 5 and10 years.

Care was taken to avoid homogeneous groups in sex and professional experiences.

2- Experimental design

The researchers used the experimental design with one control group and one experimental group design. They were trained in the educational technology center in AlDakhlia Governorate. Figure (6) shows the experimental design of the research.

Group	Pre-test O1	Independent variable X	Post-test O2
Experimental and Control Groups	Cognitive test O11	X1	Cognitive test O21
Experimental and Control Groups	Attitude scale O12		Attitude scale O22

Figure 1- Research experimental Design.

Where O11, O12 are the pre-test of cognitive test and attitude scale, respectively.
Where O21 and O22 are the post-test of cognitive test and attitude scale, respectively.
where X1 is the experimental group with independent variable treatment.

2.5 Research hypothesis

Depending on the previous literature review and various studies results, the study hypotheses can be represented as follows:

1- There is a statistically significant difference at the level of (0.05) between the average degrees of the pre-test and the average degrees of the post-test of the experimental group in the Online training program cognitive test valid to post-test.
2- There is a statistically significant difference at the level of (0.05) between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group valid to the experimental group in the Online training program cognitive test.
3- There is a statistically significant difference at the level of (0.05) between the average degrees of the pre-test and the average degrees of the post-test of the experimental group in attitudes scale towards online professional development valid to post-test.
4- There is a statistically significant difference at the level of (0.05) between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group in attitudes scale towards online professional development valid to the experimental group.

2.6 Procedures

First of all, the researchers searched for the appropriate OER needed for the training program. There were many options, but SHMS met the properties that the researchers were looking for, such as complete support for Arabic language, OER supportive, no registration needed to view and ability to use any educational resources. Then, the researchers determined the suitable content to be presented in SHMS according to the objectives needed to be achieved. The researchers depended on the content design on lots of other courses on SHMS related to the objectives of the training program, which was mentioned before in the instructional design. After that, the researchers designed the training program as an interactive presentation lecture and uploaded it to the platform. The teachers participating in the study were chosen from 150 teachers responding positively to the survey, then 40 teachers were chosen intentionally who had prior training at Intel for education to ensure the participants are heterogeneous in terms of sex and professional experiences. This in turn will lead to knowledge sharing, exchange and modification among the participants. So, each experimental group consisted of 10 males with 10 female teachers (to avoid sex variable interfere with the study results) with professional experiences ranging from 5 to10 years. The control group also consisted of 10 males with 10 female teachers with professional experiences ranging from 5 to10 years.
Before starting the training program, the cognitive test and the attitude scale were prepared in the form of Google forms to make sure all participants have them, since the training is on an online environment. The links are provided in the training program.
After the pre-test of both the cognitive test and the attitude scale were implemented for the experimental

group, the participants were allowed to access the training course in the OER platform and started learning the content. The researchers posted a subject on the discussion board provided for the course and made sure that all participants have access to it without facing any issues. Later, the researchers posted a discussion subject that all participants exchange their new knowledge after completing the course, which takes only 2-hours for the session. Next day, at the same time, the researchers posted an activity that the participants could access and criticize any other course content available in the platform. They can choose the course by their own interest. The third day, the researchers requested that each participant edit the content of the course that were chosen by him/her the previous day and revise it and exchange the new editing course with the other colleagues. Furthermore, each revised content will be criticized by others for further editing. There has been an emphasis on all participants to share all the resources of information that anyone of them obtained under a cooperative framework. The researchers made available external resources of some technological tips with a full explanation of them, so any participant can benefit from them. All available tools were utilized by the participators such as the discussion board in the group provided at the platform, downloading any course materials of interest for the participants, editing any course content, revising them and redistributing them among colleagues. On the other side, the control group was trained in the same course conventionally in the training center for one session only.

Throughout the three days sessions, there was a careful follow-up to increase highly positive participation and interaction among participators. There was a continuous and precise follow-up on the performance of the participants, guiding them and providing advice among the sessions by utilizing the communication tools provided in the platform and the emails. After the completion of the experiment period, the post-test of cognitive test and attitude scale were distributed again to all participants, and then statistical treatments were conducted as required, as will be discussed in the study discussion part.

3. Results and Discussion

Data processing and analysis of this study were done using the SPSS statistical program for MAC V23.0.

3.1 Test the validity of the first hypothesis

There is a statistically significant difference at the level of (0.05) between the average degrees of the pre-test and the average degrees of the post-test of the experimental group in the Online training program cognitive test valid to post-test. To check the validity of this hypothesis, the researchers measured the difference between the average degrees of the pre-test and post-test of the cognitive test for the experimental group using the Paired samples T-test as follows:

Group	Test	No	Mean	S.D.	T	Sig. (2-tailed)
Experimental	Pre	20	20.8	8.2	8.3	0.001
	Post		36.4	2.5		0.001

Table 1 - Paired Samples T-test results of pre-test and post-test of the experimental group.

A paired-samples T-test was conducted to compare the average degrees of the pre-test (M=20.8, SD= 8.2) and post-test (M= 36.4, SD= 2.5) of the cognitive test for the experimental group; t (19) = 8.3, P= 0.001, shows that the first hypothesis is valid. From table (1), it is clear that there is a positive improvement in the degrees of the pre and post-test of the experimental group in the cognitive test. This is confirmed by the previous studies mentioned in the literature review. The results indicate the effectiveness of OER training program in achieving some technical skills and instruction competencies of the participators, which has a positive effect on the teachers learning. This can be explained by that OER allows the teachers to encourage themselves to participate and learn the way they are capable of, and this encourages and promotes the teachers' self-learning through dealing directly and freely with the OER materials, provided in the platform. This was confirmed by Alkhasawneh (2020) and Zidan (2018), who ensured that teachers who learned by online training achieved a higher level of learning compared to teachers who were trained conventionally and that the social interaction within the discussion forums provided by the platform increases learning opportunities for all participants. Hodgkinson-Williams (2017) also ensured that learning with OER encourages the teachers to feel free and safe when downloading any educational materials, thus contributing to the development of a sense of belonging to a trustful community where teachers can share their educational resources with no fear plus the nature of OER in terms of ease of use and the time available for teachers to cooperate in the forums and discussion group provided by the platform. This is confirmed also by (Abu Khatwa, 2016) when discussing the advantages of the MOOCs in encouraging participants to feel more engaged in the course and group of work which consequently results in increasing the desire of participants to learn more for achieving their educational objectives, which reflected directly and obviously with the increase in the cognitive test degrees of the post-test degrees. Barrera-Pedemonte (2016) assured that the online environment provided the participants with the appropriate tools of self-learning which develop their performance and teaching competencies and this is completely different from the training in the conventional environment, which offers limited opportunities of participation and limited social exchange of educational materials, which may result in unaccepted objectives achievements or desired goals. The researchers believe that the heterogeneity among the participators increases the degree of sharing and exchanging the educational experiences through mutual participation, and sharing educational resources with the others affected positively the cognitive test results, and that exactly what discussed by (Al-Hadi, 2010).

3.2 Test the validity of the 2nd hypothesis

There is a statistically significant difference at the level of (0.05) between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group valid to the experimental group in the online training program cognitive test. To check the validity of this hypothesis, the researchers measured the difference between average degrees of the post-test of the experimental group and the average degree of the post-test of the control group in the cognitive test valid to the experimental group using the Independent samples T-test as follows:

Group	Test	No	Mean	S.D.	T	Sig.(2-tailed)
Experimental	Post	20	36.4	2.5	7.5	0.001
Control	Post		22.7	7.9		0.001

Table 2 - Independent Samples T-test results of post-test of the experimental and control group.

An Independent samples T-test was conducted to compare the average degrees of the post-test of the experimental group (M=36.4, SD= 2.5) and post-test of the control group (M= 22.7, SD= 7.9) of the cognitive test for the control group; t (19) = 7.5, P= 0.001, shows that the second hypothesis is valid. From table (2), it is clear that there is a statistically significant difference between the post-test of the experimental and the control group of the cognitive test valid to the experimental group, which demonstrates the positive effect of the training by online OER training program. This might be explained by the same reasons mentioned in discussing the results of the first hypothesis and to which (Laurillard, 2016) confirmed that the online training programs represent an effective means and tools of professional and skills development and contribute to providing all participants with the adequate skills of scientific research where the platforms are provided with external resource links that encourage the participants to seek more knowledge in a very short time. Agreeing with what was mentioned above, (Hassan, 2019; Goodyear, 2017) added that online training allows participants to obtain a higher level of thinking; hence, they exchange their educational materials with others and also can edit others' educational materials and criticize, reuse, remix and redistribute them freely. Besides, the participants are getting closer to other colleagues in the same group, so that they can solve the problems facing each other and exchange their new knowledge with each other, so the learning environment becomes very rich, which reflects directly on their cognitive knowledge as the post-test results showed. On the contrary, the control group trained by the traditional training, where they all stayed in the same class and meet the trainer face to face. Although this form of training for any professional development program is very powerful since the participants are meeting the trainer directly and obtaining their knowledge from direct experiences (Al-Hadi, 2010), it is still a poor environment of the self-obtaining skills that any participant is capable of if the educational environment is provided by the appropriate tools. In the researcher's own belief, once the educational environment is rich and full of negotiation, discussion, and collaboration opportunities, it will definitely ensure the consistency of the knowledge provided by it. That is why in the researchers' opinion, the experimental group post-test degrees increased compared to the post-test degrees of the control group, who were trained traditionally as (Al-Zahrani, 2018) confirmed as well.

3.3 Test the validity of the 3rd hypothesis

There is a statistically significant difference at the level of (0.05) between the average degrees of the pre-test and the average degrees of the post-test of the experimental group in the attitudes scale towards online professional development valid to post-test. To check the validity of this hypothesis, the researchers measured the difference between average degrees of the pre-test of the experimental group and the average degree of the post-test of the experimental group in the attitude scale valid to the pre-test of the experimental group using the Paired samples T-test as follows:

Group	Test	No	Mean	S.D.	T	Sig.(2-tailed)
Experimental	Pre	20	90.30	11.2	11.1	0.001
	Post		117.5	18.1		0.001

Table 3 - Paired Samples T-test results of pre-test and post-test of the experimental group of the attitude scale

A paired-samples T-test was conducted to compare the average degrees of the pre-test of the experimental group (M=90.30, SD= 11.2) and post-test of the experimental group (M= 117.5, SD= 18.1) of the attitude scale valid to the experimental group; t (19) = 11.1, P= 0.001, which shows that the third hypothesis is valid. As shown in table (3), it is clear that there is a statistically significant difference between the average degrees of the pre-test of the experimental group and the average degrees of the post-test of the experimental group valid to post-test, which demonstrates the positive effect of the training by online OER training program on the participants' attitudes. It is clear that there is a significant improvement in the attitudes towards the OER training programs of the experimental group, which the researchers believe is a logical result as the OER online training programs contributed to the high level of cognitive knowledge that all participants obtained after the training program. This can also be emphasized, in my opinion as a result of the teamwork in the OER community and the level of openness and access provided by OER which has greatly contributed to the positive attitude of the participants of the experimental group, which is in line with Niemi et al. (2016). As the sense of security provided by the OER, it will naturally increase the participants' positive attitudes towards this evolutional and technological tool that contributed to a change in getting the knowledge and improving the educational skills that teachers all over the world demanded. This also is discussed by (Su, Tu-Sheng, 2016).

3.4 Test the validity of the 4th hypothesis

There is a statistically significant difference at the level of (0.05) between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group in attitudes scale towards online professional development valid to the experimental group. The researchers measured the difference between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group in the attitude scale using the Independent samples T-test as follows:

Group	Test	No	Mean	S.D.	T	Sig.(2-tailed)
Experimental	Post	20	117.5	18.2	10.2	0.001
Control	Post		90.90	11.0		0.001

Table 4 - Independent Samples T-test results of post-test of the experimental group and the control group of the attitude scale

An Independent samples T-test was conducted to compare the average degrees of the post-test of the experimental group (M=117.5, SD= 18.2) and post-test of the control group (M= 90.90, SD= 11.0) of the attitude scale valid for the experimental group; t (19) = 10.2, P= 0.001, shows that the hypothesis is valid. Moreover, the two standard deviations of the two groups are less than the difference between the means, which supports the results of the results of the *p*-value and this hypothesis. From table (4), it is clear that there is a statistically significant difference between the average degrees of the post-test of the experimental group and the average degrees of the post-test of the control group of the attitudes scale valid to post-test of the experimental group, which demonstrates the positive effect of the training by online OER training program on the participants' attitudes. As researchers, this result is expected due to two main reasons. It is all about curiosity and the great opportunities provided by the OER for teachers while learning such as free download of any content, authority to transform any educational materials, and the sense of belonging to the educational community as discussed by Al-Shamrani (2019). As the researchers mentioned in discussing the results of the 3rd hypothesis, and as (Kwak, 2017) discussed, this new trend of open pedagogy is starting to diffuse and spread in the education society that encourages teacher's curiosity about it, and so the desire of learning and using it in their professional career and the new channels of obtaining knowledge provided by OER platforms. Despite that, there is a hesitation in utilizing these resources due to fear and ignorance. OER and open pedagogy are still very justified by so many teachers and faculty members who are used to teaching behind doors. They are concerned about opening up their research for others to see, to be judged, or to reuse it. The researchers admit that the challenges facing the utility of OER, especially in Arab Countries, should not stop us from benefiting from these educational treasures. The researchers believe that with the invasion of Coronavirus, it is a good time to rely on OER to train teachers remotely, especially since all training programs in educational institutions have stopped altogether because of the pandemic. So, the Ministry of Education should adopt a platform to provide OER for professional development for educators. The holdings of this platform should be from ready-made OER and also locally designed.

4. Conclusion

The findings of the study showed that a significant role for the OER platforms such as SHMS in terms of teachers' professional development, especially enhancing their knowledge and skills of teaching. Besides, the study showed that there are different aspects that increase the positive role of MOOCs such as exchanging knowledge and teaching skills, and interactivity while doing the requested tasks. The positive impact of these activities is reflected in the sharing of diverse educational resources and references among them, and there was clear development in their knowledge and skills with regard to the technical skills targeted in the training program. The participants seriously pursued obtaining all the information related to the topic of the training program and share it with colleagues through the online environment based on OER, which shows the positive effect of the training program in SHMS platform on the teachers' professional development. Besides, the participants have a positive attitude towards the impact of the training program in SHMS platform on their professional development. It is concluded that the online training programs overcome and solve many problems related to the current situation of educational professional development programs. Besides, these online platforms provide teachers with an interactive cooperative environment that helps the participant teachers in getting feedback from other' experiences which helps in enhancing teachers' innovative teaching skills. Future studies can make an in-depth investigation for the feedback in MOOCs using multimodality since these platforms help to gather different types of data from the participants.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 29-38

Adults' motives and barriers of participation in mixed and asynchronous learning training programs

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(submitted: 6/5/2020; accepted: 7/4/2021; published: 22/6/2021)

Abstract

This paper explores the motives, barriers and the facilitators of adults' participation in two training programs, organized by the Center of Training and Lifelong Learning (KE.DI.VI.M.) of the Aristotle University of Thessaloniki, Greece. 215 trainees completed the questionnaire in the first program, entitled 'Training of Lifelong Learning Adult Trainers', while 70 students having attended the second program 'Vocational Education and Training: Specialization of Adult Executives, Teachers and Trainers' completed the questionnaire. It was found that the professional and personal development are the main reasons for participating in training. Regarding the barriers, the situational and institutional ones are the most important factors for non-participation in the training. Regarding the facilitators to participation in training, distance learning, recognition of certifications acquired from participation to training programs, salary's improvement and dissemination of seminars taking place are the main facilitators for participating in lifelong learning programs.

KEYWORDS: Adult Education, Motives, Barriers, Facilitators.

DOI
https://doi.org/10.20368/1971-8829/1135256

CITE AS
Mavropoulos, A., Pampouri, A., & Kiriatzakou, K. (2021). Adults' motives and barriers of participation in mixed and asynchronous learning training programs. *Journal of e-Learning and Knowledge Society*, *17*(1), 29-38.
https://doi.org/10.20368/1971-8829/1135256

1. Introduction

The rapid development of the economy and technology in international and national level has led to the continuous growing of Adult Education. Lifelong learning plays a significant role in modern societies as it can contribute to the employability of adults, economic growth, personal development and social inclusion. The need for high-quality human resources with autonomous actions and skills capability combined with the development of modern technological tools have stimulated new human resource development practices, resulting in an increasing demand and supply of training programs. At the same time, the increase in unemployment and the number of pensioners, the need for new skills, the changes in lifestyle and work, such as increasing women's entry into the labor market, have led to the need for adult education (Vergides, 1998). Adult education has been a primary topic on the European agenda since 2001, when Lisbon Strategy identified education as an essential resource for European development (European Commission, 2001). However, despite the developments having been launched in recent years, those developments alone cannot explain adults' participation motives and barriers of participation in training programs. As a current trend in training programs, blended learning methods which "combine

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face-to-face instruction (e.g. lecture, cases or games) with on-line technology-based learning" (Noe, Tews & Dachner, 2010, p. 288) aim to combine the social context of classroom included in face-to-face learning with the flexibility of on-line learning, according to Bonk and Graham, (2012, as cited in Noe, Clarke & Klein, 2014: 253).

The aim of the study is to investigate adult trainers' motives and barriers of participation in two training programs, addressed to adult trainers of lifelong learning, offered by the Center of Lifelong Learning of the Aristotle University of Thessaloniki. Those two programs were implemented: a) the first one between October 2016 until December 2017, as a blended learning program and b) the second one between September 2018 until June 2019, as an asynchronous learning training program. One of the objectives of the research was also to explore factors that facilitate adult trainers' participation in professional training programs.

1.1 Motives of participation in lifelong learning

Adult learners through lifelong learning acquire new skills and competences, modern knowledge and create an environment of professional autonomy and self-confidence. Motivational orientation is of the utmost importance and is described as the most important factor driving the individual to participate in continuing education programs, as demonstrated by many surveys, researching the participation motives in continuing education (Boeren, Holford, Nicaise, & Baert, 2012; Brookfield 1995a; Hiemstra & Sisco, 1990; Yousef, Chatti, Wosnitza, & Schroeder, 2015; Karalis, 2017; Mavropoulos, Sipitanou & Pampouri, 2019).

Motives are related to the perceptions and values of the individual, but also to the expectations the individual has from his profession. Initially, motive is defined as anything that pushes the individual into action. The motives that encourage adults to participate in educational programs are distinguished into two categories: a) the learning motives and b) the participation motives.

Motives are classified as intrinsic, extrinsic or a combination of both. So, some reasons could be the filling of educational gaps, the best work performance, the enhancement of job opportunities and the personal development. The adult learners' reason and purpose for learning creates the motivation to engage in adult learning. Houle (1961) was the first researcher who tried to investigate the adults' motives of participation in continuing educational training activities. According to Houle, there are three types of learners: a) goal oriented who through the educational process want to achieve clear objectives, b) activity oriented who are socially involved, and c) learning oriented who seek knowledge for their own development and cultivation.

In 1973, Boshier, based on Rogers's theory, proposed a congruence model of conflict-agreement between the individual, the educational organization and the rest of the people, with their ideal self. The main factor of participation is the correspondence of self-esteem and self-image that individuals have for them with the form of the educational system. Disagreement between the individual and the educational environment has the effect of denying participation or abandoning the educational process. He created the Educational Participation Scale (EPS). According to the scale, the motives of participation are social relationships, external expectations, social welfare, professional advancement, escape/stimulation, and cognitive interest.

The Cross Chain-of-Response Model (1992), called the 'chain of response' model, consists of seven stages with their own impact on the decision-making process of participation in adult education courses. Every stage influences one another. The seven steps are: a) Self-evaluation, b) attitudes about education, c) the importance of objectives and the expectations that these will be implemented, d) life transitions, e) opportunities and barriers, f) information on educational opportunities, g) the decision to participate. According to Cross (1981), all relevant research shows that "the more people learn, the more they are interested in further education" or else: "learning is addictive; the more people have the training, the more they want it". The main obstacle to adult learning for the less trained is the lack of interest. At this point, it is necessary to note that in the international literature the term 'reason for participation' rather than motivation is used to a large extent, as the latter refers more to the concept of deeper internal affluence (see, for example, Boshier & Collins, 1996).

1.2 Barriers of participation in lifelong learning

Regarding the barriers to participation, the most common and widely used typology is that of Cross (1977, 1981), where barriers are divided into three categories:

- *Situational*: the barriers attributed to the situation in which an adult is during a particular period, including factors such as lack of money, lack of time due to professional and home responsibilities, childcare or transportation etc.
- *Dispositional*: the barriers include negative attitudes and perceptions about further education, its usefulness and the appropriateness of engaging in learning; low self-esteem and evidence of prior poor academic performance are also dispositional barriers.
- *Organizational*: barriers associated with institutions and organizations that offer adult education, such as inconvenient schedules or locations, inappropriate courses lack of interesting, practical or relevant courses; administrative or procedural issues; the lack of information about programs and procedures, etc. (Cross, 1992) etc.

Merriam & Cafferella (1991) stated that studies have categorized barriers of participation to adult learning into situational (a person's situation at a given time), institutional (practices and procedures that discourage adults from participation), dispositional or psychosocial (person's beliefs about self and learning) and informational (person's unawareness of the availability of educational programs). Other barriers based on the social structure are geographic and demographic factors, socioeconomic conditions and educational and cultural determinants (Chao, 2009).

Rubenson & Desjardins (2009) grouped the first two types of Cross-typology barriers (situational and institutional) into one category, the structural barriers, because both types are ultimately referred to social conditions and structures, while they retained the third category (dispositional). Specifically, the typology they propose is as follows:

- Structural barriers, which essentially incorporate both the state and institutional obstacles of the Cross typology (family, work and obstacles related to institutional and organizational issues).
- Individual barriers, including capabilities and consciousness.

2. Methodology

This section is describing the aim of the research, participants, instruments and data analysis.

2.1 The aim of the study

The aim of the study was to investigate adult trainers' motives and barriers of participation in two training programs addressed to adult trainers of lifelong learning, offered by the Center of Lifelong Learning of the Aristotle University of Thessaloniki. Those two programs were implemented: a) the first one between October 2016 until December 2017 and b) the second one between September 2018 until June 2019. One of the aims of the research was also to explore factors that facilitate adult trainers' participation to professional training programs.

2.2 Participants

The survey was based on the responses given by the trainees who participated in two professional training programs, which were organized and implemented by the Center of Training and Lifelong Learning (KE.DI.VI.M.) of the Aristotle University of Thessaloniki. The first, blended learning program, entitled 'Training of Lifelong Learning Adult Trainers', (E.E.E.D.V.M.) was addressed to: a) prospective adult trainers of all cognitive subjects, b) those registered in the National Organization for the Certification of Qualifications and Vocational Guidance (E.O.P.P.E.P.) as well as in other registers of adult trainers, who wanted to update their knowledge, and c) existing and prospective staff members of lifelong learning structures, such as Institutes of Vocational Training, Second Chance Schools, Lifelong Learning Centers, etc., who wanted to upgrade their knowledge and gain additional certification (Mavropoulos, Sipitanou & Pampouri, 2019).

The second, asynchronous learning program, entitled 'Vocational Education and Training: Specialization of Adult Executives, Teachers and Trainers' (E.E.K.), was addressed to active and prospective executives as well as formal and non-formal educators or trainers wishing to update and upgrade their knowledge of Vocational Education and Training and design an educational program of their specialty. The benefits of the program included the allocation of teachers, the maximum allocation to trainers and executives for their participation in Calls for Proposals at the Public Institutes for Vocational Training (D.I.E.K.) and Public Vocational Training Schools (D.S.E.K.), certificate of attendance and Certificate of Training with the corresponding ECTS units (*ibid.*).

At the first program fourteen cycles of studies had been implemented since October 2016 to December 2017, with each cycle lasting between seven to eleven weeks, while the second program started from September 2018. Both programs had been implemented by using the electronic asynchronous distance learning platform (e-learning) of the Aristotle University of Thessaloniki.

The sampling was carried out during the programs' period until June 2019 and the sample consisted of 215 trainees having participated in the first E.E.E.D.V.M. program and 70 trainees in the second E.E.K. program.

2.3 The instrument

The questionnaire constructed by researchers was used as a research tool, with the use of questions from surveys by Karalis (2013) based on the Educational Participation Scale (EPS) of Boshier (1973). The instrument was divided into three parts. The first part which concerns the motives in learning contained 4 items for professional upgrade motives, 2 items for certification/education recognition, 2 items for the interest in learning, 4 items for motives concerning personal/family life and 2 items for motives concerning social participation. The second part, based on Cross typology (1992), consisted of 21 items, 5 items for situational barriers, 12 items for organizational barriers and 4 items for dispositional barriers. The third part consisted of 7 items investigating the facilitators of participation in training programs. The questionnaire was completed by participants through the e-learning platform of the Aristotle University of Thessaloniki (Moodle) and included 27 questions.

The questions concerned the demographic characteristics of the participants and the level of certified knowledge and study. Still, specific questions related to the motives of participation in training actions, the barriers to their participation as perceived by themselves and the facilitators to their participation in training. In particular, the question that explored the motives for participating in the training consisted of 14 statements with the choice of the three most important reasons. The question that explored the obstacles to participation in training consisted of 22 statements and trainees were asked to choose from the same list of factors the three most important, while the question concerning the facilitator factors contributing to facilitating participation in the training consists of 7 questions with the choice of three answers.

3. Results

3.1 Research results from the 'Training of Lifelong Learning Adult Trainers' Program (E.E.E.D.V.M.)

From the 'Training of Lifelong Learning Adult Trainers' program, 215 trainees completed the questionnaire, 48 were men (22.33%), 159 were women (73.95%), and 8 did not respond (3.72%). Regarding the age, 45.58% of the sample trainees is aged between 24 and 35, 33.49% from 36 to 45, 15.35% is aged between 46 and 55, 1.9% from 56 to 65, while 3.25% of respondents did not indicate in which age group they belong.
Regarding the educational level, 43.26% of the participants hold a postgraduate degree, 40.93% are graduates of Higher Education, 5.58% are graduates of Secondary Education and 2.79% hold a PhD degree, while 4.19% did not respond to this question. Regarding the working status, 133 participants (61.86%) are employees, while 74 participants (34.42%) are unemployed. 50 participants of the employees (23.26%) are educators, 8 are teachers of non formal education (3.7%), 22 are civil servants (10.23%), 35 are private sector employees (16.28%) and 23 are self-employed (10.70%).
Table 1 shows the percentages of respondents' answers to the survey regarding the motives of their professional advancement. According to Table 1, the statement 'to be more efficient at my work' gathered 40%, the statement 'to find a better job' gathered 39.07% and the statement 'to increase my income' 20.93%, while the statement 'to keep my job' had the lowest rate of 6.51%. As far as the motives for obtaining a certification the statement 'to increase my qualifications' had the highest rate of 67.44% while the percentage of the statement 'to obtain a certificate' was 46.05%.
It is worth noting that the motives connected to the value of learning ranked very high since the statements "because education should be lifelong" and "because I like to learn new things" gathered the same percentage of 48.37%. The rest of the statements ranged to low preference rates (Table 2).
In Table 3 we observe that the motives concerning personal/family life and social participation gathered low percentages. So, the statement 'to give my children a good example' reached 9.3%, and the statement ´because I didn't have the opportunity to study as much as I wanted in the past', reached 6.98%, while the statements 'to be more accomplished citizen' and 'to make the best of my free time' gathered 6.51% each.
Observing Table 4, we find that half of the participants recognized barriers that refer to the lack of time due to occupational obligations (47.44%). The lack of time due to childcare or due to other activities are the third and fourth major barriers to participation in training with percentages of 25.59% and 24.65% respectively.

Table 1 - Percentages of learners' responses to the motives for participation concerning professional upgrade and certification/education recognition.

Professional advancement	**Percentages**
To keep my job	6.51%
To increase my income	20.93%
To be more efficient at work	**40%**
To find a better job	**39.07%**
Certification/Education recognition	**Percentages**
To obtain a certificate	**46.05%**
To increase my qualifications	**67.44%**

Table 2. Percentages of learners' responses to the motives for participation concerning the interest in learning

Interest in learning	**Percentages**
I like to learn new things	**48.37%**
Education should be lifelong	**48.37%**

Table 3 - Percentages of learners' responses to the motives for participation concerning personal/family life and social participation.

Personal/family life	**Percentages**
To give my children a good example	9.3%
To escape from personal/family problems	0.5%
To make the best of my free time	6.51%
I didn't have the opportunity to study as much as I wanted in the past	6.98%
Social participation	**Percentages**
To be more accomplished as a citizen	6.51%
To improve my social network	3.26%

Table 4 - Percentages of learners'responses to the situational barriers.

Situational barriers	**Percentages**
Taking care of children	25.58%
Taking care of relatives	5.12%
Occupational obligations	47.44%
Other activities	24.65%
Negative attitude of family/friends	1.4%

Then, there were a number of organizational barriers such as seminars' timing, lack of information, transportation difficulties to the venue and undesirable organization and operation of seminars at rates of 21.4%, 18.14%, 14.41 % and 12.09% respectively,

while the dispositional barriers had almost zero percentages (Table 5).
Figure 1 shows the percentages of learners' responses for the factors that would facilitate them in attending training programs. According to figure 1, the most important facilitating factor for attending seminars would have been distance learning seminars (63.26%), while the recognition of certificate obtained by the seminars is the second facilitator with a percentage of 58.6%. The next facilitators for attending seminars were 'better dissemination of seminars' and 'salary improvement', which accrued the same rate of preference (33.49%). In addition, 30.23% of the sample indicated the work facilities as a significant factor. Other facilitators, such as the best quality of seminars and the availability of child labor services during the seminar had lower rates, 16.74% and 5.12% respectively.

Table 5 - Percentages of learners' responses to the organizational and dispositional barriers.

Organizational barriers	**Percentages**
Participation cost	**60.47%**
I won't improve my work position	1.86%
Days and time I cannot attend	21.4%
The selection procedure	0.93%
Transportation difficulties	14.41%
I do not have the essential skills	1.4%
Lack of information	18.14%
A certificate is not provided	5.12%
The programs last too long	8.84%
The quality and the organization of the programs	12.09%
It is not an asset at my work	3.72%
I don't meet the typical requirements	0.93%
Dispositional barriers	**Percentages**
I have health issues	0.93%
I have learnt enough	0.47%
Such programs remind me of school	0%
I am too old to learn	0%

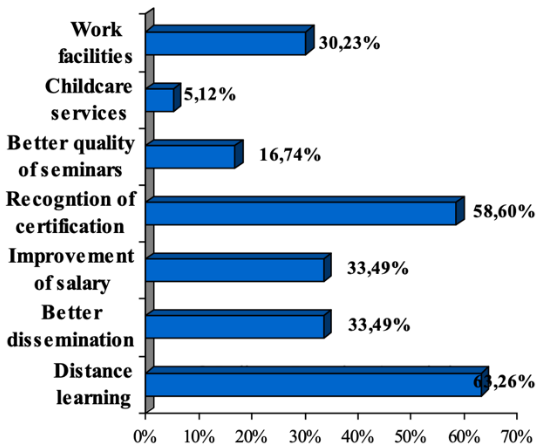

Figure 1 - Percentages of learners' responses for participation facilitators to training.

3.2 Results of the 'Vocational Education and Training: Specialization of Adult Executives, Teachers and Trainers' Program (E.E.K.)

From the EEK program, 70 questionnaires were filled out, of which 23 (32.86%) were men and 46 were women (67.14%), while 1 respondent did not answer. 17 trainees are 24 to 35 years old, 26 are 36 to 45 years old, 22 are aged between 46 to 55, and 4 are between 56 to 65 years old, while 1 respondent did not respond. Concerning the educational level, 4 trainees are graduates of secondary education, 24 are graduates of tertiary education, 8 hold a second degree, 31 hold a postgraduate degree and two have a doctorate, while 1 respondent did not answer. Regarding the working status, 47 are employees (67.14%), 21 are unemployed (40%) and 2 had not responded. From the 47 employees, 22 are educators, 16 are D.I.E.K. (Public Vocational Training Institute) trainers, 5 are O.A.E.D. (Labor Force Employment Agency) trainers and 2 are V.E.T. (Vocational Educational and Training) executives.
Table 6 below shows the percentages of the statements concerning the professional advancement motives and the motives for obtaining a certification. Analyzing Table 6, we note that the statement 'to increase my qualifications' had 64.29% percentage. A relatively high percentage (41.43%) was also accounted for the statement 'to obtain a certificate'. Regarding the motives for professional upgrade, the statement 'to be more efficient at my work' gathered 55.71%, while the statements 'to keep my job', 'to find a better job' and 'to increase my income' gathered 17.14%, 14.29% and 12.86% respectively.
Table 7 below shows the percentages of the statements concerning the motives for learning. The statement 'because education should be lifelong' gathered 52.86% of the sample's preferences, while the statement 'because I like to learn new things' statement accounted for 50%.

Table 6 - Percentages of learners' responses to the motives for participation concerning professional upgrade and certification/education recognition.

Professional advancement	**Percentages**
To keep my job	17.14%
To increase my income	12.86%
To be more efficient at work	**55.71%**
To find a better job	14.29%
Certification/Education recognition	**Percentages**
To obtain a certificate	41.43%
To increase my qualifications	**64.29%**

Table 7 - Percentages of learners' responses to the motives for participation concerning the interest in learning.

Interest in learning	**Percentages**
I like to learn new things	**50%**
Education should be lifelong	52.86%

Finally, low rates were observed for other statements such as ‘to give my children a good example’ at 8.57%, ‘to be more accomplished as a citizen’ at 7.14%. The statements ‘because I didn’t have the opportunity to study as much as I wanted in the past’ and ‘to make the best of my free time’ had the same rate of 5.71%, while the statement ‘to meet new people and improve my social network’ accounted for 4.29%.
Table 9 illustrates the percentages of learners’ statements related to situational barriers to participation in the training process. Observing Table 9, we find out that the main situational barrier to participation in training courses was the lack of time due to work commitments with 60%. Significant barriers were also considered by the trainees the lack of time due to childcare or other activities (27.14% for each of the two statements). Then, some organizational barriers were following such as the transportation difficulty to the seminar and the timetable of the seminar by gathering the same percentage of 15.71%, while the duration of the seminars as a barrier to participation gothered the 10% of the sample preference.
The cost of participation was the main barrier from the organizational barriers as it accounted for 55.71%. Then, someother organizational barriers were following, such as the transportation difficulty to the seminar and the timetable of the seminar by gathering the same percentage of 15.71%, while the lack of information and the absense of certifiaction as barriers to participation gathered the 7.14% of the sample preference. Concerning the dispositional barriers, all statements gathered low rates (Table 10).

Table 8 - Percentages of learners’ responses to the motives for participation concerning personal/family life and social participation.

Personal/family life	**Percentages**
To give my children a good example	8.57%
To escape from personal/family problems	0%
To make the best of my free time	5.71%
I didn’t have the opportunity to study as much as I wanted in the past	5.71%
Social participation	**Percentages**
To be more accomplished as a citizen	7.14%
To improve my social network	4.29%

Table 9 - Percentages of learners’ responses to the situational barriers.

Situational barriers	**Percentages**
Taking care of children	27.14%
Taking care of relatives	5.71%
Occupational obligations	**60%**
Other activities	27.14%
Negative attitude of family/friends	0%

Table 10 - Percentages of learners' responses to the organizational and dispositional barriers.

Organizational barriers	**Percentages**
Participation cost	**55.71%**
I won't improve my work position	4.29%
Days and time I cannot attend	15.71%
The selection procedure	1.43%
Transportation difficulties	15.71%
I do not have the essential skills	0%
Lack of information	7.14%
A certificate is not provided	7.14%
The programs last too long	1%
The quality and the organization of the programs	4.29%
It is not an asset at my work	2.86%
I don't meet the typical requirements	0%
Dispositional barriers	**Percentages**
I have health issues	0.93%
I have learnt enough	0.47%
Such programs remind me of school	0%
I am too old to learn	0%

Figure 2 shows the percentages of the learners’ responses to the facilitators that can be provided for attendance of training programs. As can be seen in Figure 2, an important facilitator to participate in training programs was ‘distance learning’ programs, as it collected a significantly high percentage (71.43%). The second most important facilitator was ‘the recognition of certificate’ acquired from the attendance of training programs as it gathered 50% of the sample’s preferances, while ‘better dissemination of seminars’ and ‘salary improvement’ gather 27.14% of the learners’ preferences. An important parameter for the participation of the trainees in the training was also the ‘work facilities’ with 24,29%, while the ‘childcare services during the seminars’, as a facilitator, accumulated a low percentage (5,71%).

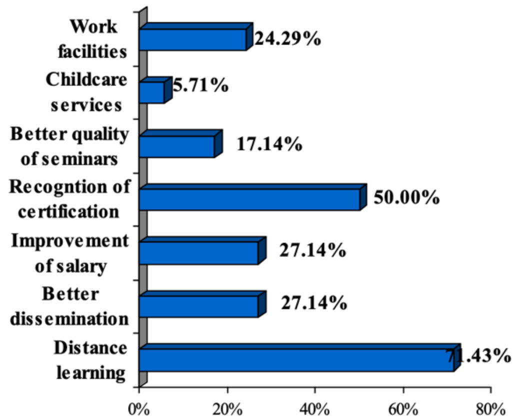

Figure 2 - Percentages of learners’ responses for participation facilitators to training.

4. Discussion

It is worth noting that the trainees' majority of both samples were young people (up to 45 years old), with a high level of education and employees. Research reveals young, employed and highly educated individuals, who seek both intrinsic motives (interest in the subjects of educational programs, personal development) and extrinsic motives (job related) for participation, are the individuals who participate in adult learning mostly (Berker & Horn, 2003). Lower participation rates are observed among less qualified and unemployed adults who report mainly professional reasons for educational training, such as finding a better job (Daehlen & Ure, 2009; Konrad, 2005).

Regarding the age, in the present study, we observe that the majority of the trainees in both programs are aged up to 45 years (61.4% in the program 'Vocational Education and Training: Specialization of Adult Executives, Teachers and Trainers' and 79.07% in the 'Training of Lifelong Learning Adult Trainers' Program). According to research findings, participation tends to decrease as age increases (specially above 45) mainly because as adults approaching retirement, they perceive less advantages coming from education to their professional development and they experience less support from their employers (Kyndt, Michielsen, Van Nooten, Nijs, & Baert, 2011). However, there is an increasing body of research that shows higher levels of intrinsic motivation to nontraditional age undergraduates (above 25) rather than younger, traditional age undergraduates (Bye, Pushkar, & Conway, 2007; Steinberg, 2006), and the same results were noted for the nontraditional female students (Justice & Dornan, 2001; Murphy & Roopchand, 2003).

Regarding the participation motives in the training process, comparing the findings of the two research samples, it was found that high rates are recorded for the reasons that are included in the categories 'certification/ recognition of education' (to obtain the certificate, to increase my qualifications), 'cognitive interest' (because I like to learn new things, because education must last throughout our lives) and 'professional advancement (to find a better job, to increase my income, to be more efficient in my work). It is worth noting the difference percentage between the two samples regarding the motive of finding a better job, since the percentage at the E.E.E.D.V.M. program is up to 39.07%, while in the E.E.K. program the percentage reaches to 14.29%. Also, the percentage of income's raising as a motive to participation shows a fairly significant difference between the two samples, as the trainees' rate of the E.E.E.D.V.M. program reaches 20.93% and the trainees' rate of the E.E.K. program reaches 12.86%. The above mentioned differences may appear due to the fact that the first program has been attended by several unemployed trainees and workers who are preparing to take part in the E.O.P.P.E.P.'s examinations in order to raise their income or to find a job, while the second program is mainly addressed to training staff and executives who have started their career and probably do not intend to change jobs.

According to literature, the main motives of adult participation in training programs are: (a) the development of social relations, (b) the external expectations, (c) the social contribution, (d)the professional development, (e) and (f) the interest in knowledge (Boshier, 1971; Boshier, 1973; Boshier & Collins, 1985). In Greece, the study of Karalis (2013) in education programs reveals that the answer "because I like to learn new things" gathered the highest rates, while high rates are accounted for the answer "because education has to last throughout our lives". High acceptance rates are also noted for reasons of professional development such as an increase in earnings, formal qualifications, finding better work, and securing a job. The same results were also found in the Karalis survey (2016) which reports the results of the three phases of his survey (2011, 2013, 2016) and it appears that the main trends remain the same, i.e. high rates are found in the categories 'cognitive interest' and 'professional advancement', while it should be noted that the findings for civil servants are not different from those of other professional categories. However, some studies show that less qualified people say that they enroll in a training course because they want to improve their self-esteem (Valentine, 1990) and to meet young people (Daehlen & Ure, 2009, Kim & Merriam, 2004).

In a survey of a sample of 223 Primary Education Teachers in two regions of Greece, the two main factors influencing their participation in training were firstly the personal development and, secondly, the acquisition of better qualifications (Salpigidis, 2011). At the survey of the National Center for Social Research (2008) the most important reasons teachers would follow a training program in the future is the improvement of teaching methods (46%) and techniques (25%) and the improvement of their scientific knowledge. On the other side, formal certification from a training program (0.7%), avoiding the daily routine (4.7%) and meeting with colleagues (4.4%) do not seem to be particularly important motivators. In a survey of 272 teachers for the assessment of ICT (Level 1 and Level 2) Training Programs, it was found that the majority of the sample (80.2%) declared personal development as a motive to participation in ICT programs, 54.1% and a 16.2% curiosity (Sergis & Cottman, 2014). Also, in a survey with a sample of 556 Primary and Secondary Teachers, teachers were found to be involved in training for their professional development (MO = 6.13) and to a lesser extent in the career development (Pampouri, Tsolakidou & Mavropoulos, 2020), while a similar survey to adult educators at the Aristotle University of Thessaloniki found that the main reasons for participation were professional (Mavropoulos, Sipitanou & Pampouri, 2019).

Regarding the barriers to participation in training, it was found that situational barriers are the main factors for not participating in training (lack of time due to work obligations, childcare, to other activities or taking care relatives). Also, the main obstacle regarding the institutional barriers is the participation cost, which accounts for a high percentage of trainees for both programs. Of the remaining institutional barriers, relatively high rates in both samples were: (a) the seminars taking place in inconvenient days and hours, (b) the lack of information on the seminars and (c) the quality and the organization of seminars which are not at the desired level. It is worth noting the percentage's difference between the two samples regarding the barrier of professional obligations, since the percentage at the E.E.E.D.V.M. program is up to 47.44%, while in the E.E.K. program the percentage reaches to 60%. This difference may be explained by the fact that the first program was attended by several unemployed trainees who had free time while, the participants in the second program were mainly employees.

As we can see, the cost of participation is the biggest barrier since it is selected by more than 60% of both research samples, as is the case of Karalis survey (2016) in all its phases, while in the 2016 survey there is a significant increase in the percentage of those who state as a barrier the lack of time due to childcare (from 28.3% in 2011 to 41.8% in 2013 and 46.2% in 2016). As we can assess, many individuals have a difficulty to self-finance their education or even participate in offered programs. It is necessary to point out that the first ten barriers are structural barriers according to Rubenson–Desjardins typology, seven factors are organizational barriers and three are mostly situational barriers according to Cross typology. Respectively, the dispositional barriers recorded low rates, a fact that we can assume the positive predispositions of adults' learners toward education. It is worth noting that in his survey, Karalis (2016) concluded in the same results, regarding the predominant types of barriers.

Regarding the factors that facilitate adults' participation in training, it was found that: (a) distance learning is the most important factor in both research samples, perhaps because both programs were distance learning programs; (b) recognition of qualifications acquired through monitoring is the second most important facilitating factor; and (c) salary improvement and more information on seminars held are the following factors indicating the same rates in both samples (27,14% in the first sample and 33.49% in the second sample). It is worth noting that the first four facilitating factors to participation in training coincide with the results of Karalis survey (2016).

5. Conclusion

The present study aimed to highlight the reasons and obstacles for the participation of trainees in two training programs of the Aristotle University of Thessaloniki. It was found that the main motives for participation concerned professional development ('in order to maintain my job', 'to increase my financial earnings', 'to be more profitable in my work') and personal development ('because I like to learn new things', 'because education has to last throughout our lives'), observing that adult learners have both intrinsic motives and extrinsic motives regarding the registration and the participation in adult education (Berker & Horn, 2003, Carré, 2001; Pires, 2009; Vertongen et al., 2009). As far as the barriers to participation are concerned, the main barriers are the situational and the organizational ones according to the statements of the survey respondents. Different categories of barriers to participation in adult education can be considered to affect an individual at different stages/needs of his life and different dimensions of learning. Most importantly, the emotional and environmental dimension seems to be mainly influenced by the different barriers and therefore requires a great deal of attention and can be the subject of future research. Currently, a critical challenge for adult learning is to overcome multidimensional barriers to participation and provide flexible services and relevant responses for the demands of the labor market and society.

The experience and the way an adult really appreciates education in relation to the stages of his life needs to be further studied. How do the motivational factors and barriers to adult education affect the different dimensions of learning and how do the different dimensions really interact with each other and shape the decision to participate in adult education, especially in a multi-faceted life of an adult learner? Finally, in order to better understand the involvement of adults in learning, it is also important to explore the level of autonomy and self-determination, i.e. whether they have a more autonomous or more controlled motivation.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 39-48

Online learning amid Covid-19 pandemic: students' experience and satisfaction

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(submitted: 6/7/2020; accepted: 22/6/2021; published: 29/6/2021)

Abstract

The outbreak of COVID-19 Pandemic forced most higher education institutions around the globe to move their teaching and learning to online mode. This had huge impact on the students, especially for those who had not been used to being online for learning before. This mixed methods study utilized correlation, factor analysis and multiple regression techniques to identify significant predictors of students' satisfaction with online learning in a higher education institution in Vietnam amid COVID-19 Pandemic. The study results show that learners' interaction with content, peers and instructors correlated to and predicted student satisfaction. The study also indicated that although students valued the chance to be online for learning during the historic time, they viewed that interaction was limited and instructors should improve online teaching pedagogy. These findings provide learners, teachers and curriculum developers with new insights into learner interaction and its relation to course contents, teaching pedagogy and learning satisfaction in an Asian context.

KEYWORDS: Satisfaction, Course Content, Interaction, Online Pedagogy, Vietnam, Covid-19.

DOI
https://doi.org/10.20368/1971-8829/1135293

CITE AS
Pham, T., Lai, P., Nguyen, V., & Nguyen, H. (2021). Online learning amid Covid-19 pandemic: students' experience and satisfaction. *Journal of e-Learning and Knowledge Society*, *17*(1), 39-48.
https://doi.org/10.20368/1971-8829/1135293

1. Introduction

The beginning of 2020 was marked by an unprecedented phenomenon when most countries in the world were engulfed by Coronavirus infection disease (called COVID-19). It was generally viewed that air travel and tourism were the worst affected sectors, but the biggest change was in education whereby a record number of students at all levels were forced to study online because of class suspension. In this process, all countries affected by the pandemic became large-scale experimental sites for online teaching. While educational institutions in the West had delivered online courses before and were ready for the change, many schools and universities in the developing world had to rely on free applications like Zoom, G-suit to have 'classes on'. However, these make-shift online lessons could hardly satisfy students, many of whom might have never been online for learning before.

During this period a few studies were conducted worldwide on different aspects of online learning such as technology, achievements and deficiencies of online

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teaching implementation, effectiveness of online session (Lowenthal, Borup, West & Archambault, 2020; Nagar, 2020). From technological aspect, it seems that applications like Zoom and Google Meet were opted by many institutions; however, there were issues with Internet security, bandwidth for both teachers and students (Joseph, Kerryn, Rudolph & Matthias, 2020; Mukhtar, Javed, Arooj & Sethi, 2020). The main purpose of using these applications was to maintain traditional classes in an online mode due to social distancing and meeting the need of students and teachers to see and support one another in learning (Lowenthal, et al., 2020). In the same line of argument, a study by Nagar (2020) on students' perception toward e-learning and effectiveness of online lessons indicated that the use of appropriate technological facilities were key contributors of effective online learning.

Vietnam was praised by global media as having the best-organised epidemic control programs in the world, but like most of other countries, this tough measure affected people of all walks of life, especially students. They had the longest lunar new year in its modern history. Nonetheless, many schools, universities and television stations started to develop and deliver online courses for learners. According to statistics from the country's Ministry of Education and Training, although universities responded quickly to the situation, nearly half of them could not conduct online teaching professionally due to the lack of prior investment in learning and content management systems (Bich, 2020).

During the COVID-19 outbreak, most Vietnamese HEIs had to switch to online teaching and learning. The country's Ministry of Education and Training (MOET) issued an official document to provide guidelines for teaching most of subjects through the Internet and on TV (MOET, 2020). At higher education level, while a few universities had been used to this mode of lesson delivery with a certain level of readiness, for example, an existence of learning management systems (LMSs), most of other institutions did not have any options but to start training their teachers and students on pedagogical and technical skills to use Zoom or G-suite for lesson delivery. These video conferencing applications were preferred choices by most universities because not all teachers and students were well prepared for LMSs in their respective institutions while Zoom or G-Suite were more economical, user friendly and had the ability to provide many educational tools in one application (Spathis & Day, 2020; Thanh, Thong & Thao, 2020). While some educators and teachers consider this emergency delivery of lessons as online learning, specialists in the field view that these video conferencing applications and tools cannot replace a fully functional LMS (although they were both called 'Học trực tuyến' in Vietnamese language).

The migration from offline to online delivery of courses met the government's policy of "School is Out, but Class is On"; however, many issues emerged including technological and academic readiness of both teachers and students, quality assurance of online courses as well as motivation and satisfaction of all people who involved in the process. As learners have become the centre of learning process, it is crucial to conduct studies on factors that influence their satisfaction in online learning in order to lay suitable foundations for future investment and implementation of online teaching and learning. This is also the aim of this study entitled "Online learning amid COVID-19 pandemic: Students' experiences and satisfaction".

The study is guided by the following three research hypotheses.

- H1: Learner-learner interaction is positively related to learning satisfaction.
- H2: Learner-instructor interaction is positively related to learning satisfaction.
- H3: Learner-content interaction is positively related to learning satisfaction.

Learners' experiences and satisfaction in online learning is rooted in various works (Cox, Black, Heney & Keith, 2015; Kuo, Walker, Schroder & Belland, 2014) but studies in online interaction were based on Moore's (1989) model which classified online interaction into three main types: learner-content, learner-learner and learner-instructor. We believe that these three types of interaction are key contributors to students' enhancement of knowledge and skills, which in turn, make them satisfied with online learning experience. In order to confirm and complement the aforementioned hypotheses, we analysed participants' answers to the opened-ended question at the end of the questionnaire.

Interaction has consistently been considered as an important element of student satisfaction together with instructors' and learners' efficacies such as Internet, self-regulation, online teaching pedagogy as well as support from educational institutions for online learning (Kuo et al., 2014; Zaili, Moi, Yusof, Hanfi & Suhaimi, 2018). In this study, however, we only reported the influence of three types of interaction on the learners' satisfaction during their fully online study amid COVID-19.

1.1 Learner–Content Interaction

Interaction with content is the process in which learners exploit the materials that are embedded in the online course for their study purposes. Content delivered in an online course can be in different forms and formats, and be complete, relevant and accurate (Marzban, 2011). The online resources involve not only learning materials but also learning activities and assignments to help learners achieve learning outcomes (Abraham, 2008). With advanced evolution of different learning management systems (LMSs), the content of an online course (e.g., study materials and activities) can be structured according to a variety of pedagogical needs of the course developers.

1.2 Learner–Instructor Interaction

In online learning environments, learner–instructor interaction has been found to be a significant predictor of student satisfaction and the most important one in guiding learners to interact with content and peers (Cox, et al, 2015; Kuo et al., 2014). Learners' behaviours in the online learning process depend a great deal on the quantity as well as the quality of instructors' guidance and feedback. In terms of quantity of interaction, learners naturally react positively to attentive instructors. Instructor's online presence could be an important factor to increase learner online presence and make them motivated and satisfied with the online learning environment (Kang & Im, 2013). In this regard, study by Gómez-Rey, Barbera & Fernández-Navarro (2017) found that instructors' pedagogy is considered the most important role, followed by being a designer, social and promoter, which include sending messages to learners to promote learning.

In developing countries, where college students' autonomy is still low, and students are used to being told what to do (Le, 2013; Loi, 2016), the role of instructors is even more important. Technical and cultural barriers also make learners' interaction with their instructors more limited. For example, in Vietnam, although Internet coverage for the whole population has increased year on year, learners who come from the countryside and stay in the university dormitory may have fewer advantages than those who live at home with their families and have broadband connection. From the cultural perspective, Asian learners view their teachers as a respectable authority, a role model and an ultimate source of knowledge in their field (Loi, 2016). Accordingly, they are reluctant to argue with instructors, ask questions for clarification, or share different views about academic matters (Raymond & Choon, 2017).

1.3 Learner–Learner Interaction

The third type of online interaction is among learners themselves, which can be in one-to-one or one-to-many format. Interaction with peers gives learners strong motivation to excel through mutual collaboration and moderation for learning (Ghadirian, Ayub & Salehi, 2017). Some studies have shown that learner–learner interaction has a positive impact on learners' satisfaction in online learning environments (Eneau & Develotte, 2012). However, studies by Gameel (2017) and Kuo et al. (2014) revealed the opposite results: learner-learner interaction was not a significantly associated with student satisfaction. This type of interaction needs to be meaningful in order to avoid the feelings of isolation, alienation disconnection and being superficial, which may cause negative effects on learners' participation (Kim, 2017).

In short, past studies have shown that in an online learning environment key factors that contributed to student satisfaction could be categorized into those relating to learner interaction with peers, instructors and course content. Is this true during the special period of COVID-19 in a developing country like Vietnam? The aim of this study is to investigate learners' satisfaction with online learning delivered at a university in Vietnam. The study was conducted through an online survey with over 3000 learners who were forced to study online due to the outbreak of COVID-19.

2. Materials and Methods

2.1 Participants and Online Courses

Participants were over 3,000 undergraduate students of a Vietnamese university. They were divided into two groups of those who learnt foreign languages like English, Chinese, Japanese, and those who studied other subjects such as business administration, information technology, banking and finance through the media of English and French. They started learning online when Vietnam had to ban large gathering of people from the end of February and exercised social distancing from the 1st to 23rd of April, 2020. Figure 1 presents the information about the participants of the study.

Data from Figure 1 shows that the majority of participants were female, accounting for over 90%. This was the common situation in foreign language universities in Vietnam where female students often outnumbered male ones. The number of language participants were also doubled that of non-language major ones (66.3% versus 33.7%). This was due to a bigger number of language faculties (10) than non-language ones (3). The Figure also depicts the participants' experience of online learning. Interestingly, before the Pandemic outbreak, the majority of participants (73%) had not experienced online learning, and only 27% had. When they had to study online, using home wifi was the most common way to connect to the Internet, followed by mobile data (3G or 4G) and other methods. Most of them also used laptop and smartphone for online learning. The connection was also stable or very stable (accounting for nearly 70% in total); however, still one third of the students experienced unstable connections.

The students had online lessons for all courses of language practice, interpreting and translation (for language major students) and specialized courses (for non-language major students) with the exception of physical education. The online courses were designed with the principle of maximizing interaction, not only between the instructors and learners but also among the learners who were requested to use the institutional email accounts for their teaching and learning. These accounts were associated with G-Suite for Education, a package that includes Google's main components for online classroom, collaboration, and communication. As mentioned earlier, before rolling out the courses, all the teachers were trained on using the applications (Zoom and G-suite) in general and imbedded communication tools in particular; for example, how to create break-out room, record lessons and even setting up social networks for out of live sessions.

In terms of instructor-learner interaction, many tools were used to support synchronous and asynchronous learning activities by textual and audio-visual tools in G-Suite. These tools allowed the teachers and students to interact before, during and after the live sessions. For example, the teachers granted access to the shared materials in Google Drive, then students followed the instructions to prepare for the upcoming lessons. The teachers also scheduled live sessions in Meet or Zoom, shared the events in Google Calendar and in the Stream section of the Google Classroom, and sent reminders to the students. During the live session, the teachers were encouraged to record their lectures and store the recordings in Google Drive for absent students to watch asynchronously. Some teachers used Zoom for their live sessions because the breakout room function allowed them to divide the class into different groups for discussion. Other teachers preferred Google Meet because it was already included in G-Suite. After live sessions, Google Classroom helped the teachers communicate with students, distribute course materials, set and collect assignments, as well as grade their work. Google Forms were also used substantially by the teachers to set quizzes and collect information from the students.

Regarding learner-learner interaction, students were involved in many activities both synchronously and asynchronously. For example, they concurrently worked on a project in a shared document while giving and receiving peer feedback. During their collaboration, the students often exchanged ideas in Google Docs in form of comments, chatted in Hangouts, or discussed on Meet or Zoom if they wanted to share screen at the same time. Another example was when students worked together to conduct a survey via Google Forms, used Google Sheets for data analysis, and then presented their findings using Google Slides. These collaborative activities were done while students maintained their communication via chat, comments, or teleconference tools.

2.2 Instruments, Data Collection and Data Analysis

At the university where this study was conducted, online lessons were delivered from the end of February to the end of May 2020. However, online teaching and learning continued after the lift of social distancing. The teachers and students either went to their offices or stayed at home and continued to deliver and access online lessons via Zoom or G-suite applications. They also made use of online chat tools, such as Zalo and Facebook, for synchronous and asynchronous interaction. Similar to the country's situation, while the university in this study has developed an LMS for some disciplines like English language studies, IT, business management, etc., the delivery of online lessons during this period relied mainly on the utilization of video conferencing applications (mostly Zoom and G-suite).

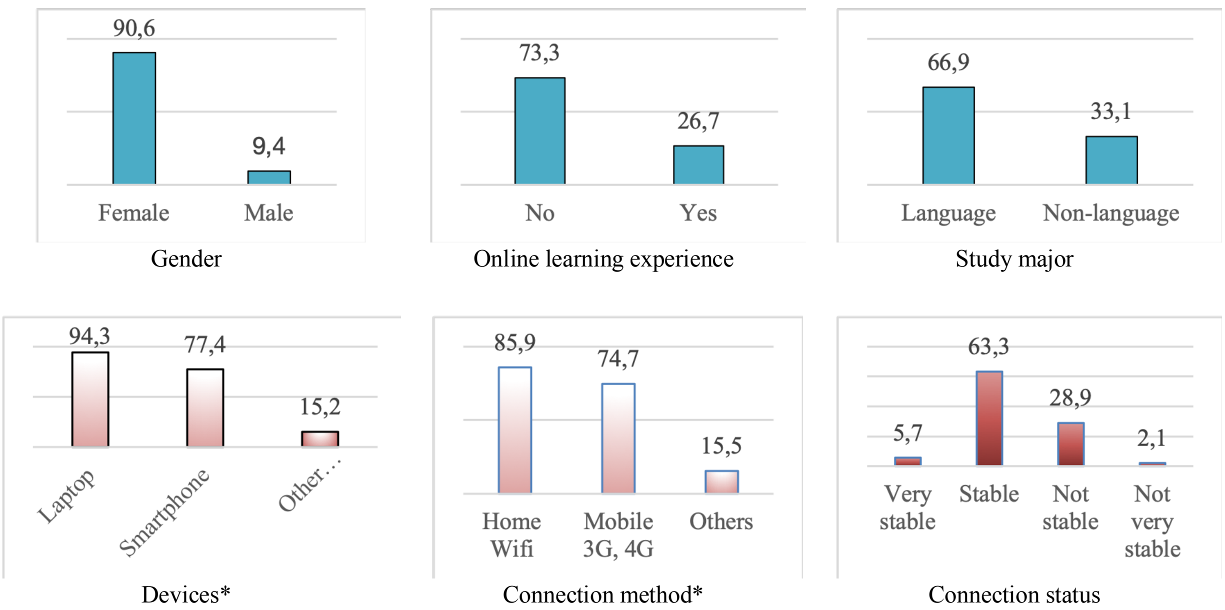

Figure 1 - Participants' profile.
** participants could choose more than one device or connection method*

In this study, the researchers adapted the survey instruments based on the prior literature (Kuo et al., 2014; Moore, 1989) which included, among other things, factors that would influence learners' satisfaction in online learning. The interaction and satisfaction subscales were revised to fit the fully online environments of this study and translated into Vietnamese. Each interaction subscale had 8 items and the satisfaction one had 4 items. The survey also included an open-ended question which aimed to collect learners' additional comments about the online study during the emergency learning.

The biggest modification to the questionnaire was in the number of points in the Likert scale. In this study, 4-point Likert-scale was used to measure learner levels of interaction and satisfaction. Standard surveys often use 5-point or 7-point Likert scales; however, there are certain drawbacks associated with the use of midpoint in Asian context. Past studies have shown that Asian students tended to choose the middle option (e.g. neither agree or disagree) in order to avoid conflict (Lee, Jones & Mineyama, 2002; Wang, Hempton, Dugan, & Komives, 2008).

Two stages were involved in the instrument development process. Stage 1: To ensure the content validity of the instrument, an expert judgement session was organized. Eight teachers, who were involved in online teaching during the COVID-19 period were invited to read the questions. They were asked to comment whether the questions were appropriate for this study. Slight modifications such as item deletion, addition and wording changes were made to assure the suitability of the questions. Stage 2: The questionnaire was piloted on 80 students who were learning online at the time. These students were later on excluded from the participants list. The Cronbach's coefficient alpha values, calculated based on the pilot sample of this study, indicated that the developed instruments were reliable (0.93).

After the pilot, the survey was hosted in Google Forms. The survey links were distributed, via email and some alternative means, to all the students. To increase the response rate, follow-up emails were sent to students as a reminder. To improve reliability, data cleaning was also conducted by removing corrupted, incorrectly formatted, duplicate, or incomplete data within the dataset. For some reasons, there were many invalid responses. For example, there were cases where participants selected one scale (usually the highest one) for most items in the questionnaire. Altogether about one fourth of the responses were removed, and only 2,279 responses were retained for analysis, accounting for 75% of the total.

The quantitative data were analysed using both simple descriptive and inferential statistics with the help of Statistical Package for Social Sciences (SPSS), version 22 (Pallant, 2011). Descriptive analyses were conducted to present the participant basic information and inferential analysis was performed to investigate factors that influenced learners' satisfaction. Qualitative data (students' answer to the open-ended question) were processed using content analysis (Miles, Huberman & Saldaña, 2014). A triangulation technique (Teddlie & Tashakkori, 2009) was adopted in the analysis of data in which the quantitative results were supported and/or explained by findings from the qualitative data.

3. Results

3.1 Hypothesis Testing

In order to test the aforementioned three hypotheses of the study, we conducted three inferential analyses, namely principal component analysis (PCA), Pearson correlation and multiple regression. These results are then confirmed by a qualitative analysis of participants' answers in the open-ended part of the questionnaire.

Principal component analysis

Before finding the correlation between three groups of factors (learner-content, learner-learner and learner instructor interaction) and learners' satisfaction, we conducted a principal component analysis (PCA). The 24 items on interaction that were supposed to influence the students' satisfaction were subjected to this analysis. Prior to performing the PCA, the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of 17 items with coefficients of 0.3 and above. The Kaiser-Meyer-Olkin (KMO) value was 0.92, exceeding the recommended value of 0.6, and the Bartlet's Test of Sphericity indicated statistical significance, supporting the factorability of the correlation matrix ($p < 0.01$).

In the PCA, eigenvalue cut-off of 1.0 was specified and the results show that 20 questions produce 5 components, which is higher than the three proposed variables. Learner-learner interaction construct was devided into two components and learner-content interaction was divided into two sub-groups of the interaction itself and the course content or materials. The total variance explained by the 5 components solution is 60.68%, which exceeded the minimum threshold of 50% variance explained. The five items on learner-learner construct were related to their answers and feedback to peers, proactiveness in the interaction and peers' feedback to their opinions. Items on learner-instructor interaction were timeliness, usefulness, proactiveness and fullness of instructors' responses to the learners. In terms of interaction with content, the items were related to their preparation before the lessons, proactiveness in the interaction with the course content, completion of online exercises and full attendance of online lessons. Regarding the course content, the items were related to its usefulness in enhancing their theoretical knowledge and skills as well the suitability of the design of the course materials and online lessons. The factor loadings for all factors ranged from 0.43 to 0.84, exceeding the threshold of 0.3.

Pearson Correlation Analysis

Table 2 shows the Pearson correlation coefficients among the variables (20 items). All three types of interaction were positively related to satisfaction ($p < 0.01$).

Learner-content interaction had the strongest correlation with student satisfaction ($r = 0.676$), followed by learner-instructor and learner-learner interactions respectively (0.597 and 0.489, respectively). All the relationships were of moderate level (Hair, Celsi, Money, Samuoel, & Page, 2011). Based on the results of Pearson correlation analysis, we can summarize the 3 hypotheses statements in this research in Table 3.

Multiple Regression Analysis

Multiple regression analysis was performed to see how much the independent variables could predict student satisfaction. Preliminary analyses were conducted to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity (Pallant, 2011). After the entry of the three variables (components), the total variance explained by the model (adjusted R square) was 0.55, which indicated that the model explained 55 per cent of the variance in perceived satisfaction.

Table 4 shows that learner-learner interaction ($t = 11.91$), learner-instructor ($t = 15.20$), learner-content interaction ($t = 23.90$) were significant predictors in explaining student satisfaction ($p < 0.001$). Comparing the contribution of each independent variable, it is shown in Table 4 that when the variance explained by all other variables in the model was controlled for, learner-content interaction made the strongest contribution to explaining the satisfaction ($ß = 0.43$). Beta values for two other variables (learner-instructor and learner-learner interactions) indicated relatively similar contributions (0.19 and 0.27 respectively).

3.2 Confirmation of Quantitative Results

As mentioned earlier, in order to confirm and compliment the above findings, we analysed the qualitative data which came from the participants' answers to an open-ended question at the end of the survey questionnaire. Around two thirds of participants expressed their opinion about different aspects of online learning. We grouped these opinions into those related to the aforementioned results of quantitative analysis and also those concerning their experiences about online learning during COVID-19 period.

The quantitative data analysis indicated that learners' interaction with content was the strongest predictor of students' satisfaction. The specific items included effectiveness, quality, design of online materials and learners' proactiveness in their interaction with it. In terms of online materials, due to the emergency of the lessons, most instructors prepared PowerPoint slides and presented them directly in the lessons or pre-recorded the lessons and broadcast them for the students to watch. The instructors then designed exercises in form of big assignments, case studies, multiple-choice practice for the students to work individually, in pairs or groups. In the answers to the open-ended questions, many participants viewed that the online contents should be more appropriately designed or shortened to produce interesting lessons.

I am aware that it takes more time and efforts to design online lessons. However, I want course materials to be better designed so as to fit with the online class length (ID 2091).

Instructors should record lessons and upload for students to watch in advance in order to increase understanding and re-watch if necessary (ID 1497).

In short, the course content in general and learners' interaction with it received a lot of attention from the learners. This seems to indicate that they did care about the quality of the course content, materials and how these were delivered in an online environment.

The results of quantitative analysis revealed that interaction with peers and instructors were also significant predictors of student satisfaction, despite at lower levels. Nonetheless, in their answers to the open questions, the participants had different views on this issue. While some claimed that *'the online learning saved time and cost, however, interaction was not effective*"(ID 1356); some others commented that *"online learning is very effective and interaction with the instructors is easy"* (ID 1544) or "*Instructors provide a lot of real examples, which helps learners easily understand the lessons"* (ID 1326). Followings were some of other comments on interaction during the online study period.

There was no interaction in online learning like this, especially for writing course. It took the instructors a lot of time to answer my question because of unstable Zoom (ID 2412).

I do not want to learn online in the future because in language learning, it is necessary to have face-to-face interaction with instructors and peers for learning effectiveness (ID 304).

The applications allowed students to enter chat rooms and work in pairs or groups. However, due to a number of reasons, this interaction was still limited and many participants wanted to see more online interaction.

I hope instructors will design more questions for learners to discuss and interact during the lesson (ID 2532).

I am really disappointed in the use of the applications because they were not effective for groupwork, which led to less interaction among the students (ID 2290).

There was a common sense among the participants that instructors play a very important role in promoting online interaction through applying effective teaching pedagogy.

Table 1 - Rotated factor loadings for constructs.

Rotated Pattern Matrix					
	Component				
	1	2	3	4	5
1. I usually gave feedback to peers' opinion.					0.804
2. I usually answer peers' questions.					0.835
3. Peers often responded to my opinions.		0.637			
4. I was proactive in interaction with peers.		0.755			
5. I usually work with peers to do assignments.		0.787			
6. My peers were proactive in interaction with me.		0.799			
7. I used different tools to interaction with peers.	0.429				
8. Instructors often posted questions on forum for discussion.	0.565				
9. I received full answers from instructors when necessary.	0.713				
10. Instructors' answers were useful to me.	0.757				
11. Instructors proactively interacted with me.	0.758				
12. Instructors responded to my questions in a timely manner.	0.824				
13. I proactively interacted with online materials.			0.622		
14. I read the materials before online lessons.			0.671		
15. I fully attended online lessons.			0.675		
16. I completed exercises as requested by the instructors.			0.728		
17. The lesson content helped me enhance theoretical knowledge.				-0.654	
18. The lesson content help improve my practical skills.				-0.678	
19. The materials were suitably designed for online learning.				-0.825	
20. The lesson content was suitably designed for online learning.				-0.839	

Table 2 - Correlation between variables.

Interaction	1	2	3	4
1. Learner-learner	1	0.390**	0.446**	0.489**
2. Learner-instructor		1	0.585**	0.597**
3. Learner-content			1	0.676**
4. Satisfaction				1
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 3 - Hypothesis testing.

Hypotheses	Correlation coefficient	Conclusion*
H1: Learner-learner interaction is positively related to learning satisfaction.	0.489	Supported: Moderate relationship
H2: Learner-instructor interaction is positively related to learning satisfaction.	0.597	Supported: Moderate relationship
H3: Learner-content interaction is positively related to learning satisfaction.	0.676	Supported: Moderate relationship

Table 4 - Multiple regression of three predictors of student satisfaction.

	Coefficient	t	Sig.	Tolerance	VIF
(Constant)		-4.567	0.000		
Learner-learner	0.191	11.907	0.000	0.776	1.289
Learner-instructor	0.269	15.197	0.000	0.637	1.569
Learner-content	0.434	23.896	0.000	0.602	1.661
Adjusted R squared: 0.55					

Many instructors do not have suitable online teaching pedagogy. Hence, the lessons became difficult to grasp. I hope instructors will change their pedagogy (ID 134).

I want the university and instructors to have more effective pedagogy and to reduce pressure on the students (ID 2564).

In short, the participants' written comments partially supported findings of the quantitative results, which further consolidate the importance of interaction in online teaching and learning. The comments also demonstrated that due to the emergency of online teaching, the instructors did not seem to prepare well for the live lessons and learners wanted to see higher quality course content and more interaction with peers and instructors.

4. Discussion and Conclusions

This study aimed to explore factors that influenced online learning satisfaction at a large university in Vietnam. The combined analyses of quantitative and qualitative data sets indicated that course content, interaction and instructors' online teaching pedagogy were three groups of factors affecting online learners. The results of this study will now be compared to the findings of previous works.

In this study, the PCA results were consistent with previous research on the factors influencing satisfaction in online learning, with learner-instructor related items loading strongly on Component 1, learner-learner items loading strongly on Components 2 and 5, and course-related item loadings strongly on Components 3 and 4 (learner-content interaction). The Cronbach alpha values for all the retained items were over .70, which suggests acceptable internal consistency among the items (DeVellis, 2003).

Correlation and multiple regression analyses indicated that learners' interaction with content, peers and instructors were all positively related and significant predictors of student satisfaction. The results indicated that all hypotheses H1, H2, and H3 were supported. First, the fact that learner-content interaction was the strongest predictors and received a lot of written comments from the participants indicated that content of an online course should be appropriately designed and delivered for optimal effectiveness of interaction. This result is consistent with previous studies (Goh, Leong, Kasmin, Hii & Tan, 2017; Kou et al., 2014).

To promote learning-content interaction, firstly, the quality of the course content has to meet learner expectation. One of the key elements of course content is the design, which had proven important in student satisfaction (Chen & Yao, 2016; Zaili et al., 2019). Due to the emergency of online teaching and learning during the COVID-19 Pandemic, not all instructors and learners were prepared well academically for an online teaching and learning environment. Hence, the interaction did not occur as they had expected. In addition, the migration of traditional teaching method to online one needs more efforts from the instructors and supports from educational institutions.

Both learner-instructor and learner-learner interactions were significant predictors for student satisfaction but the contribution was relatively small (beta of 0.24 and 0.23, respectively). Although this finding seemed to be consistent with some research (Shen, Cho, Tsai, & Marra, 2013), they differed from other published studies (Gameel, 2017; Kuo, et al., 2014). The small contribution of these two types of interaction could be explained by the fact that the interactions mostly occurred during the online lessons. In addition, learners might have viewed that in learning language and other subjects through media of languages, interpersonal interaction did not help much in improving their language competence.

In order to increase learner-instructor interaction, instructors play a crucial role, especially in providing pedagogical instructions, using different types of interactional matrices, technological tools, and learning analytics (Chen & Yao, 2018; Cox et al., 2015; Gómez-Rey, et al., 2017). In language learning, providing valuable in-text written, audio, personalized or holistic feedback to both individuals and groups of learners would make them feel the interaction more meaningful (Cox et al., 2015; Kim, 2017). In other words, the instructors' messages should be of high quality and useful to attract learners' desire to interact (Ghadirian, et al., 2017; Gómez-Rey et al., 2017). This combination of findings provides some support for the conceptual premise that it is necessary to provide instructors with necessary pedagogical, social, and technical skills in online teaching (Yükselir, 2016). It is also worth mentioning that in Asian culture, learners view their teachers as a respectable authority, a role model and an ultimate source of knowledge (Loi, 2014; Raymond & Choon, 2017).

In short, the study results show that online interactions with content, instructors and peers were significant predictors of student satisfaction. However, in order to have meaningful online interaction, a lot more efforts are needed, especially training on pedagogy for instructors. In an Asian context where students are passive and tend to rely on their teachers, these findings are meaningful, suggesting that more attention should be paid to pedagogical training of online teachers, who should not only be equipped with knowledge and skills in online content design, lesson delivery but also with facilitation and promottion of online social interaction (Gómez-Rey et al., 2017).

There are a number of other important implications from this study. First, it has gone some way towards enhancing our understanding of student satisfaction in online learning. It confirms previous findings and contributes additional evidence which suggests the need to pay a close attention to the course content (e.g. design, usefulness of interaction, flexibility of delivery), instructors (e.g. pedagogy), and learners (e.g.

proactiveness). Second, whilst this study did not confirm the role of Internet self-efficacy, it did partially substantiate the need to conduct careful hands-on orientations for both learners and instructors before the delivery of an online course and to provide continuous technical support during the course implementation. In short, the combination between academic and technical experts is strongly recommended to ensure quality of course materials on one hand and design and ease of use on the other hand. These factors are important in promoting student satisfaction with an online course.

The findings in this study are subject to at least three limitations. First, these data applied only to the learners' perceptions about the online course. In order to get a fuller picture of learner interaction with course content, peers and instructors, future studies should include factual data on grades, time-on-task and online messages to increase validity. Second, the study was conducted at only one university in Vietnam, thus the findings might not be transferable to other online teaching and learning contexts. Third, the study did not conduct a survey with the instructors, who should play the role of content facilitators, designers, social interaction and even life skills promoters (Gómez-Rey et al., 2017). Future research should therefore concentrate on the investigation of instructor perceptions about their experience in online supervision and other related factors in different online teaching and learning contexts.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 49-61

Classification models in the digital competence of higher education teachers based on the DigCompEdu Framework: logistic regression and segment tree

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(submitted: 4/3/2021; accepted: 1/7/2021; published: 2/7/2021)

Abstract

To promote and develop the digital competence of higher education teachers is a key aim in the 21st century. Teachers must have a leader or expert digital competence in order to prepare future school-leavers for a competent professional qualification. Therefore, the purpose of this study is to determine the predictor variables encouraging high digital competence, using two statistical classification techniques: multiple logistic regression and classification trees. The analysis of teachers' digital competence was carried out in each of the areas of knowledge in which the teachers are assigned, as well as overall. For data collection, a non-experimental ex post facto design was used. A total of 1,104 higher education teachers from Andalusia (Spain) completed the DigCompEdu Check-In instrument prepared by the European Commission's Joint Research Centre. In terms of general classification, the results found that the logistic regression technique ranked teachers' digital competence with greater probability of success (83.7%) in comparison to the segment tree (81.7%). The results found that the level of digital competence of teachers in the creation and use of digital resources varies according to the area of knowledge to which the teachers are assigned. At a general level, the development of digital competence at the leader, expert or pioneer level is related to various factors, such as the time spent on creating web spaces and digital content, and the use of virtual reality, robotics, and gamification. Further research is recommended to validate these preliminary findings in each of the areas of knowledge.

KEYWORDS: Digital Competence, Digital Literacy, DigCompEdu, Higher Education, Teacher Training, Multiple Logistic Regression, Classification Trees, Research Methods

DOI
https://doi.org/10.20368/1971-8829/1135472

CITE AS
Cabero-Almenara, J., Guillén-Gámez, F.D., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2021). Classification models in the digital competence of higher education teachers based on the DigCompEdu Framework: logistic regression and segment tree. *Journal of e-Learning & Knowledge Society*, *17*(1), 49-61. https://doi.org/10.20368/1971-8829/1135472

1. Introduction

The significance of information and communication technologies (ICTs) in the information society and in the Fourth Industrial Revolution make digital competence a key domain to operate in such digital scenario, which has been defined as a competence that "involves the safe and critical use of information society technologies for work, leisure and communication purposes" (EU Council, 2018, p. 9). Its presence in society is also perceived in educational institutions, where teachers have never had so many technological resources available to carry out their professional activities (Falloon, 2020). And this presence, as successive Horizon reports have highlighted, requires teachers to be equipped with relevant levels of digital competence to manage these media educational environments (Alexander et al., 2019).

At the university level, research highlights the lack of teacher training for the incorporation of ICT in teaching (Guillén-Gámez & Mayorga-Fernández, 2020a; Rolf et al., 2019), and the need to develop training plans. These programmes should be carried out using models other than technological-instrumental ones, and be focused on the instrumental training of teachers in technologies, as well as adopting other perspectives, such as TPACK (Mishra & Koehler, 2006), the model for developing digital teacher competence by Krumsvik (2011), or the so-called SAMR (Substitution, Extension, Modification and Redefinition) Puentedura model (Garcia-Utrera et al., 2014). This lack of digital training is due to the fact that teachers often focus more on the pedagogical than on the didactic (Cabero & Martínez, 2019; Solís de Ovando & Jara, 2019), since pedagogical training is presented as a good predictor for its didactic use (Li et al., 2019), and who's training simultaneously improves teachers' beliefs and attitudes towards the educational use of ICT (Semerici & Kemal, 2018). It is also interesting to change from a traditional view of ICT to broader conceptions, such as LKT (Learning and Knowledge Technologies) and TEP (Technologies for Empowerment and Participation) (Pinto et al., 2017; Gómez-Triguero et al., 2019; Guillén-Gámez et al., 2020a).

Regarding teachers' level of digital skills, it should be noted that there is a low level of competence (Alarcón et al., 2020; Guillen-Gamez et al., 2020b). Thus, more study and analysis are required to establish training actions in regard to the pedagogical-didactic component than in the technological-instrumental component (Cabero-Almenara & Barroso, 2016; Pozos & Tejada, 2018; Mercader, 2019; Pérez-Díaz, 2019; Guillén-Gámez & Mayorga-Fernández, 2020b). These points require the analysis of this competence because teachers' low level of skills in this area results in less and unskilled educational use of ICT by teachers (Padilla-Hernández et al., 2020). On the other hand, as this domain has a cross-sectional impact on other competences that the teacher must have in their study and analysis, it becomes even more necessary (Almerich et al., 2019).

Such is the importance of these latter aspects, that the Horizon 2019 EDUCASE Report identified the following six emerging technologies as likely to have the most significant impact on higher education for the next five years (2019–2023): mobile learning, analytical technologies, mixed reality, artificial intelligence, blockchain, and virtual assistants (Alexander et al., 2019). To use these with their students, university teachers must possess sufficient competencies.

Different studies have identified a range of variables which may contribute to improving the level of digital teacher competence (DTC), including:

a) The teaching experience this professional group has of implementing ICT (Fernández et al., 2018; Oudeweetering & Voogt, 2018; Cheng et al., 2020).
b) Gender, which commonly reveals different uses (Pozo et al., 2020), and generally negative effects on women (Balta & Duran, 2015; Cabero et al., 2017; Ilkan et al., 2017; Guillén-Gámez et al., 2020); although the female gender is more favorable for virtual training (López et al., 2018).
c) The age of teachers, where younger teachers demonstrate a higher level of skill and a more positive attitude towards the use of ICT (Gallardo et al., 2018), and who are, in turn, more interested in their training regarding these competences (Garzón et al., 2020).
d) The time of use spent on technology, which represents a determining factor in the acquisition of new digital procedural skills (Krumsvik et al., 2016; García-Marco et al., 2020).
e) Profiles on social networks, where the use of these networks in didactic tasks supposes a moderate level of digital competence (García-Pérez et al., 2016; Porlan & Sanchez, 2016; Eyo, 2016; Sánchez-Gómez et al., 2017).
f) The creation of collaborative sites (webs, blogs, wikis) is related to the production of knowledge, promoting digital competence (Tusiime et al., 2019; Ligurgo et al., 2019; Varela-Ordorica & Valenzuela-González, 2020).
g) The ability to create digital content such as posters, concept maps, infographics, online activities, and online questionnaires (Yuyun, 2018; Badia et al., 2019).
h) The adequacy of incorporating gamification into the learning process for the acquisition of digital skills (Torres-Toukoumidis & Mäeots, 2019).
i) The use of virtual worlds to generate content, fostering an optimal learning environment (Lamb & Etopio, 2019; Sanglub et al., 2019).

All previous studies are based on self-made models. However, different competency frameworks have been proposed from an institutional perspective; according to different authors (Lázaro et al., 2019; Rodríguez-García et al., 2019; Feerrar, 2019; Silva et al., 2019; Cabero-Almenara & Palacios-Rodríguez, 2020; Ranieri & Bruni, 2018), the following can be considered as the most consolidated and significant of these: the European Union Framework for Digital Teacher Competence-DigCompEdu (Redecker & Punie, 2017); the Framework of the International Society for Technology in Education (ISTE) for teachers (Crompton, 2017); the UNESCO ICT skills framework for teachers (Butcher, 2019); the common framework of digital teaching competence of the National Institute of Educational Technology and Teacher Training (INTEF, 2017); the UK Digital Teaching Framework (Education and Training Foundation, 2019); ICT skills for the professional development of teachers in the Colombian National Ministry of Education (Fernanda et al., 2013); and ICT skills and standards for the teaching profession of the Chilean Ministry of Education (Elliot et al., 2011). These frameworks, besides proposing the competences teachers must be trained in, aim to identify training needs and propose personalized training plans (Flores-Lueg & Roig Vila, 2016; Leaning, 2019; Lee, 2019; Yazon et al., 2019).

Taking into consideration the scientific literature on digital competence in higher education teachers, as well as in current research DigCompEdu has been selected as the most appropriate model to measure digital competence of teachers (Cabero-Almenara et al., 2020a, 2020b), this study focuses on this competence framework. For this reason, the main objective of this study is the identification of those predictors that significantly influence the acquisition of digital competence (according to DigCompEdu) by university teachers at an expert, leader or pioneer level, depending on the area of knowledge to which they are assigned, as well as overall. To achieve this, two classification techniques are used: a multiple logistic regression model to identify the significant predictor variables; and, a segment tree to identify significant relationships between pairs of categories in the predictors presenting a greater probability of achieving high or low digital competence.

2. Materials and methods

2.1. Design

To achieve the objectives of the study, we applied a non-experimental design using surveys. Once the data was collected, inferential analysis was carried out to predict high digital competence among university teachers in the Andalusian territory.

2.2. Participants

Non-probability sampling was used to purposefully select 1,104 higher education teachers in Andalusia (Spain) during the academic year 2019–2020. Specifically, 72.8% (n = 804) of the teaching staff belonged to the University of Seville, 14.3% (n = 158) to the University of Malaga, and 12.9% (n = 142) to the University of Almeria. Data privacy was guaranteed since the survey was anonymous, and participants were informed of the study purpose prior to completion of the survey. In terms of the demographic profile of participants, 46% (n = 508) were female, and 54% (n = 596) were male. Teachers under 29 years old represented 9.1% (n = 101) of the sample; 12.5% (n = 138) were between 30 and 39 years old; and 78.4% (n = 865) were over 39 years old.

In terms of academic profile, teaching staff from the Arts and Humanities area represented 13.6% (n = 150) of the sample; of these, 69.3% had at least ten years of teaching experience, 62.7% had been using educational technology for at least 10 years, and only 34.7% had more than four social media accounts. Science teachers represented 12.5% (n = 138) of the sample; of these, 83.3% possessed at least 10 years' experience, 72.5% had been using technology for at least 10 years, and 14.5% had more than three social media networks. Health sciences teachers represented 15.4% (n = 170) of the sample; of these, 71.8% had at least 10 years of teaching experience, 52.9% had been using technology for at least 10 years, and 67.1% had more than three social networks. Engineering and architecture teachers represented 22.8% (n = 252) of the sample; of these, 81.3% had at least 10 years of experience, 72.2% claimed to have been using technology for at least 10 years, and 25.4% had more than three social media accounts. Finally, social and legal sciences teachers represented 35.7% (n = 394) of the sample; of these, 73.1% had least 10 years teaching experience, 70.6% claimed to have been using educational technology for at least 10 years, and 35% had more than three social media accounts.

2.3 Instrument

The DigCompEdu Check-In instrument designed by Ghomi and Redecker (2018) and published by the Joint Research Centre (JRC) of the European Commission, was used to measure the digital competence of teachers.

It is a specific framework aimed at educators at all stages of an educational system, from early childhood to higher education, including vocational training, education for special needs and non-formal learning contexts. The authors chose this instrument as it is a general reference framework for those who develop models for the development of digital competence, such as the Member States of the European Union, regional governments, national agencies and both public and private vocational training centers.

The instrument was translated and adapted to the Spanish context by Cabero-Almenara and Palacios-Rodríguez (2020). The 22 items scored in the questionnaire relate to six areas of competence: the professional commitment dimension focuses on the teachers' work environment, in order to take into account the different agents of the educational community (4); the digital resources dimension is related to the creation and distribution of digital resources in the classroom, respecting copyright rules (3); the digital pedagogy dimension is associated with knowing how to design and plan the use of technologies in student learning, focusing on active methodologies (4); the evaluation and feedback dimension focuses on the use of ICT resources for student evaluation (3); the empowering students dimension relates to ensuring digital access to all students, offering learning activities adapted to their level of competence, their interests, and educational needs (3); and finally, the facilitating the digital competence of students dimension (5).

To measure the level of competence, a five-point Likert scale was used as well as the original DigCompEdu instrument (Cabero-Almenara & Palacios-Rodríguez, 2020; Ghomi & Redecker, 2018; Redecker & Punie, 2017), with the different values on the scale referring to the following progressive levels: novice, with very little experience and contact regarding educational technology (A1); explorer, little contact with educational technology, in need of external guidance for integration in the classroom (A2); integrative, who experiments with technology and tries to adapt it to their educational context (B1); expert, who makes use of a wide range of ICT resources to improve their teaching practice (B2); leader, who is able to adapt ICT resources to the individual needs of students, as well as provide inspiration and creativity for other teachers (C1): and pioneer (C2) who lead innovation with ICT and are a role model for other teachers.

However, the instrument and its psychometric properties had not been fully validated, as only content validity had been established, through expert judgement and reliability analysis, not construct validity (Caena & Redecker, 2019; Ghomi & Redecker, 2018).

2.4 Procedure and analysis

Once the sample data was collected, atypical cases were eliminated through exploratory graphic visualisation methods (blank answers). To test the internal structure of the test, Cronbach's alpha was used to check reliability, and exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were used to check construct validity. In terms of statistical software, SPSS V.22 and AMOS V.22 were used to check the modelling of structural equations (SEM) based on the relationships between the items of the instrument. For the logistic regression technique, the stepwise procedure (step by step) was used to select the best model, with all the variables described in Table 1. For the classification trees, the CHAID (Chi-square automatic interaction detection) method was applied to detect relationships between pairs of significant variables using the maximum likelihood technique. CHAID was chosen since it allowed the automatic detection of interactions using Chi-square. At each step, CHAID chose the independent variable that exhibits the strongest interaction with the dependent variable

For both classification techniques, the total score of the teachers' digital competence was recoded into a dummy variable with two categories: high digital competence at the expert, leader or pioneer level (value 1), and low digital competence at the novice, explorer or integrator levels (value 0). The characterization of variables employed in the study can be found in Table 1: all of them are nominal qualitative in nature.

3. Results

The results will be presented in the following sections: first, the psychometric properties of the instrument; second, the results of the multiple logistic regression model; and finally, the segment tree results.

3.1 Psychometric properties of the instrument

The reliability of the instrument was verified through two analyses: Cronbach's alpha and McDonald's omega coefficient. Both coefficients produced very satisfactory results, both in the dimensions of the instrument and as a whole. Table 2 shows the different calculated coefficients. All values, according to O'Dwyer and Bernauer (2014), denote high levels of reliability.

In the EFA, we used the maximum likelihood method using oblique rotations. The Kaiser-Meyer-Olkin index was appropriate (KM = 0.963), and the result for Bartlett's Chi Square test was significant (χ^2 =

Factors	Variable	Categories
VD	Digital competence of teachers	0: Low 1: High
Demographic and academic factors	Gender	0: Male - 1: Female
	Age	0: Up to 29 years old - 1: Between 30 and 39 - 2: Over 40 years old
	Teaching experience	0: Under 10 years - 1: Over 10 years
	Time using educational technology	0: Less than 10 years - 1: More than 10 years
	Number of social media	0: Up to three - 1: More than three
Factors in educational technology	Creation of educational websites	0: No - 1: Yes
	Creation of online activities	0: No - 1: Yes
	Creation of online questionnaires (test)	0: No - 1: Yes
	Digital posters, conceptual maps	0: No - 1: Yes
	Creation of blogs or wikis	0: No - 1: Yes
	Working with robotic technology	0: No - 1: Yes
	Use of gamification (Kahoot, Plickers, Menti)	0: No - 1: Yes
	Use of virtual reality	0: No - 1: Yes

Table 1 - Description of variables.

11701.781; df = 171; sig. <0.05). The proposed model explained 71.86% of the true variance in the instrument scores, sequentially classified as follows: 49.83% for the evaluation and feedback dimension; 5.98% for digital pedagogy; 4.68% for empowering students; 4.24% for digital resources; 3.87% for facilitating the digital competence of the students; and, finally, 3.25% for professional commitment. However, three items did not produce correct results in their dimensions and showed values below 0.3, and so were removed from the questionnaire.

	Cronbach's Alpha	McDonald's Omega
Professional commitment	0.767	0.957
Digital resources	0.691	0.958
Digital pedagogy	0.746	0.957
Evaluation and feedback	0.823	0.956
Empower students	0.810	0.957
Facilitate students' digital competence	0.835	0.967
TOTAL	0.942	0.993

Table 2 - Reliability of the instrument.

The CFA was verified with the theoretical proposal of the six dimensions with the 19 selected items. For this, the maximum likelihood method was selected, using the thresholds recommended by Bentler (1989) and Hu and Bentler (1999): CMIN/DF (mean chi square/degree of freedom<3) = 2,822, p = <0.05; CFI (comparative fit index>0.7) = 0.960; TLI (Tucker-Lewis index>0.7) = 0.950; IFI (incremental fit index>0.7) = 0.960; RMSEA (root mean square error of approximation<0.1) = 0.057, with thresholds between 0.051 and 0.064. The proposed model with 19 items and 6 correlated latent dimensions showed the factorial structure formulated in the CFA. Figure 1 shows the Structural Equation Model.

3.2 Verification of assumptions in classification techniques

The assumptions allowing this type of classification techniques were verified. It was found that there were no multicollinearity problems concerning the predictor variables, and no correlations greater than 0.6 were found (Silva & Barroso, 2004). The Hosmer and Lemeshow test (1989) determined that the interaction between the predictors and their logarithmic transformations was significant in the proposed model (χ^2 = 7.408; df = 8; sig.> 0.05), so there was a linear relationship with the logic one. Finally, Josephat and Ame (2018) explain that one of the general rules in logistic regression requires a sample size where N> 50 + (8 * the number of predictor variables). In our case, we relied on four predictor variables (50 + 8 * 14) = 162. In terms of segmentation techniques, Berlanga et al. (2013) advise avoiding samples with less than 1,000 cases. In the present study, a sample of 1,104 subjects was obtained, so we fulfilled the assumption.

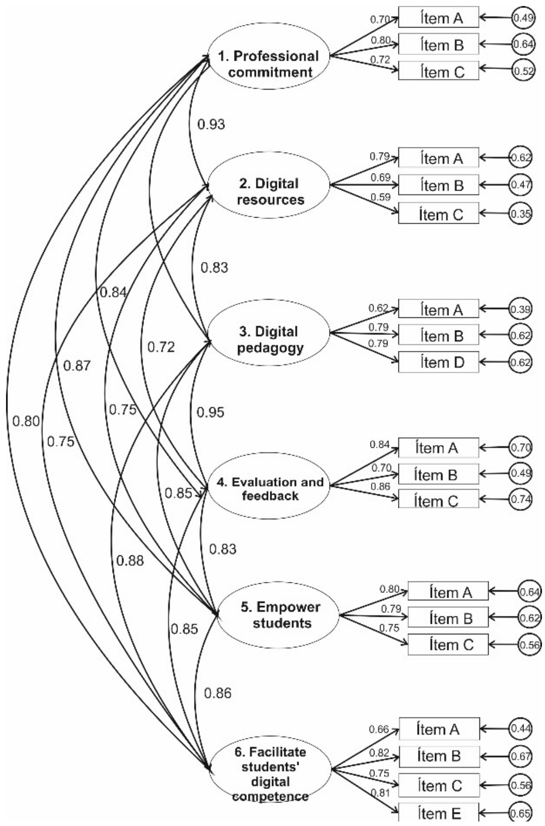

Figure 1 - Model of structural equations.

3.3 Determination of the multiple logistic regression model

The Omnibus test indicated that the proposed model contributed to predicting high digital competence by making a correct and significant estimation (χ^2 = 471.6516 df = 14; p. <0.05). The model explained 49.3% of the variance in VD according to Nagelkerke's R2. Likewise, we showed that it was able to correctly predict 83.7% of the cases; thus, the model produced satisfactory results (Table 3). Regarding the case of teachers who had low digital competence at the novice, explorer, or integrator level, we correctly classified a total of 91.74% of teachers having such levels (model specificity), and 62.62% who had high digital competence at a leader, expert or pioneer level.

	Predicted		
Observed	Low competence	High competence	% of accurate cases
Low digital competence	733	66	91.7
High digital competence	114	191	62.6
% of accurate cases			83.7

Table 3 - Number and percentage of cases correctly classified regarding the prediction of digital competence.

Table 4 shows that the proposed model contains 12 significant predictor variables: length of use of educational technology; number of social networks; length of educational experience; the creation of digital activities, as well as posters and concept maps; influence students to create blogs, work robotics, gamification, virtual reality, websites, just as age ranges up to 29 years old and between 30–39 years old. If p- is denoted as the probability of success in achieving high digital competence and q- as the probability of failure in low digital competence, it is true that p + q = 1, since there are not two possible outcomes. The linear function falls on the logarithm of the following equation, where β represents the constant, and χ is the factorial significance in view of the following predictive variable:

$$\gamma = \beta 0 + \beta 1 * \chi 1 + \beta 2 * \chi 2 \ \ldots\ldots \ \beta k * \chi k$$

Using the odd ratios of each predictor, the probability of success when acquiring a high digital competence at the leader or expert level can be calculated for the different values of each of the significant predictors.

The equation is: $$\boldsymbol{p = \frac{1}{1+e^{-Y}}}$$

For example, for a teacher aged between 30 and 39, who has been using ICT for at least 10 years, has at least 10 years of experience and knows how to create digital activities, posters and concept maps, blogs, works robotics, gamification and virtual reality with students, their probability of having a high digital competence at an expert, leader or pioneer level according to the coefficients in table 4 is:

Y=-3.073+1.169*1+0.814*1-1.202*1+0.772*1+1.288*1+0.924*1-0.757*1+0.612*1+0.812*1+0.766*1+1.009*1=3.134

$$\boldsymbol{p = \frac{1}{1+e^{-(3.134)}} = 95.83\%}$$

To calculate the probabilities in each of the areas of knowledge the teaching staff are assigned to, the coefficients in Table 5 can be input to the equation γ = β + β1 * χ1, as well as the exponential values of the Exp (β) themselves. It should be pointed out that in the area of sciences, no coefficient appears for the robotic variable since there was no teacher who employed this technology; thus, the regression model did not include it. Furthermore, the proposed model takes the age range as the reference characteristic of the category 0, so it does not provide coefficients.

3.4 Classification tree analysis

With the same sample of 1,104 university teachers and the same independent variables, we created a classification tree for digital competence using the CHAID algorithm. Digital competence was separated by category using the same characteristics as the logistic regression model: low digital competence with a novice, explorer, or integrator profile; or high digital competence with an expert, leader or pioneer profile. The analysis obtained 15 nodes (Figure 2). The first variable defining digital competence was encouraging students to create posters and concept maps, which two initial nodes were linked with. The most significant nodes were: node 1, which classifies those teachers who did not know how to create posters and concept maps, consequently representing 87.4% of the low digital competence group; node 3 reflected teachers who did not know how to create posters and concept maps, but who also did not know how to create digital activities, consequently representing 91.3% of the low digital competence group. Moreover, those who, in addition to not knowing how to create the aforementioned ICT resources, had not worked with gamification resources, representing 95% of the low digital competence group.

Node 2 classified those teachers who knew how to create posters and concept maps representing 54.8% of the high digital competence group. Aside from knowing how to correctly use these resources, they had the competency to create websites, representing 88.7% of the high digital competence group. In addition, those with profiles on more than three social networks represented 100% of the high digital competence.

Table 6 shows that the proposed model correctly described 81.7% of the teachers. Specifically for each category of the digital competence variable, the model offered a higher correct percentage for the “low digital competence” category, representing the 92.2%.

4. Discussion

The main objective of this study was to evaluate and compare two statistical classification techniques for the development of high digital competence among higher education teachers at the leader, expert or pioneer level: multiple logistic regression and classification trees. In addition to identifying which predictor variables can accurately predict the possibility that teachers possess high digital competence in the specific branches of knowledge they are attached to, the segmentation tree offers the additional opportunity to understand the associations between digital competence and the most significant predictor variables.

The results showed that the logistic regression leads to a slightly higher rate of correct classification of high education teachers’ in regard to their level of digital competence (83.7%) compared to the classification tree (81.7%). However, the latter technique presents a better adjustment to the percentages corresponding to specificity (ability to correctly differentiate those with low digital competence), while sensitivity (ability to correctly differentiate those with high digital competence) is greater using the regression technique.

In relation to the logistic regression and the Wald statistic test, the most influential variable was knowing how to create digital content such as posters, concept maps, and blogs.

	B	Standard Error	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B) Lower	Higher
Length of use of technology	1.169	0.313	13.909	1	0.001	3.218	1.741	5.948
RRSS	0.814	0.188	18.826	1	0.001	2.257	1.563	3.260
Teaching experience	-1.202	0.326	13.617	1	0.001	0.300	0.159	0.569
Creation of activities	0.772	0.214	13.041	1	0.001	2.163	1.423	3.288
Creation of tests	0.324	0.214	2.292	1	0.130	1.383	0.909	2.104
Creation of posters and concept maps	1.288	0.186	47.801	1	0.001	3.627	2.517	5.226
Creation of blogs	0.924	0.209	19.602	1	0.001	2.520	1.674	3.794
Robotics	-0.757	0.350	4.675	1	0.031	0.469	0.236	0.932
Gamification	0.612	0.193	10.034	1	0.002	1.844	1.263	2.692
Virtual reality	0.812	0.242	11.299	1	0.001	2.253	1.403	3.618
Gender	0.115	0.184	0.392	1	0.531	1.122	0.783	1.608
Creation of websites	0.766	0.241	10.070	1	0.002	2.152	1.340	3.454
Age (0)			10.926	2	0.004			
Age (1)	1.009	0.318	10.027	1	0.002	2.742	1.469	5.118
Age (2)	0.057	0.297	0.036	1	0.849	1.058	0.591	1.894
Constant	-3.073	0.287	114.466	1	0.000	.046		

Table 4 - Influence of independent variables based on the probability of having a high digital competence (n =1104).

Variables / Areas	A-H		C		CS		I-A		CS-J	
	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)	B	Exp(B)
Length of use	1.77	5.89*	5.92	374.06*	1.27	3.55	2.34	10.35*	0.67	1.958
RRSS	0.02	1.02	0.02	1.02	2.93	18.77*	1.07	2.93*	0.95	2.59*
Experience	-1.03	0.36	-5.30	0.01*	1.05	2.86	-0.86	0.43	-1.42	0.24*
Creation of activities	0.42	1.52	2.28	9.80*	2.52	12.44*	1.87	6.51*	0.67	1.95*
Creation of tests	0.46	1.58	3.48	32.59*	0.81	2.25	-2.04	0.13*	0.75	2.12*
Creation of posters	2.230	9.30*	-1.45	0.24	0.82	2.27	2.30	9.97*	1.20	3.31*
Creation of blogs	2.10	8.13*	3.58	36.03*	-2.57	0.08*	0.45	1.57	1.07	2.92*
Robotics	-3.14	0.04*	-		-2.26	.10	0.70	2.00	-0.48	0.62
Gamification	0.34	1.41	0.48	1.62	1.79	5.99*	1.61	4.98*	0.16	1.17
Virtual reality	1.77	5.85*	3.07	21.44*	-3.32	0.04*	0.40	1.50	1.13	3.11*
Gender	0.14	1.15	-0.90	0.41	0.31	1.36	1.18	3.27	0.11	1.11
Creation of website	-0.54	0.58	1.49	4.44	6.11	450.94*	2.06	7.88*	0.55	1.74
Age (range 0)	-		-		-		-		-	
Age (range 1)	1.45	4.24	-17.00	0.00	1.65	5.22	2.00	7.42	0.68	1.97
Age (range 2)	0.74	2.10	0.30	1.34	0.80	2.23	1.40	4.05	-0.10	0.90
Constant	-3.454	0.032	-3.812	0.022	-6.746	0.001	-6.097	0.002	-2.527	0.080

Legend: A-H) Art and Humanities; C) Sciences; CS) Health Sciences; I-A) Engineering and Architecture; CS-J) Social and Legal Sciences. * Predictive variables significant at 95% confidence

Table 5 - Variables in the multiple logistic regression equation.

Observed	Predicted Low competence	High competence	Correct percentage
Low competence	737 (92.24 %) *	62	92.2%
High competence	140	165 (54.10%) *	54.1%
Total percentage	79.4%	20.6%	81.7%

* The percentages of the main diagonal correspond to the sensitivity and specificity characteristics.

Table 6 - The decision tree ranking.

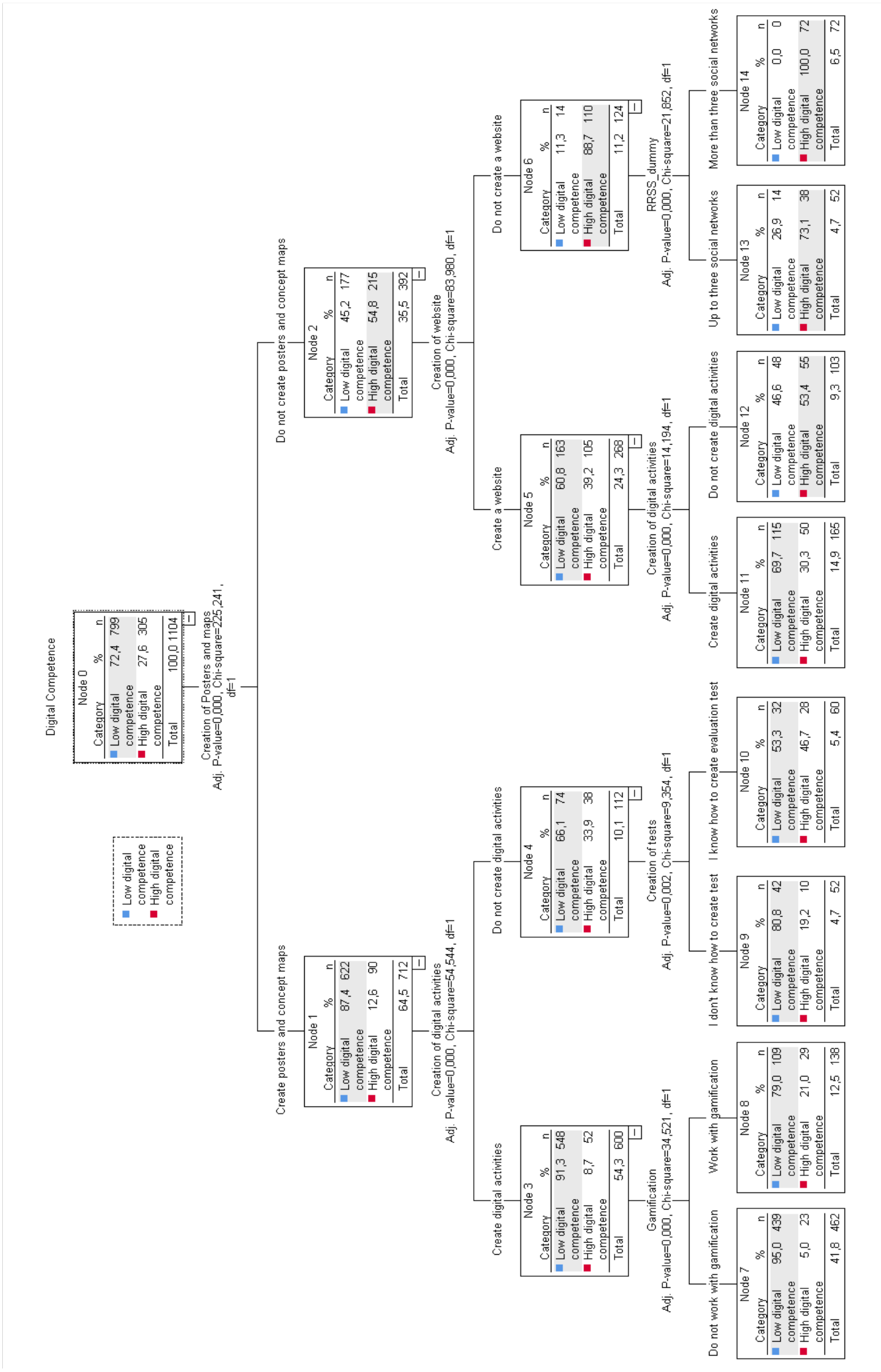

Figure 2 - Segmentation of teachers' digital competence.

These results are similar to those of Gago and Gómez-Gonzalvo (2016), Yuyun (2018), Tusiime et al. (2019), Ligurgo et al. (2019), Badia et al. (2019), and Varela-Ordorica and Valenzuela-González (2020). These results support the assumption that, although Parsons et al. (2020) observe that computational thinking is a fundamental resource which may have great effects on the development of digital competence, teachers are still influenced by the creation and management of more traditional ICT resources that emerged at the beginning of the 21st century.

It should be highlighted that the number of social network accounts held by the teachers who participated in our study is a good indicator of digital competence, supporting the findings of García-Pérez et al. (2016), Porlan and Sanchez (2016), Eyo (2016) and Sánchez-Gómez et al. (2017). These results make us reflect on the time required by teachers to use technology correctly, which is in turn related to the significant results we have found concerning the time spent using technology, similar to Krumsvik et al. (2016) and García-Marco et al. (2020). Instead, two variables appear as a reflection of the decrease observed in the level of competence, teaching experience and age, which are related. These results reflect those of Gallardo et al. (2018) and Garzón et al. (2020), where younger teachers were found to be more interested in receiving training in these skills.

In regard to the classification established by areas of knowledge, the use of augmented reality and the creation of blogs seem to be determining factors in the areas of art and humanities, sciences, health sciences, and social sciences. Although there is no consensus among the areas in terms of significant predictors, gamification and robotic technology begin to emerge in the development of digital competence in some areas. These findings support the view of Pinto, Cortés and Alfaro (2017) and Gómez-Triguero, Ruiz-Bañuls and Ortega-Sánchez (2019) that teachers are moving from a digital conception focused on the use of ICT resources, to a broader conception including, for example, knowledge creation through LKTs and participation in collaborative environments through TEPs. Regardless of the area, what remains clear is the need to train teachers in these competences, since their poor knowledge implies an education not focused on the most-demanded professions in the 21st century (Padilla-Hernández et al., 2020).

Regarding the classification tree, the results support those already found in the regression concerning the high significance of the creation of activities and digital content (posters, concept maps, collaborative websites), indicating that those teachers who also have several social media accounts and have begun to gamification in the classroom are immersed in the development of high competence in order to achieve some of the aims proposed in the 2019 Horizon Report (Alexander et al., 2019). These findings highlight the need to implement relevant teacher training plans.

5. Conclusion

The results of the study have identified the predictors that influence in a special way the acquisition of high digital competence by university teachers at a leader, expert or pioneer level. Twelve significant predictive variables were obtained using the multiple logistic regression model, which revealed the importance of the age range of teachers to possessing adequate digital competence, as well as their ability to create digital materials, and to use gamification or robotic technology, as the most relevant variables. Therefore, it is necessary to promote adequate training plans that will enable the incorporation of ICT in high-quality education to be adapted to meet current demands and social conditions.

We understand that the conclusions proposed in this study should be interpreted cautiously. The non-experimental design and the nature of the non-probability sampling employed are associated with some limitations regarding the generalization and application of the results. Future research may consider a larger sample, differentiated by knowledge area. Furthermore, it is important to carry out international studies in order to extend the scope of the results and statistical techniques. Therefore, the aim is to continue improving and expanding the characteristics of this study to validate these preliminary findings.

Funding. This work was supported by the Department of Economy, Knowledge, Business and University of the Junta de Andalucía (Spain) under grant number US-1260616.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 62-71

Prediction of engineering students' virtual lab understanding and implementation rates using SVM classification

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(submitted: 28/12/2020; accepted: 8/7/2021; published: 13/7/2021)

Abstract

In 2020 many universities were forced to switch to a distant form of education because of the COVID-19 lockdown. This was especially challenging for the engineering specialties, where laboratory and practical exercises are a fundamental part of the educational process. This study presents results from the electrical engineering education in two Bulgarian universities, where the Engine for Virtual Electrical Engineering Equipment was used as a tool for providing virtual labs. At the end of the semester the students were asked to fill in a survey, accounting for their learning program, years of studying, experience with virtual and real labs and the instructions delivery methods used. Data mining algorithms were utilized with the aim to predict students' rate of understanding and rate of implementation when dealing with virtual labs. Initially, a regression analysis model was created which achieved R-squared above 95%. However, the verification of the model showed an unsatisfactory prediction success rate of 37%. Next, SVM classification was utilized. The verification showed its success rates for predicting the rate of understanding and rate of implementation were 83% and 86%, respectively. This approach could be used to optimize the educational experience of students, using virtual labs, as well as for identification of students that might need additional support and instructions.

KEYWORDS: Classification, Prediction, Virtual Labs, Rate of Understanding, Rate of Implementation

DOI
https://doi.org/10.20368/1971-8829/1135420

CITE AS
Hristova, T., Gabrovska-Evstatieva, K., & Evstatiev, B. (2021). Prediction of engineering students' virtual lab understanding and implementation rates using SVM classification**.** *Journal of e-Learning and Knowledge Society*, *17*(1), 62-71. https://doi.org/10.20368/1971-8829/1135420

1. Introduction

Announced measures to protect the population during the COVID-19 pandemic in many countries have led to the closure of schools, universities, large shops, hotels and even factories. In the era of Internet technologies with developed communication channels, the education continued in various remote forms - asynchronous and synchronous, using video conferencing, sent documents, chat rooms, with various feedback between teachers and students (Dimitrov, 2020). Each teacher or school chose the most appropriate way according to the nature of the discipline, course, base, and personal training. Furthermore, teachers and professors had to decide when to organize online consultation, make sure students keep to the deadlines, prepare different assignments and verify the submitted ones in a timely manner (Mladenova et al., 2020). In this situation, difficulties arose with some engineering courses that required laboratory training of students. During these classes, students are commonly trained in a real environment to work with machines and equipment, which includes measuring, connecting circuits, tuning and starting motors, adjusting devices of apparatus.

With the announcement of isolation, teachers from technical universities had to quickly develop programs

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for electrical engineering education of specific laboratory exercises. The existing Engine for Virtual Electrical Engineering Equipment - EVEEE (University of Ruse Angel Kanchev, n.d.) was used to prepare and conduct laboratory exercises in several electrical engineering courses of the University of Ruse Angel Kanchev (URAK) and the University of Mining and Geology (UMG). EVEEE is a 2D environment, representing a 3D virtual reality, which includes all the phases a real laboratory exercise has: connecting the equipment together using virtual cables, plugging/unplugging elements, tuning the equipment and conducting measurements. Considering most of the students didn't have enough experience with virtual labs, they received instructions using different methods, such as video conferencing, text materials and recorded video instructions. The training was relatively successful according to the results shown by the students at the end of the semester. Nevertheless, considering the uncertainty of the COVID-19 situation, it was important to investigate the students' success rate when working with the virtual equipment. Therefore, it was necessary to assess the ease of understanding and ease of implementation by students when dealing with the virtual laboratory exercises using data mining algorithms (DMA). DMA are widely used in education for predicting dropouts (Kumar et al., 2017b), improving institutional effectiveness (Alturki et al., 2020), predicting student amelioration (Anoopkumar and Rahman, 2016), faculty performance analysis (Anoopkumar and Rahman, 2016) and others.

The educational data mining is an iterative process that includes raw data, application of data mining techniques, interpretation of the results and recommendations for the educational system (Romero and Ventura, 2007; Kumar, 2015). In Alyahyan and Düştegör (2020) was proposed a six-stage framework for implementation of data mining techniques to predict student success: data collection; data preparation; statistical analysis; data preprocessing; data mining implementation; and result evaluation.

Previous studies have shown that predicting students' performance can help universities provide timely measures in order to improve the success rate (Alyahyan and Düştegör, 2020). Anoopkumar and Rahman (2016) performed a review on the data techniques used to predict student amelioration from 2005 to 2015. Classification methods are leading significantly, followed by statistical methods and visualization analysis. In another study (Alturki et al., 2020) was performed a review on the prediction of higher education achievements. It showed that classification and regression algorithms are commonly used for forecasting students' achievements at course and degree level. In Kumar et al. (2017a) were investigated different data mining algorithms used for prediction of students' performance in education. According to their findings, the most commonly used algorithms are Decision trees, Naïve Bayes, Artificial neural networks, Rule based and K-Nearest neighbor (kNN). The reported maximum and minimum prediction accuracy vary depending on the algorithm but are generally within the range 55%-100%.

Numerous studies have used various data analysis methods to predict student's performance. Al luhaybi et al. (2018) used classification algorithms to predict students at high risk of failing a module. The results showed that the Naïve Bayes (NB) gives higher accuracy, compared to the C4.5 decision tree algorithm. In another study (Osmanbegovic and Suljic, 2012), the authors used three data mining algorithms to predict the success in a course and the performance of the learning methods. The study showed that the Naïve Bayes method achieved better results, compared to Multilayer Perceptron (MLP) and decision trees. The comparison was based on their predictive accuracy.

In Saa (2016) models for prediction of students' grades were created, based on training data collected through a survey. Multiple decision trees and Naïve Bayes algorithms were used. The average classification accuracy varied from 33.3% to 40%. In Bhutto et al. (2020) were used logistic regression and the Support Vector Machine (SVM) classification to predict student's academic performance. The results showed that the SVM algorithm has higher accuracy in the investigated cases. Kabakchieva (2013) compared six classification algorithms for predicting student's performance – C4.5, Naïve Bayes, Bayes Net, kNN 100, kNN 250 and the rule-based JRip. The most influencing factors were the admission score and the number of failures at the first-year exams. Nevertheless, all algorithms didn't perform very good with predictions rates varying in the range 52%-67%.

Alqurashi (2019) used regression analysis to investigate the relationship among four independent variables (online learning self-efficacy, learner-content interaction, learner-instructor interaction and learner-learner interaction). The results showed that the first three have a critical role on students' satisfaction and perceived learning. In another study. Tsiakmaki et al. (2020) tried to predict students at risk of failure using neural networks with different predictors, such as gender, course, pass/fail, page/folder views, assignment views, etc.

Other studies were aimed at engineering education. In Adekitan and Salau (2019) a data mining approach was used to validate the assumption that the performance of engineering students in the first three years is the most important for their final cumulative grade point average. The study used the program and the year of entry as predictors with different data mining algorithms. The highest accuracy of 89% was achieved using linear and quadratic regression models with coefficient of determination 0.955 and 0.957, respectively. In another study, Taodzera et al. (2017) used five classification algorithms to predict engineering students' success – decision trees, NB, SVM, artificial neural networks and linear regression. The predictors used were Math score, Physics score, ethnicity, school province and age. The prediction accuracy varied from 60% to 67%. In a similar study, Buenaño-Fernández et al. (2019) used data from the academic management system and decision trees classification to predict the pass/fail rates of different engineering courses. To the best of our knowledge, there are no studies investigating the rates of implementation of virtual labs in engineering education.

The aim of this study is to forecast the student's understanding and implementation rates when working with virtual laboratories in their engineering classes. It will be demonstrated that analysis of data obtained from a preliminary survey could be used to optimize the virtual labs learning experience, which is its main novelty. This will help students to successfully graduate with the acquisition of quality knowledge. The remaining of the paper is structured as follows: in section two is presented the structure of the questionnaire and the methodology for its analysis; in section three are presented a summary of the survey results, statistical analysis, the obtained forecasting models and a case study presenting its application; in the fourth section the obtained results are discussed and summarized.

2. Materials and Methods

2.1 The teaching methodology

The standard training for engineers in Bulgaria includes three types of frontal lessons: lectures, laboratory exercises and tutorials. During the labs, students work either in groups or individually and perform different tasks, such as connection of circuits, measurements of electric quantities (voltage, current power, resistance), verification of different laws and theorems (Kirchoff's laws, Faraday's law, Thevenin's theorem, etc.), comparison between experimental and theoretically expected values, etc. Thereafter, each student summarizes the obtained experimental results and makes appropriate conclusions in an individual report, which is given to the lecturer for verification and assessment.

This study presents results from the courses "General Electrical Engineering", "Theoretical Electrical Engineering" and "Electrical Measurements" which were taught remotely to students studying Mining engineering, Electrical engineering and Computer engineering. All instructions were delivered via several channels: video conferencing, e-learning websites, pdf files, pre-recorded video instructions, etc.

The implementation of the educational process during the spring semester of 2020 was done in several steps: needs analysis, preparation of teaching materials, selection of teaching methods, increase of competencies and selection of assessment methods (Evstatiev and Hristova, 2020).

In order to follow the standard training procedure, the labs training was implemented in the EVEEE environment, where the students can do the necessary tasks in a realistic environment. Furthermore, the implemented virtual equipment is an exact copy of the real one, which allows trainees to learn to work with the equipment. In the EVEEE environment student can implement a given circuit by plugging elements in a breadboard, connecting the equipment with virtual cables, tuning it up and observing its readings. Furthermore, the students had to write down, analyze and summarize the lab results in specially prepared online reports, which were implemented in Google Sheets. During the training the students gradually got used to the virtual environment, performed the set tasks and submitted electronic reports. The acquisition of useful skills for working with a specific software product has been previously reported as an advantage (Anastasova, 2016).

2.2 The questionnaire

In order to perform this study a questionnaire has been developed. It can be divided into two parts. The first part includes six questions aimed at identifying the profile of the participants (Table 1). The fifth and the sixth question were aimed at obtaining the previous experience of students in terms of using virtual and real laboratory equipment.

№	Questions	Answers
1	In which university do you study?	Open question
2	What is the specialty of your study?	Open question
3	What is the form of your studying?	Single choice question: Full-time student Part-time student
4	How long have you been studying?	Single choice question: First year student (1) Second year student (2) Third year student (3) Fourth year student (4)
5	Have you used virtual labs before?	Yes/No question
6	Have you done similar laboratory exercises with real equipment?	Yes/No question

Table 1 - First group of questions regarding the profile of the participants.

The next group of questions was aimed at evaluating the experience of the students with the application of the EVEEE environment (Table 2). The first question is open and allows students to list the courses in which they have used the environment. The next three questions were aimed at identifying the types of synchronous and asynchronous instruction delivery methods, their tutors used - "recorded video instructions", "instructions in text form" and "audio/video conference instructions". The fifth and the sixth questions of the group were aimed at obtaining the student's understanding and implementation of the given instructions, with the answers varying from "Strongly disagree" to "Strongly agree".

№	Questions	Type
1	In which courses have you used the EVEEE virtual environment?	Open question
2	Did your tutor use recorded video instructions?	Yes/No
3	Did your tutor use instructions in text format (PDF files, e-mails, etc.)?	Yes/No
4	Did your tutor deliver synchronous instructions using audio/video conferencing (Skype, ZOOM, BBB, etc.)?	Yes/No
5	Do you agree with the following statement: It was easy to understand how to work with the virtual equipment?	Agree/disagree question
6	Do you agree with the following statement: It was easy to implement the assigned tasks during the virtual laboratory exercises?	Agree/disagree question

Table 2 - Second group of questions regarding the experience with the EVEEE environment.

In order to analyze the survey results, the answers of the "Agree/Disagree" questions and of the "Yes/No" questions were given numerical values as shown in Table 3. Furthermore, numerical meanings were given to the student's specialty answers.

Answers	Numerical value
Agree…disagree questions	
I strongly disagree	1
I disagree	2
Cannot decide	3
I agree	4
I strongly agree	5
Yes/No questions	
No	1
Yes	2
What is your specialty question	
General engineering	1
Computer systems and technologies (CST)	2
Electrical power engineering (EPE)	3

Table 3 - Corresponding numerical values of the single choice answers.

2.3 Data analysis

The goal of the study is to obtain a model that allows prediction of the student's rates of understanding and implementing virtual laboratories. This would allow us to understand which factors could be used to influence the success rate as well as to identify students which might need additional support with the labs. Therefore, nine factors were selected for further analysis (Table 4). Out of them, 7 are predictors, one is either predictor or target (the Ease of understanding - u) and one is a target (the Ease of implementation - i).

Factor	Abbreviation	Role
Specialty	sp	Predictor
Years of studying	y	Predictor
Experience with virtual labs	ve	Predictor
Experience with real labs	re	Predictor
Application of recorded video instructions	r	Predictor
Application of text instructions	t	Predictor
Application of synchronous video conferencing	v	Predictor
Ease of understanding	u	Predictor/Target
Ease of implementation	i	Target

Table 4 - Predictors and targets of the analysis.

Our initial goal is to assess the correlations between the selected predictors and targets. This is done in two ways:

- By obtaining the average target values for the different values of the predictors – this would allow us to obtain preliminary information about the distributions of u and i depending on the values of the predictors;
- Using Pearson's correlation to obtain the "u" and "i" dependency on the other predictors – this would allow us to identify if strong correlations exist.

The next step is to obtain a model, which allows accurate prediction of the factors u and i using the available predictors. Two approaches are selected for investigation – multiple regression and classification. The aim is to compare the results of the two approaches in order to select the most effective teaching methods for laboratory virtual exercises. In both studies, the target function is the ability of students to cope with the assigned tasks.

Multiple regression model

Regression analysis methods are designed for analysis of continuous variables in numerical form. In the investigated situation, the variables are heterogenous, and many of them are of type Boolean (the Yes/No questions), which is not very appropriate for multiple regression analysis. Therefore, a decision was taken that all variables should be normalized to take values in the range (0…1]. For example, the scale for the Agree/Disagree questions become: I strongly disagree – 0.2; I disagree – 0.4; Cannot decide – 0.6; I agree – 0.8; I strongly agree – 1. Similarly, the Yes/No questions become: No – 0.5; Yes – 1. Using the normalized values, a Fischer matrix is synthesized. After an appropriate multiple regression model is selected it is verified using the training data. Considering the model returns continuous data, it is categorized as shown in Table 5.

Rule	Category
If $i_{mod} \geq 0.9$	$i_{mod} = 1$
If $i_{mod}. \geq 0.7$ and $i_{mod} < 0.9$	$i_{mod} = 0.8$
If $i_{mod}. \geq 0.5$ and $i_{mod} < 0.7$	$i_{mod} = 0.6$
If $i_{mod}. \geq 0.3$ and $i_{mod} < 0.5$	$i_{mod} = 0.4$
If $i_{mod} < 0.3$	$i_{mod} = 0.2$

Table 5 - Categorization of the modelled multiple regression data.

Classification model

Another data analysis is performed using the SVM classification algorithm. Unlike the regression analysis approach where the data should be numerical, the classification methods can accept both numerical and categorial predictors/targets. Considering the nature of the survey data, all variables are considered to be categorical. Once a classification model is trained, it is verified using the training data.

3. Results

3.1 Preliminary analysis

The study was performed at the end of the summer semester of 2020 in two Bulgarian universities where the EVEEE environment is used. All students were engaged in a formal education during the COVID-19 pandemic. Furthermore, ERASMUS+ students from France visiting RUAK also took part in the education process and survey.

Considering the different participants, the described questionnaire was developed in two languages – Bulgarian and English, to be used by the Bulgarian and French students, respectively. After the semester's end, they were asked to fill in the survey. The profile of the participants is summarized in Table 6. Students from several engineering programs participated, most of them studying Computer systems and technologies and Electrical power engineering. Furthermore, most of them were first year full-time students and 71% of them have not used virtual laboratories before.

Next, according to the developed questionnaire, the respondents answered six questions on their experience with the EVEEE environment. When asked for the methods, which their tutors used to deliver their instructions for implementing the virtual labs, 54% of them stated that recorded video instructions were used, 46% stated they received instructions in text form (PDF, etc.) and 23% of them were instructed using audio or video conferencing. It should be noted that this was a multiple-choice question and therefore many of the participants selected more than one answer. The survey results are summarized in Table 7 where the average understanding rate and the average implementation rate are shown for the different values of the predictors. The distributions of the u and i answers are presented in Figure 1.

Category	Profile
University	UMG: 30 URAK: 36 ECE Paris (at RUAK): 4
Specialty	General engineering: 14 CST: 32 EPE: 24
Type of formal education	Full-time students: 46 Part-time student: 24
Years of study	First year: 36 Second year: 26 Third year: 6 Fourth year: 2
Experience with virtual labs	No: 50 Yes: 20
Experience with real labs	No: 30 Yes: 40

Table 6 - Profile of the participants.

Predictor	Answers	Average u	Average i
y	1	4.17	3.78
	2	4.15	3.54
	3	4.33	4.33
	4	4.00	5.00
sp	Other engineering	4.08	3.67
	CST	4.19	3.88
	EPE	3.71	3.71
r	No	3.81	3.44
	Yes	4.47	4.05
t	No	4.32	3.89
	Yes	4.00	3.63
v	No	4.19	3.74
	Yes	4.13	3.88
ve	No	4.05	3.85
	Yes	4.44	4.11
re	No	4.47	4.00
	Yes	3.90	3.75

Table 7 - Average values of u and i for the different predictors.

Next, the Pearson's correlations between the predictors and the targets were investigated (Table 8). It can be seen that the understanding u has a low correlation with the specialty sp, the experience with virtual labs ve and the use of recorded video materials r. This shows that students are computer literate and able to cope successfully in a virtual environment, regardless of their specialty. The results also showed that the ease of implementation has a low correlation with the virtual labs experience and the use of recorded video materials. Furthermore, there was a medium correlation with the rate of understanding. In other words, in order to achieve good rate of implementation, the students should understand how to work with the virtual equipment. The last statement is expected but it also confirms that the ease of understanding could be used as a predictor for forecasting the ease of implementation. In general, there were no strong correlations between the predictors and targets. This indicates that it is necessary to create a more complex model in order to assess the specifics of the situation.

3.2 Multiple regression model

Previous authors reported that there is no universal tool when it comes to educational data mining (Slater et al., 2017). The different software tools are suited for different tasks, which is also the reason we selected different tools to create the two models. A multiple regression analysis has been implemented using the STATGRAPHICS software. According to the developed methodology, all predictors and targets were normalized to take values in the range (0…1]. In the initial modeling, the following variables were included independently of each other: year of study, specialty, previous experience and teaching methods to determine their correlation with the ability to perform the tasks. The models were adequate according to the theory with a coefficient of determination as high as 91%. In subsequent simulations, the variable teaching methods according to the specialty and our understanding according to the long-term experience were investigated.

The following solution candidate was selected for forecasting the rate of implementation i:

$$i = 0.462938 \cdot y^2 + 0.257946 \cdot ve \cdot \sqrt{u} + 0.178005 \frac{v}{ve} + 0.415603 \cdot u \cdot \sqrt{r}$$

The obtained continuous model has the following accuracy:

- R-squared - 95.75%;
- Standard Error – 0.171.

Considering the standard error is 0.171, the accuracy of the model might not be appropriate for the situation, which should be further investigated.

The statistical analysis for the coefficients of the multiple regression is presented in Table 9. Considering all P-values are lower than 0.05, the terms are statistically significant at the 95.0% confidence level.

The model shows that the ability of students to perform the assigned tasks corresponds in direct proportion to the understanding of the taught material. For parameters such as experience with virtual laboratories and years of experience at the university, no exact conclusion can be made, as these parameters are interrelated. It is also not possible to determine exactly the most effective method of teaching. Considering the model generates continuous data, it was rounded to the nearest category, as explained in the methodology. After the categorization, 63% of the samples were identified incorrectly, thus its success rate is only 37%. Therefore, the obtained multiple regression

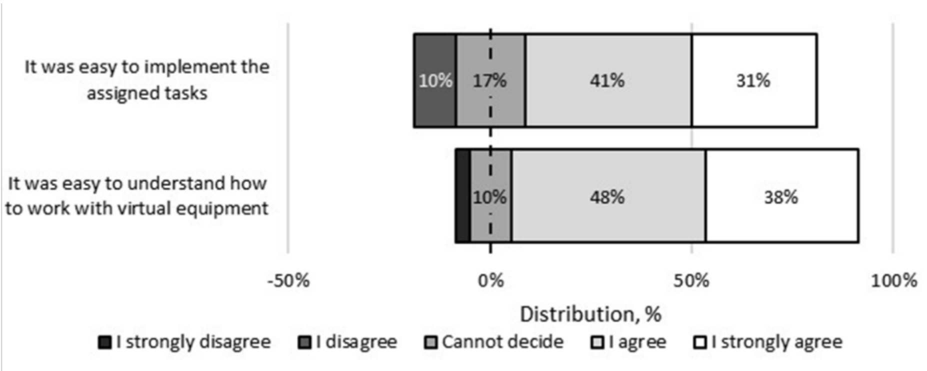

Figure 1 - Overall distribution of the u and i indicators.

	y	sp	ve	re	r	t	v	u
u	0.0092	-0.27	0.22	-0.088	0.35	-0.17	-0.027	1.0
i	0.15	0.033	0.20	0.032	0.30	-0.13	0.056	0.52

Table 8 – Correlations between the predictors and the indicators.

Parameter	Estimate	Standard Error	T Statistic	P-Value
y^2	0.462938	0.138778	3.33582	0.0022
ve*sqrt(u)	0.257946	0.117291	2.19919	0.0355
v/ve	0.178005	0.0594278	2.99531	0.0054
u*sqrt(r)	0.415603	0.175673	2.36577	0.0244

Table 9 – Statistical results for the multiple regression coefficients

model is not appropriate for prediction of the student's implementation rate.

3.3 Classification model

Two classification models were generated using the developed methodology. Even though some of the predictors showed insignificant correlation with both u and i, it was decided to use all of them:

- The dependency of the student's understanding rate on all available predictors: $u = f(sp, y, ve, re, r, t, v)$;
- The dependency of the student's implementation rate on all available predictors, including the understanding u: $i = f(sp, y, ve, re, r, t, v, u)$.

The SVM classifications was implemented with the Orange Data Mining software. The used parameters for the models are $C = 5.00$, $\varepsilon = 0.10$ and an RBF kernel.

The setup of the classification model and its verification in the Orange software are presented in Figure 2. For the u model, the obtained precision and recall are 0.825 and 0.829, respectively, which means that 58 samples out of 70 were identified correctly (83% success rate). In a similar manner, a second SVM model was trained for i. The obtained precision and recall are 0.864 and 0.857, respectively, which means that 60 out of 70 samples were predicted correctly (86% success rate).

3.4 Case study

Out of the two models, the classification approach showed significantly better success rate at predicting student's ease of understanding and ease of implementation rates. Therefore, using the obtained SVM models a case study was implemented. It is assumed that 20 first year students studying "Computer systems and technologies" are taking virtual laboratory classes. Furthermore, it is assumed that a preliminary questionnaire provides information about their experience with virtual and real equipment. The test data is summarized in Table 10.

The goal of the case study is to obtain the optimal learning scenarios for the investigated students. Therefore, four scenarios are investigated:

- **Scenario 1:** Only text documents are used;
- **Scenario 2:** Text documents and video conferencing is used;
- **Scenario 3:** Recorded video instructions and text documents are used;
- **Scenario 4:** All three types of materials are used.

Using the trained SVM models were forecasted the expected results for the above scenarios. The results from the simulations are presented in Table 11.

The obtained results indicate that if such students are to be trained, the optimal scenarios are 3 and 4, i.e. recorded video instructions + text documents or all materials at once are used.

4. Discussion and Conclusions

In this study was made an attempt to predict the students' ease of understanding and ease of implementation of virtual labs in electrical engineering classes. It reflects results obtained in two Bulgarian universities during the 2020 spring lockdown due to COVID-19, when the traditional education process was forced into distant form. A questionnaire for the students was prepared and conducted at the end of the semester. A total of 70 students took part in the survey, including Erasmus students from France, which were in the University of Ruse when the lockdown occurred.

During the education process, different forms of delivering the lab instructions were used, including written text instructions (PDFs, etc.), recorded video instructions and video conferencing. The analysis of the results showed that on average, it was easy for the students to understand and implement the instructions – 86% were positive in terms of understanding and 72% in terms of the implementation. The survey results showed that recorded video instructions were the preferred form of content delivery, followed by video conferencing and text materials.

The survey questions were used to define two types of variables – predictors and targets. The selected predictors were the specialty, the years of studying, the previous experience with virtual labs, the previous experience with real labs, and the application of text instructions, recorded video instructions and video conferencing. The ease of understanding was selected as both a predictor and target and the ease of implementation as a target only.

The Pearson's correlation was used to investigate the dependencies between predictors and targets. The results showed that there is a medium correlation between the ease of understanding u and the ease of implementation i, which means it is very important that students correctly understand the instructions for performing the virtual lab before they can implement it. This also shows that the ease of understanding is a very important predictor when forecasting the ease of implementation.

Furthermore, low correlations were obtained between u and the students' specialty sp, previous experience with virtual labs ve, the application of recorded video materials. The ease of implementation i also showed a low correlation with sp and ve. This is probably caused by the better virtual experience of Computer systems and technologies students, compared to those from other specialties. Furthermore, the study results suggest that the recorded video instructions could be an important content delivery method when virtual labs are used.

Using the questionnaire data, two types of models were trained. The first one was based on multiple regression and achieved coefficient of determination R-squared above 95% when modelling the ease of implementation i. The model proves the need for students to understand the material in order to complete the tasks. The

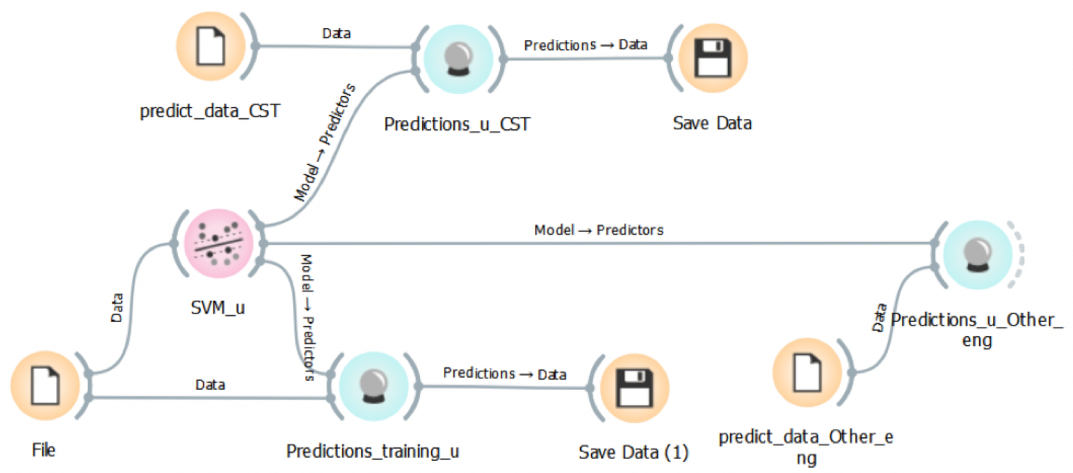

Figure 2 - Setup of the SVM modelling, verification and prediction in the Orange 3 software.

y	sp	ve	re
1	2	1	2
1	2	2	2
1	2	1	2
1	2	1	2
1	2	1	2
1	2	2	1
1	2	1	1
1	2	1	1
1	2	2	2
1	2	2	2
1	2	1	1
1	2	1	2
1	2	2	2
1	2	1	1
1	2	1	1
1	2	2	1
1	2	2	2
1	2	1	1
1	2	2	2
1	2	1	2

Table 10 - Input data for the case study.

	1	2	3	4	5	Average
Scenario 1						
Understanding	12		8			1,8
Implementation		12	8			2.4
Scenario 2						
Understanding	6			12	2	3.2
Implementation		6		14		3.4
Scenario 3						
Understanding				12	8	4.4
Implementation				18	2	4.1
Scenario 4						
Understanding				12	8	4.4
Implementation				18	2	4.1

Table 11 - Prediction results for the case study using the SVM model.

specialty's influence is inversely proportional, which can be explained by the fact that most students in electrical specialties have already conducted real laboratory exercises. Nevertheless, after the verification of the model with the training data, only 37% of the training data was categorized correctly. This means that the multiple regression approach is not appropriate in this situation.

The second model was implemented using SVM classification. Similarly, it was verified with the training data and scored 83% an 86% successful categorization rate, respectively for the ease of understanding u and ease of implementation i . Therefore, the SVM classification model has been selected as appropriate for forecasting student's performance with virtual labs.

Finally, a case study was conducted in order to demonstrate the application of the model. It was assumed that 20 first year Computer systems and technologies students should be trained using virtual labs. Furthermore, it is assumed that the students previous experience with virtual and remote labs is obtained using a preliminary questionnaire. For the needs of this case study, they were randomly selected.

The goal of the case study is to obtain the optimal content delivery methods to be used with these particular students in order to achieve optimal learning outcome. Therefore, four teaching scenarios were investigated: only text documents are used; text documents and video conferencing are used; recorded video instructions and text documents are used; all three types are used. The results from the case study showed that in this particular case the optimal approach would be to use scenario 3 and 4. Considering scenario 4 would require more efforts, the optimal scenario would be to use instructions in text form (PDF documents, etc.) and recorded video instructions.

The developed approach and model could be used to optimize the educational experience of students with virtual laboratories, which is the key novelty of this study. As demonstrated in the case study, it could be adopted by starting the course with a short survey in order to obtain the profile and previous experience of students with laboratory exercises. Furthermore, such approach could be used to identify students that might need additional instructions when dealing with virtual labs.

Considering the COVID-19 crisis is far from over, the authors of this article will continue to improve the accuracy of the selected SVM model by adding additional survey results to it. This would allow to increase the representativeness of the sample and hopefully will improve the prediction accuracy of the model. Furthermore, it would allow us to monitor the students' success rate when working with virtual labs.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 72-80

The Structural Equation Model of actual use of Cloud Learning for Higher Education students in the 21st century

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(submitted: 16/7/2020; accepted: 8/7/2021; published: 26/7/2021)

Abstract

The purposes of this research were to 1) develop the structural equation model of the actual use of cloud learning for higher education students in the 21st century (SEMAC), 2) investigate the validity of the SEMAC, and 3) study the effects of the SEMAC. This study was a correlation research. The research sample consisted of 1,170 undergraduate students, randomly selected using multi-staging, from 18 universities in Thailand. The research instruments were questionnaires about system quality, convenience, social interaction, perceived ease of use, perceived usefulness, and actual use. Data analyses were descriptive statistics and the analysis for model validation used LISREL 9.2. The study found that the validation of the structural equation model indicating actual use of cloud learning showed that the model fit to the empirical data ($\chi 2$ = 34.659 df = 23 p = .056 GFI = .989 AGFI = .974 RMR = .006). The variables in the structural equation model could explain 62.4 of the variance in actual use. The research results can be used as data to improve the actual use of cloud learning.

KEYWORDS: Cloud Learning, TAM, Technology Acceptance Model, Structural Equation Model.

DOI
https://doi.org/10.20368/1971-8829/1135300

CITE AS
Amornkitpinyo, T., Yoosomboon, S., Sopapradit, S., & Amornkitpinyo, P. (2021). The Structural Equation Model of actual use of Cloud Learning for Higher Education students in the 21st century. *Journal of e-Learning and Knowledge Society*, *17*(1), 72-80. https://doi.org/10.20368/1971-8829/1135300

1. Introduction

Cloud technology is one of the revolutions of 21st century computer operations (Yamin, 2019). It supports industrial, social (Buyya et al., 2012), business, medical, and educational (The Economist Intelligence Unit Limited 2016; Jaleel, 2018) operations. Moreover, cloud technology is a problem-solving tool for the basis of communications technology in various organizations. This is because it helps to reduce the network costs of the company's investment in both software and hardware. It also helps to reduce the duration of operations and resource management that is essential and allows cooperation in real-time (Sathaporn, 2014).

Based on these innovations, the Thai government realized the importance of cloud technology, and decided to plan for its support. This encompasses projects about information technology and the country's communications, in order to improve technology, and the rapid deployment of a national communications infrastructure that is extensive, expandable, and able to serve high speed internet efficiently, everywhere at any time (Ministry of Information and Communication Technology, 2016). To support the execution of cloud

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technology and communication in both the public and private sectors (especially, the education sector), the Thai government created a development policy to improve the economy and society called 'Digital Thailand' from 2559 B.E. to 2561 B.E. This provided access to digital technology in Thailand, which was aimed at helping to improve the Thai people's potential for creativity and provide technology advantages. Thus, this helped the country to develop a basic infrastructure of innovation, information, and human resources, that enabled the country's economy and society to consistently, prosperously, and sustainably improve. This is related to the third strategy, which is to create equality among Thai citizens via the use of digital technology. Hence, there is an increased the opportunity for all Thai citizens to receive a standard education anywhere and anytime (Ministry of Information and Communication Technology, 2016).

By the execution of the above-mentioned policy, the Office of the Higher Education Commission (OHEC) had realized how important it was to rapidly improve education. Therefore, it decided to construct the 12th Higher Education Development Plan: 2017 – 2021. This created a basic infrastructure policy for higher education that required information technology and communication tools as well as development in classrooms (Office of the Higher Education Commission, 2016), especially cloud learning, to satisfy the standards of 21st century lesson design. This development plan urges the higher education institutes to prepare for the essential learning system factors in different fields, such as the learning system environment, cloud computing or cloud services, lecturers, learners, and system administration (Chanin et al., 2020). Moreover, as the COVID-19 pandemic has had a severe impact on people globally, and disrupted the traditional methods of learning and teaching, cloud learning has been implemented in several institutes as a tool to prevent disruption to learning and teaching. This tool also enables both learners and lecturers to access classes and lessons from their home at any time (WP, 2020).

As mentioned above, the researcher's objective for studying the structural equation model of the actual use of cloud learning for higher education students in the 21st century (SEMAC) was to use statistical techniques to analyse causal relationships. The findings obtained identify both the cause and variables. Both direct and indirect influencing paths of variables could be shown. In addition, the correctness or validity of the theory was also able to be investigated.

2. Research Questions

The research questions that guided the investigation of the actual use of cloud learning for higher education students in the 21st century were the following:

1. What is a concept framework of the structural equation model of the actual use of cloud learning for higher education students in the 21st century?
2. How relevant is the structural equation model of the actual use of cloud learning for higher education students in the 21st century towards empirical data?
3. How much impact can the structural equation model of the actual use of cloud learning for higher education students in the 21st century have?

3. Research Objectives

The purposes of this study were:

1. To develop a structural equation model of the actual use of cloud learning for higher education students in the 21st century.
2. To investigate the validity of the structural equation model of the actual use of cloud learning for higher education students in the 21st century.
3. To study the effects of the structural equation model of the actual use of cloud learning for higher education students in the 21st century.

4. Concept Framework

This section describes the analysis of the SEMAC model results. The researcher studied, synthesized, and designed these concepts from nine related subject resources, including official public research and journals supporting the research as shown in Figure 1. These were used to scope out the positive direct effect of the concept framework as follows.

System quality has a positive direct effect on perceived ease of use, and perceived usefulness (Chang & Chiang, 2012; Alshibly, 2014; Calisir et al., 2014). System quality has a positive direct effect on actual use of cloud learning (Alshibly, 2014; Alzu'Bi & Hassan, 2016). Convenience has a positive direct effect on perceived ease of use, and perceived usefulness (Chang et al., 2013; Hsu & Chang, 2013; Yung Ming Cheng, 2015). Convenience has a positive direct effect on actual use of cloud learning (Chang et al., 2013; Yung Ming Cheng, 2015). Social interaction has a positive direct effect on perceived ease of use, and perceived usefulness (Chang & Chiang, 2012; Elkaseh et al., 2016). Social interaction has a positive direct effect on actual use of cloud learning (Essam & Al-Ammary, 2013). Perceived ease of use has a positive direct effect on perceived usefulness (Hsu & Chang, 2013; Calisir et al., 2014). Perceived ease of use has a positive direct effect on actual use of cloud learning (Hsu & Chang, 2013). Perceived usefulness has a positive direct effect on actual use of cloud learning (Chang & Chiang, 2012; Hsu & Chang, 2013). Furthermore, the findings showed that system quality, convenience, social interaction, perceived ease of use, and perceived usefulness have positive direct effects on actual use of cloud learning. Hence, these five factors supported cloud learning to be more effective and efficient.

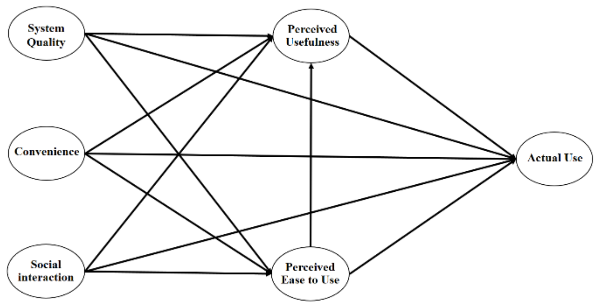

Figure 1 - Conceptual Framework.

5. Research Hypotheses

According to the study of the SEMAC, five hypotheses were determined by the researcher as follows:

1. System quality has a positive direct effect on actual use and an indirect effect via perceived ease of use and perceived usefulness.
2. Convenience has a positive direct effect on actual use and an indirect effect via perceived ease of use and perceived usefulness.
3. Social interaction has a positive direct effect on actual use and an indirect effect via perceived ease of use and perceived usefulness.
4. Perceived ease of use has a positive direct effect on actual use and an indirect effect via perceived usefulness.
5. Perceived usefulness has a positive direct effect on actual use.

6. Research Methodology

6.1. Population and Samples

The population of this study were undergraduate students who had used cloud learning from universities that are under the Office of the Higher Education Commission. The sample comprised 1,170 undergraduate students from eighteen universities selected by Multistage Random Sampling. During the first phase, the regions were selected by Cluster Random Sampling, and nine Higher Education Development Networks of the Office of the Higher Education Commission were selected. In the second phase, two universities of each Higher Education Development Network were selected by Simple Random Sampling. For the third phase, the sample of undergraduate students who had used cloud learning at each university consisted of 65 students selected by Simple Random Sampling.

6.2. Variables of research

There were six variables for this study. They can be classified into three types: 1. Exogenous latent variable, 2. Mediator latent variable, and 3. Endogenous latent variable.

6.2.1. The exogenous latent variable consisted of three indicator variables as follows:

6.2.1.1 *System Quality* (SYS): System quality refers to the efficiency of information technology in both the technical and design fields (DeLone and McLean, 1992). Thus, it was necessary to test the operation and performance of the system (Urbach and Müller, 2012). It was necessary to examine the research studies of system quality latent variables including the following three indicator variables: 1) Availability (SYS1), 2) Stable (SYS 2), and 3) Quick Response (SYS 3).

6.2.1.2 *Convenience* (CON): Convenience is a step that reduces complexity. Nowadays, convenience is created by the use of tools or technology that helps people to save time and energy. Technological innovations and tools enable services and other duties to become more efficient. This concept is relevant, and it depends on each case (Wikipedia, 2019). The research studies in convenience cover sub-variables in two dimensions including: 1) Time (CON1) and 2) Place (CON 2).

6.2.1.3. *Social Interaction* (SOC):

Social interaction is the social action of two or more people that represents the relationship between them, such as talking. Those who participate in social interactions can be family members, friends, partners, and others (Wikipedia, 2019; Rummel, 1976). The research studies of social interaction cover sub-variables in two dimensions including: 1) Social Media (SOC1) and 2) People (SOC2).

6.2.2. The mediator latent variables of this study were perceived usefulness and perceived ease of use.

6.2.2.1 *Perceived Usefulness* (PU): Perceived usefulness is an important variable that represents technology acceptance, especially innovative technology (Chtourou and Souiden, 2010). It shows the level of acceptance of using technology to improve efficiency and repair the operation (Davis, 1989; Davis et al., 1989).

6.2.2.2 *Perceived Ease to Use* (PEOU): Perceived ease of use is an explanation of the user's perception of the effort necessary to use or implement the system, and the scope of their beliefs about the ease of use of technology (Davis et al., 1989).

The two main variables in the Technology Acceptance Model (TAM) theory are perceived usefulness and perceived ease of use.

6.2.3. The endogenous latent variable was actual *use* (USE): For the core causal factor of this study, it is the 'actual use' that is stated to be the limitations of the user in the system (DeLone & McLean, 1992). This includes responses to the user and parts of the system in terms of viewing, searching, and other types of responses (Abbas

& Mahmonir, 2013). Furthermore, actual use is also a dependent variable of two theories: 1. The Technology Acceptance Model theory (Davis, 1985), and 2. The IS Success Model theory (DeLone & McLean, 1992). In this study, the research about cloud learning instructions, which is a learning tool, included co-operation, project creation, presentation, co-learning, and information management (Heng et al., 2016).

6.3. Data Collection and Analysis

The instrument used a five-level rating scale measuring the following six variables: system quality, convenience, social interaction, perceived ease of use, perceived usefulness, and actual use. The researcher developed the questionnaire by using interpretations from questionnaires developed in other countries and adapting, modifying, and creating additional statements as appropriate for the context of Thailand for each of the six parts. The statements from the questionnaire were investigated for item-objective congruence (IOC). This found that the statements had IOC values from .82 to .91. The researcher tested the questionnaire with a pilot of 40 samples to investigate its reliability using Cronbach's Alpha coefficient. This found that the reliability values were between .819 and .931. These numbers verified that it was a good quality questionnaire. Confirmatory factor analysis of the six variables was performed by using LISREL 9.2 and found that all six variables had construct validity.

Data was collected by the researcher after seeking permission from the lecturers at each university. They were followed up with reminders in order to maximize the return rate and an appointment was made with each recipient for the researcher to collect the online questionnaire in person. There were 1,170 questionnaires issued with rate of 100% of returned questionnaires. The validity of the causal model was investigated by the researcher based on hypotheses one to five using LISREL 9.2.

7. Result

The results of the study consist of two parts as follows: 1) The result of relationships between observable variables, and 2) The result of the structural equation model.

The details are as follows:

1. The result of relationships between observable variables. The researcher analysed the data of the relationships between ten observable variables and the findings are shown in Table 1.

The findings of the analysis of observed variables investigating the relationships between the nine observed independent variables and one observed dependent variable showed that the relationship between system quality (SYS) variables and actual use (USE) variables ranged between .472 and .545. The second

Variable	SYS 1	SYS 2	SYS 3	CON1	CON2	SOC1	SOC2	PEOU	PU	USE
SYS1	1.000									
SYS2	.719**	1.000								
SYS3	.574**	.633**	1.000							
CON1	.555**	.479**	.576**	1.000						
CON2	.556**	.498**	.593**	.757**	1.000					
SOC1	.449**	.499**	.436**	.489**	.523**	1.000				
SOC2	.471**	.414**	.489**	.481**	.527**	.761**	1.000			
PEOU	.424**	.354**	.433**	.409**	.396**	.461**	.516**	1.000		
PU	.456**	.418**	.459**	.477**	.460**	.619**	.681**	.733**	1.000	
USE	.545**	.472**	.522**	.567**	.608**	.540**	.590**	.626**	.670**	1.000
Mean	4.091	4.107	4.166	4.004	4.030	4.183	4.107	4.209	4.242	4.153
S.D.	.521	.576	.564	.552	.556	.514	.497	.588	.508	.526

Note ** $p<.01$

Table 1 - The mean, standard deviation, and matrix of correlation coefficient between the observed variables using in the research study (N = 1,170).

order was the relationships between convenience (CON) variables and actual use (USE) variables, which ranged from .567 to .608. The relationship of social interaction (SOC) variables with actual use (USE) variables ranged from .540 to .590. The relationship of perceived ease of use (PEOU) variables with actual use (USE) variables was .626, and the relationship of perceived usefulness (PU) variables with actual use (USE) variables was .670. The analysis findings of the relationships between a total of ten observed variables showed that the reliability coefficient of all nine observed variables, or a total of 36 pairs, ranged for the correlation coefficient from .354 to .761 which was different from zero at the .05 significance level, and therefore showed no problem with multi-collinearity.

2. The findings of the investigation of SEMAC consisted of exogenous variables, which comprised three variables including system quality (SYS), convenience (CON), and social interaction (SOC), and mediator variables including two variables: perceived ease of use (PEOU) and perceived usefulness (PU). The endogenous variable of actual use (USE) found that the Chi-square = 34.659, df= 23, GFI = .989, AGFI = .947, and RMR = 005. This showed that the structural equation model developed by the researcher was in harmony with the empirical data. The variables in the structural equation model could explain the variance of actual use (USE) for 62.4 % as shown in Figure 2 and Table 2.

The size of the effect of each of the five independent variables on actual use can be divided into two groups as follows: 1. the variable showed direct effects and indirect effects, and 2. the variable showed only direct effects, as shown in Figure 2.

2.1 The variables which represented both direct and indirect effects were convenience (CON), system quality (SYS), perceived ease of use (PEOU), and social interaction (SOC) on the actual use. The variables' total effective sizes were .191, .336, .312, and .304, respectively. System quality (SYS), convenience (CON), and perceived ease of use (PEOU) had a direct impact on actual use (USE) as well as an indirect impact. Its direct impact sizes were .116, .323 and .224 and indirect impact sizes were .075, .013 and .080, respectively. This means that when the student uses cloud learning the system quality provides convenience and perceived ease of use, which results in the student wanting to pursue the actual use of cloud learning (USE) more (direct impact > indirect impact). Social interaction had an indirect effect on actual use rather than a direct effect. Its indirect impact size was .206 and direct impact size was .106. It can be concluded that when the student engages in social interaction, he or she will pursue the actual use of cloud learning (USE) more often (indirect impact > direct impact).

2.2 The variable showed a direct effect on actual use. Perceived Usefulness (PU) had a direct effect size of .181. This indicates that when a student has acknowledged perceived usefulness, the actual use of cloud learning (USE) will increase continuously.

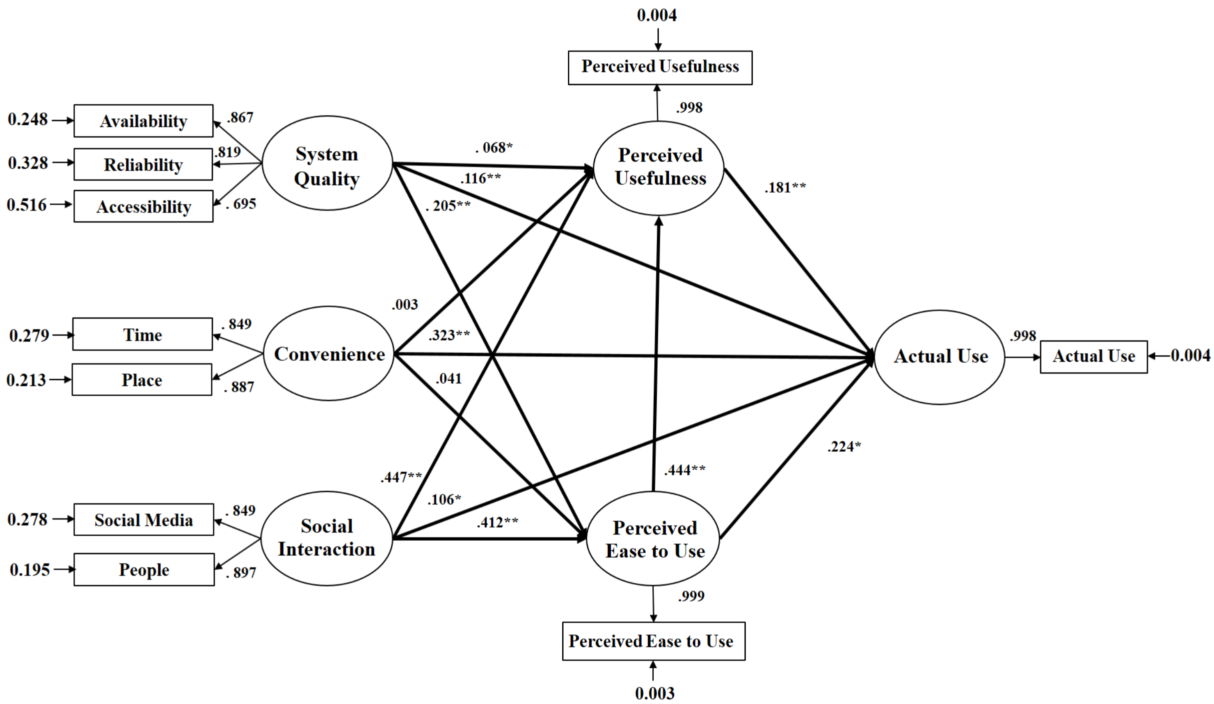

Figure 2 - The structural equation model of actual use of cloud learning for Higher Education Students in the in 21st century.

Dependent Variable		PEOU			PU			USE		
Independent Variable	Statistics	TE	IE	DE	TE	IE	DE	TE	IE	DE
SYS	CS	.205**	-	.205**	.159**	.091*	.068*	.191**	.075**	.116**
	SE	.044	-	.044	.037	.020	.031	.038	.016	.034
CON	CS	.041	-	.041	.021	.018	.003	.336**	.013	.323**
	SE	.046	-	.046	.039	.021	.032	.040	.016	.036
SOC	CS	.412**	-	.412**	.630**	.183**	.447**	.312**	.206***	.106**
	SE	.040	-	.040	.035	.019	.031	.034	.024	.037
PEOU	CS	-	-	-	.444**	-	.444**	.034**	.080**	.224**
	SE	-	-	-	.022	-	.022	.024	.016	.028
PU	CS	-	-	-	-	-	-	.081**	-	.181**
	SE	-	-	-	-	-	-	.035	-	.035

Statistic χ^2 = 34.659 df = 23 p = .056 GFI = .989 AGFI = .974 RMR = .006

Variable Reliability	SYS1	SYS2	SYS3	CON1	CON2
	.271	.321	.318	.305	.309
Variable Reliability	**SOC1**	**SOC2**	**PEOU**	**PU**	**USE**
	.264	.247	.346	.258	.277
The Structural Equation Model	**PEOU**	**PU**	**USE**		
R2	.353	.697	.624		

Note: *p < .05, **p < .01, TE = total effect, IE = Indirect Effect, DE = Direct Effect, CS = Completely Standardize Solution, SE = standard error

Table 2 - The analysis findings of validity of actual use

8. Conclusion and Discussions

According to the research implemented in respect of the SEMAC, the researcher found three major issues to discuss as follows.

1. The SEMAC had empirical validity. The study found that the Chi-square = 34.659, df= 23, GFI = .989, AGFI = .947, and RMR = 0.0006. This showed that variables in the structural equation model could explain the variance of actual use (USE) for 62.4% of cases, which is greater than the required criterion (60%). Hence, the SEMAC that the researcher has developed is considered to be a suitable model because causal variables of system quality (SYS), convenience (CON), and social interaction (SOC) were present in the study. The mediator variables were perceived ease of use (PEOU) and perceived usefulness (PU). This can explain actual use. However, there are other causal variables that the researcher did not consider using in this study such as digital literacy (Mac Callum et al., 2014), self-efficacy (Bagci & Celik, 2018), online course design (Chinyamurindi et al., 2017), and perceived risk (Tripathi, 2018). These influence the actual use of cloud learning, which helps to provide further explanation of the variance of actual use of cloud learning systems.

2. To the results of this research, system quality had a positive direct effect as well as an indirect effect on actual use at the significance level of .05. This means that higher education institutes have to improve their systems to be more effective. This is proposed in the 12th Higher Education Development Plan 2017 – 2021, which states that there must be a structural improvement of information technology and communication technology to support their implementation as learning tools (Office of the Higher Education Commission, 2016), in order to properly follow the government policy. The Ministry of Information and Communication Technology of Thailand (Ministry of Digital Economy and Society) has created the Thailand Digital Economy and Society Development Plan: Digital Thailand 2016 – 2037 to enable the country to utilize and improve creativity with the efficient implementation of digital technology in order to develop basic infrastructure, innovation, information, human resources, and other resources. Hence, this aims to drive the Thai economy and society to become more stable, prosperous, and sustainable (Ministry of Information and Communication Technology of Thailand, 2016).

Convenience had a positive direct effect on actual use at the significance value of .05. This shows that when the student obtains 'convenience' in online learning through cloud learning, he or she may select times and places to study as he or she prefers. Thus, it highlights what learning in the 21st century is becoming (Mooc-Maker, 2016).

Social interaction had a positive direct effect and an indirect effect on actual use at the significance value of .05. This is because society in the present digital period utilizes digital technology in every area or sector, including learning (Grand-Clement, 2017). Therefore, social interaction in the cloud is considered to be an important factor for employment and livelihoods, because cloud technology is a tool that helps people to communicate and connect in groups easily, especially for learning and teaching (Jenny, 2017).

Perceived ease of use had a positive direct effect and indirect effect on actual use at the significance level of .05, whereas perceived usefulness had a positive direct effect on actual use at the significance value of .05. These two variables are parts of the Technology Acceptance Model (TAM) theory that discusses and explains the acceptance factors or the actual use of information technology (Bertrand and Bouchard, 2008; Park, 2009). The results mentioned state that when the student recognizes different operational functions, he or she will perceive the ease of use. Thus, the use of the cloud learning system increases.

3. The research tool used in this study also showed an IOC value for every question with a higher significance value than the standard (greater than or equal to .5). Also, when the researcher used the 'Try Out' tool to test the quality of the tools to analyse reliability using the Cronbach's Alpha coefficient, it was found that the reliability of the questionnaire for every latent variable was at a high level. After analysing the data using Lisrel 9.2, the results indicated that only the observed variable of system quality (SYS), which was Stable (SYS2), had a value of .574 (lower than the standard of .7). Thus, if other researchers would like to use this questionnaire, they should edit the questions beforehand in order to correct this problem.

9. The expected usefulness

1. For academic usefulness, the findings show the value of the SEMAC.
2. For practical usefulness, the findings are useful for higher education institutes to prepare for the information technology infrastructure system.
3. For policy usefulness, the findings of this study are useful for higher education institutes, and their presidents may use this study as the basis of policy planning for information technology development in learning and teaching.

10. Recommendations for Policy

In this section, the researcher would like to make the following suggestions for policy development:

1. The Ministry of Higher Education, Science, Research and Innovation must encourage and support higher education institutions to implement information technology as a part of lectures to reduce the gap in literacy and education approaches.
2. Higher educational institutions should prepare basic knowledge and lessons in information technology to support cloud learning (for example, wireless networks).
3. The Ministry of Education should construct a policy that implements technology in basic education and vocational education learning to provide basic knowledge for those who are interested in pursuing higher education. This also includes educating and training lecturers about information technology and how to use it as a teaching and learning tool.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 81-89

Distance learning and teaching as a consequence of the Covid-19 pandemic: a survey of teachers and students of an Italian high school taking into account technological issues, attitudes and beliefs toward distance learning, metacognitive skills

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(submitted: 15/2/2021; accepted: 13/7/2021; published: 26/7/2021)

Abstract

The Covid-19 pandemic has forced the education system to a rapid and unprepared transition to distance learning, inducing many teachers to organize lessons via information and communication technologies (ICTs), albeit often without sufficient technological and organizational support. Our study aims to evaluate teachers' and students' experience with ICTs during the first lockdown, considering three categories of relevant factors: technical issues, attitudes and beliefs towards online learning, and metacognitive skills. Participants were 486 students and 83 teachers of a Northern Italy high school, who were administered a self-reported online questionnaire. Video-lessons and audio-lessons emerged as overlooked teaching modalities. The desktop was the less used device, teachers preferred the tablet, while students preferred the smartphone. In general, students displayed appreciation of distance learning, even if they wished for more interactive activities. Teachers' level of metacognitive competence and self-efficacy were rather high. For students, the perception of the e-learning environment predicted positively the perception of distance education and negatively the experienced anxiety, with anxiety also being higher among females. For teachers, the evaluation of distance learning was positively predicted by their beliefs about ICTs. This demonstrates the importance of promoting positive ICTs beliefs to motivate teachers in engaging in distance learning. Moreover, higher perceived self-efficacy was associated with lower levels of anxiety, thus showing the need to engage in training activities enabling teachers to feel confident when using ICTs.

KEYWORDS: Distance Learning, e-Learning, Remote Teaching, ICT, Covid-19

DOI
https://doi.org/10.20368/1971-8829/1135463

CITE AS
Cadamuro, A., Bisagno, E., Rubichi, S., Rossi, L., Cottafavi, D., Crapolicchio, E., & Vezzali, L. (2021). Distance learning and teaching as a consequence of the Covid-19 pandemic: a survey of teachers and students of an Italian high school taking into account technological issues, attitudes and beliefs toward distance learning, metacognitive skills. *Journal of e-Learning and Knowledge Society*, *17*(1), 81-89.
https://doi.org/10.20368/1971-8829/1135463

1. Introduction

The global emergency of Covid-19 represents an unprecedented shift in education. More than 1.725 billion children worldwide were affected by the closure of schools in response to the pandemic (Holme, 2020). UNESCO (2020) recommended the use of distance learning programs and open educational applications and platforms that schools and teachers could use to reach learners remotely, limiting the disruption of education. This sudden shift to online learning prompted teachers to rapidly shift the traditional ways of teaching online. This hasty transition, a general lack of

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preparedness, and technical problems led, in many cases, to an unfulfilling virtual learning experience for both teachers and students, fostering the perception of virtual learning as being of lesser quality compared to face-to-face education (Sindiani et al., 2020).

Some countries specifically witnessed a lively debate between Information and Communication Technologies (ICTs) supporters and those who think that ICTs are ineffective or even harmful for education (Schleicher & Reimers, 2020).

When the relation between ICTs and students' learning outcomes was directly analyzed, results were mixed: some studies indicated better learning outcomes by using new technologies (Chen, Chiang, & Lin, 2013), while other studies did not provide evidence of significant differences between traditional and e-learning (Higgins, Beauchamp, & Miller, 2007).

In this study, we aim to provide a general assessment how ICTs have been perceived by both teachers and students during the first lockdown due to the COVID-19 pandemic. Indeed, teachers and students can have similar, but also different or complementary perceptions, and may place greater importance on some factors over others; therefore, departing from most research, we decided to investigate ICTs perceptions from both points of views. Specifically, we conducted a study aimed at investigating the perception of ICTs use among teachers and students of a high school in Northern Italy which, like many others, had to resort to ICTs during the lockdown. Moreover, while studies on the use of ICTs in educational environment generally focus on few specific aspects, we considered several factors, broadly included in three main categories, namely technological issues, attitudes and beliefs toward ICTs, and metacognitive skills.

1.1 ICTs in learning/teaching environments

With the Covid-19 pandemic, Italian teachers resorted to remote teaching as a replacement for traditional teaching. However, the general idea emerging from the public discourse is not that of making an effort to exploit their potential but using them as a temporary replacement before returning to traditional teaching.

According to many research, digital devices can be effective in delivering content and fostering pupils' motivation (Amiri & Sharifi, 2014), promoting social interaction, peer education, and collaboration (Somyürek, Atasoy, & Özdemir, 2009), favoring a constructive didactic approach (Jonassen, Howland, Marra, & Crismond, 2008), and ultimately leading to meta-cognitive learning and to learning how to learn, rather than a specific skill (Monteith, 2002).

Of course, many factors can influence online learning: materials, activities, motivation, students' learning styles, and self-regulation (Ligorio et al., 2010).

Assuming that the students' outcomes will automatically increase by employing technologies may be wrong and even dangerous, since it can lead to overly optimistic and unrealistic expectations. In this sense, digital devices should not be understood as 'teaching machines', but as 'tools' that allow students to co-construct their own learning path, to socialize it and, therefore, to tailor it according to their personal cognitive style (Battro, 2010). Introducing ICTs in school and using them as traditional tools is not sufficient. ICTs should match the characteristics of the individual and foster an active and efficient learning process. In this sense, the real challenge does not concern introducing the ICTs in educational environments per se but using them to effectively stimulate the students' learning process, taking advantage of their potential and allowing them to overcome their learning weaknesses. These considerations lead us to underline the importance of teachers in the efficient use of ICTs (Drossel et al., 2017).

Several aspects need consideration to plan effective and motivating ICTs learning environments. Most studies focused on a single issue, from the perspective of either teachers or students. In order to provide a more systematic account of potentially relevant factors and their impact on e-learning, we grouped them into three categories.

1.2 Factors impacting online learning

Technical issues

ICTs effectiveness can be influenced by many factors, including technology availability, accessibility of ICT equipment, and technical and administrative support (Fu, 2013). According to Venkatesh and Davis (2000), when teachers are presented with new technology, two factors influence their decision to use it: external variables and perceived usefulness. Amongst the external variables, limited ICTs facilities, accessibility and network connection, lack of effective training and technical competency are the main limitations. Toprakci (2006) found that a low number of computers (in relation to the number of students), obsolescence or slowness of ICT systems, and scarcity of educational software in the school constitute barriers to the successful implementation of ICTs in schools. However, according to Becta (2004), the inaccessibility of ICTs resources is not necessarily due to the unavailability of hardware, software, or other materials within the school. It may also be the result of various factors, such as poor resource organization, poor quality of hardware and software, or lack of personal access for teachers.

ICTs competency, internet connectivity, technical issues and usability can hinder students' use of ICTs (Silin & Kwok, 2017). Volery and Lord (2000) proposed a framework to identify the critical factors for online education to succeed, focusing on three aspects: technology (ease of access and navigation, interface design and level of interaction), instructor (attitudes toward students, technical competence and classroom interaction), and previous knowledge and use of the technology.

Attitudes and beliefs toward online learning

Positive attitudes of both teachers and students towards ICTs can facilitate the process of integrating technological innovation into teaching and studying (Sang et al., 2010). Several studies have shown that teachers' and students' perceptions of whether the use of ICTs in class improves learning outcomes and motivation predict the use of ICTs in school (e.g., Davis et al., 2013; Eickelmann & Vennemann, 2017; Teo et al., 2009). Negative attitudes toward ICTs lead to being less informed about them and, in turn, to a less frequent use of digital devices (Drossel et al., 2017).

Teachers' self-reported competencies regarding pedagogical and technical knowledge have been shown to predict ICTs use (Fraillon et al. 2014). Other relevant personal characteristics analyzed are the teachers' willingness to change, their self-efficacy with respect to the use of ICTs (Roca & Gagne, 2008), as well as their expectations about their students' interest and learning outcomes (Perkmen, 2014). Balanskat et al. (2006) have shown that a low self-perceived competence of the teacher is a strong barrier to the integration of technology into education and one of the key predictors of resistance to change. Edmunds, Thorpe, and Conole (2012) reported that perceived usefulness and perceived ease of use of ICTs are key dimensions to encourage teachers' acceptance of new technologies in learning processes. Other fundamental elements endorsing the perceived usefulness of ICTs are the possibility to work faster, increased job performance and increased productivity, and superior teaching effectiveness (Venkatesh & Davis, 2000). Watson (1993) identified a wide range of features that teachers look for in a technological tool; specifically, it should be easy to learn and remember how to use it, and it should be easily understandable and controllable.

Research has shown that also students' attitudes and their readiness to accept technology in teaching are critical to their successful learning (Teo et al., 2009). Sun and Zhang (2008) showed that students' anxiety about the use of ICTs affects their satisfaction in e-learning courses. Kubiatko (2010) found that the effective use of ICTs within students improves both attitudes towards technology and computers skills, which, in turn, empower the effectiveness of ICTs, thus creating a positive feedback spiral.

Metacognitive skills

There is consistent evidence that effective ICTs use requires changes in attitudes, values, and beliefs that develop confidence for ongoing learning and adaptability to change (Phelps, Graham & Kerr, 2004). Such approach requires teachers to challenge their pedagogical beliefs and practices, identifying what they still need to learn, and what kind of teachers they are (and wish to be) in a life-long learning perspective. Teachers' understanding and use of ICTs depends on many factors, such as self-efficacy, anxiety, support, encouragement, perceived usefulness, pedagogical orientation, goal orientation, volition, problem-solving, playfulness, help-seeking, learned helplessness and attributions (Phelps & Graham, 2008).

According to Phan and Dang (2017), training, attitude, technical competence, time constraints, pedagogy and methodology are among the main predictors of efficient distance learning education. Providing pedagogical training for teachers, rather than simply training them to use ICTs tools, is of primary importance (Becta, 2004). Some studies showed that after a professional course in ICTs, teachers still did not know how to effectively integrate them in classrooms, because the courses only focused on practical skills rather than on the pedagogical implications of ICTs (Balanskat et al., 2006; Cox, 2003). Metacognitive competences allow people to think about themselves as computer learners, taking control over their learning and teaching processes and developing confidence and willingness to integrate ICTs in school.

Finally, we acknowledge the role of background variables, such as age and gender. In general, studies showed that older teachers have a lower tendency to use ICTs in class (Fraillon et al. 2014), whereas gender is related to the frequency of computer use in class: male teachers seem to use computers more frequently than their female colleagues (Eickelmann et al. 2017). Other studies however did not detect gender differences in the use of ICTs in class (Shapka & Ferrari, 2003).

With respect to students, there are mixed results regarding gender differences in attitude toward ICTs. While some studies found that males have a more positive perception of technologies than female students (e.g., Liaw, 2002), other studies did not find any significant difference (e.g., Adenuga et al., 2011).

We believe it is necessary to deeply reflect on the use of digital technologies in school, to make remote teaching a positive experience for both students and teachers. It appears crucial to investigate the availability of technologies, as well as the difficulties experienced by both students and teachers and their attitudes, to design effective distance learning interventions that do not respond only to temporary crisis.

We conducted a research on a sample of students and teachers from an Italian high-school taking into account the three main categories of factors affecting ICTs use and effectiveness, that is technological issues, attitudes and beliefs towards ICTs, and metacognitive skills. Specifically, we collected data on teaching and learning modality, tools used (devices, platforms), and problems that emerged during the lockdown caused by the pandemic. We also investigated psychological variables such as perceptions, attitudes, beliefs, metacognition, anxiety, and self-efficacy, which can contribute to bringing people closer (or not) to new technologies, thus facilitating a smooth transition to distance learning. The ultimate goal was to understand which variables predict a positive evaluation of distance learning in both students and teachers.

2. Materials and Methods

2.1 Participants and Procedure

Participants were 486 students (11.9% males, mean age = 16.3 years) and 83 teachers (24.1% males, mean age = 53.47 years) of a high school located in Reggio Emilia (Northern Italy). Participants were administered a self-reported online questionnaire.

2.2 Procedure and materials

Teaching modality. Participants were administered a list of teaching modalities among which to choose the one(s) used during the lockdown (the list was similar for students and teachers): streaming or video-lessons; audio-lessons; videos, documentaries, and other online resources; lecture notes or other school material; homeworks to be delivered to the teacher; online questionnaires and tests; individual study; projects.

Device. We asked participants to report the device used for online learning, by using the following options (participants could report more than one device): desktop, laptop, tablet, smartphone.

Problems emerged. Participants were asked to indicate the extent to which they experienced difficulties in online learning (see Table 1). All answers were provided on 5-points scales, anchored to 1 (*not at all*) and 5 (*very much*).

Anxiety. Participants were administered the STAI S-Anxiety Scale (Spielberger et al., 1983), a 20 items self-report questionnaire to measure the presence and severity of anxiety symptoms. We asked teachers and students to think about how they feel when they are about to start remote teaching, and indicate how true each statement was for them by using a 4-points scale ranging from 1 (*not at all*) to 4 (*very much*) (alpha = .94).

Students' perception of distance education (students). Participants were administered 6 items (Educational Factors) of the Distance Education Questionnaire (DEQ) (Gok, 2015) to investigate the college students' opinions about distance education courses. All answers were provided on 5-point scales, from 1 (*not at all*) to 5 (*very much*) (alpha = .79).

Students' perception of the e-learning environment (students). The students were asked to respond to a questionnaire made of 24 items loading on 11 scales, measuring various aspects of their perception of the e-learning environment (Martens et al., 2007); the different subscales are shown in Table 2. All answers were provided on 5-points scales, anchored to 1 (*not at all*) and 5 (*very much*) (alpha = .89).

Teachers' metacognitive experience (teachers). We used the Teacher Metacognition Inventory (Yingjie, Lin, & Liang, 2016), consisting of 21 items that investigate different aspects of metacognition in teachers (reported in Table 4). All answers were provided on 5-point scales, anchored to 1 (*not at all*) and 5 (*very much*) (alpha = .84).

Measure	Students		Teachers	
	M	*SD*	*M*	*SD*
Problems with online connection	3.21	1.16	2.81	0.98
Unavailability of device	1.66	1.15	1.25	0.60
Difficulties in using apps or programs	2.48	1.27	2.31	0.97
Scarce collaboration with peers (for students) or communication problems with students (for teachers)	2.51	1.38	2.64	1.00
Emotional or personal problems	2.73	1.50	2.46	1.15
Difficulties in organizing learning	2.62	1.25	/	/
Difficulties in time planning	2.72	1.24	/	/
Difficulties in translating traditional lessons in online lessons	/	/	2.72	1.16
Low preparation in how to organize a non-traditional lesson	/	/	2.49	1.15
Insufficient knowledge on how to motivate/teach in distance learning	/	/	2.69	1.02
Insufficient preparation on how to evaluate students in distance learning	/	/	3.28	1.17
Necessity of reducing the contents presented	/	/	3.18	1.12
Discomfort in being repeatedly online	/	/	3.47	1.31

Table 1 - Means and standard deviations for students (N = 486) and teachers (N = 83) in relations to problems emerged.
Note. The response scale for all measures ranged from 1 to 5.

Measures	Students	
	M	***SD***
Perceived authenticity of the e-learning environment	2.76	0.89
Extent of confusion regarding the e-learning environment	2.84	0.93
Experienced support in the e-learning environment	3.16	0.82
Extent of explorative behavior of the learner	2.58	1.10
Extent of collaboration with other learners	2.34	0.96
Positive opinion about the use of role-play	2.22	1.19
Opinion about the usefulness of discussion with other learners	2.67	1.06
The e-learning environment urges exploration	2.40	1.14
E-learning is innovative	4.14	0.86
Intrinsic motivation	2.65	1.14
Total score	**2.81**	**0.65**

Table 2 - Mean scores and standard deviations (subcomponents and total score) for students' perceptions of the e-learning environment (N = 486).
Note. The response scale for all measures ranged from 1 to 5.

Teachers' beliefs about ICT (teachers). We administered the Teachers' beliefs about ICTs, a Likert-type scale containing statements of beliefs towards ICTs and their application in education (Jimoyiannis & Komis, 2007). The questionnaire consists of three subscales (shown in Table 5). All answers were provided on 5-point scales, anchored to 1 (*not at all*) and 5 (*very much*) (alpha = .65).

Teachers' self-efficacy (teachers). Teachers were asked to answer to a 12 -item questionnaire aimed at measuring three domains of self-efficacy (see Table 6) (Klassen & Ming, 2010). All answers were provided on 5-points scales, anchored to 1 (*not at all*) and 5 (*very much*) (alpha = .84).

Evaluation of remote teaching (teachers). Teachers were administered a 12 items *ad hoc* questionnaire, created to measure the positive attitude towards remote teaching. All answers were provided on 5-points scales, from 1 (*not at all*) to 5 (*very much*) (alpha = .91).

3. Results

With respect to teaching modality, 73.5% of teachers declared the use of streaming video-lessons. The use of registered video and audio-lessons was reported by 38.1% of students, and by 15.7% (registered video-lessons) and 18.1% (audio-lessons) of teachers (for teachers, two items were used to tap response to the two modalities). Most students (55.6%) and teachers (68.7%) reported having used videos, documentaries, and other online resources. Similarly, the use of lecture notes or other school material was reported by 74.7% of students and 78.3% of teachers. Another popular modality concerned homeworks administered to students and to hand back to the teacher (91.8% students, 90.4% teachers). Interestingly, the use of online questionnaires and tests was reported by 89.3% of students and 44.4% of teachers. Finally, 68.7% of students reported resorting to individual study, and 13.3% of teachers reported having worked on projects.

The desktop was indicated as the less used device by both students (12.8%) and teachers (30.1%). In contrast, students (65.4%) and teachers (78.3%) used to a greater extent their notebooks. Tablets were used more by teachers (44.6%) than by students (24.1%); the opposite tendency emerged for smartphones, used more by students (63.2%) than by teachers (34.9%).

As can be noted in Table 1, participants experienced various types of difficulties. However, the average levels of difficulties expressed were relatively low.

Descriptives for the measure of students' perceptions of the e-learning environment are presented in Table 2. Both the global score and the single values for the different components of students' perceptions of the e-learning environment were moderate, with lower values for the components "Extent of collaboration with other learners", "Positive opinion about the use of role-play", and "The e-learning environment urges exploration." In contrast, relatively high values emerged for the dimension "E-learning is innovative."

The evaluation of distance lerning, as resulting from the average score obtained for the measure of students' perceptions, was moderately negative (M = 2.69, SD = 0.79), as also indicated by the difference from the mid-point (3), $t(485) = 8.57$, $p < .001$. Additional analyses revealed that age or gender were not reliably associated with any of the students' variables with the exception of "Students' perception of distance education". A one-way ANOVA with Class as the between-subject variable revealed that "Students' perception of Distance Education" depended on the class, $F(1,4)$= 4.67, p=.001. Differences on this variable among school grades are presented in Table 3.

In contrast, anxiety was moderately high (M = 2.84, SD = 0.88), with the average score higher than the mid-point (2.5), $t(485) = 8.52$, $p < .001$.

To understand the incremental contribution of demographic factors and students' perceptions of the e-learning environment on the evaluation of distance education and anxiety experienced, we ran a linear regression analysis. Results are reported in Table 4.

As can be noted in Table 3, students' perceptions of the e-learning environment were positively associated with both outcome variables over and above the effects of demographics. These associations were quite strong, with students' perceptions of the e-learning environment positively associated with students' perceptions of distance education and negatively associated with anxiety.

We present in Table 5 descriptives for teachers' metacognitive experiences. As can be seen, average scores are rather high (except for "Metacognitive knowledge about the self", which is moderate), as is the global score.

We present in Table 6 descriptives for teachers' beliefs about ICTs. For both subcomponents and global scores, means were moderate, although teachers showed higher scores in the component "Teachers' beliefs about ICT integration in education."

Descriptives for teachers' self-efficacy are presented in Table 7. Scores were generally indicated moderate-to-high levels of self-efficacy in teachers.

Evaluation of distance learning in teachers was rather negative (M = 2.84, SD = 0.88), with the average score lower than the mid-point (3), $t(82) = 8.91$, $p < .001$. Teachers also revealed average levels of anxiety (M = 2.49, SD = 0.53); the average score did not differ from the mid-point (2.5), $t < 1$.

To evaluate the relative contribution of the measured factors and demographics in determining teachers' perception of distance education and their anxiety, we ran linear regressions. Results are presented in Table 7.

As can be seen in Table 7, teachers' beliefs about ICTs emerged as the only significant predictor of a positive perception of distance learning. In contrast, the only predictor of anxiety was teachers' self-efficacy, with greater perceptions of self-efficacy associated with lower levels of anxiety.

Measure	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5
Students' perception of distance education	2.74 bc (0.74)	2.80 b (0.81)	2.56 c (0.84)	2.90 b (0.76)	2.40 a (0.60)

Table 3- Mean scores (standard deviations) for the measure of Students' perception of distance education by school grade (Gr.). Different letters on the same row indicate that means are significantly different, p<. 05.

	Students' perception of distance education	**Anxiety**
Age	-.05*	-.02
Gender (1 = male, 2 = female)	-.03	.10*
Students' perception of the e-learning environment	.81***	-.51***
F	317.72***	57.89***
R^2	.66	.27

Table 4 - Linear regression testing predictors of students' perception of distance education and anxiety (*N* = 486).
Note. *$p < .05$. **$p < .01$. ***$p < .001$.

Measures	**Teachers**	
	M	***SD***
Metacognitive experiences	3.89	0.83
Metacognitive knowledge about pedagogy	4.14	0.86
Teacher metacognitive reflection	3.66	0.80
Metacognitive knowledge about the self	3.01	0.90
Teacher metacognitive planning	4.07	0-80
Teacher metacognitive monitoring	3.92	0.66
Total score	**3.76**	**0.54**

Table 5 - Mean scores and standard deviations (subcomponents and total score) for teachers' metacognitive experience (*N* = 83).
Note. The response scale for all measures ranged from 1 to 5.

Measures	**Teachers**	
	M	***SD***
Teachers' beliefs about ICT as a teaching and learning tool	3.07	0.70
Teachers' beliefs about ICT integration in education	3.54	0.46
Teachers' beliefs about ICT in the educational process	3.03	0.77
Total score	**3.24**	**0.36**

Table 6 - Mean scores and standard deviations (subcomponents and total score) for teachers' beliefs about ICT (*N* = 83).
Note. The response scale for all measures ranged from 1 to 5.

Measures	**Teachers**	
	M	***SD***
Job satisfaction	3.09	1.00
Classroom management	3.89	0.71
Student engagement	3.67	0.77
Instructional strategies	3.44	0.88
Total score	**3.54**	**0.68**

Table 7 - Mean scores and standard deviations (subcomponents and total score) for teachers' self-efficacy (*N* = 83).
Note. The response scale for all measures ranged from 1 to 5.

	Students' perception of distance education	**Anxiety**
Age	-.17	-.07
Gender (1 = males, 2 = females)	-.08	.17
Teachers' metacognitive experiences	-.08	.05
Teachers' beliefs about ICT	.48***	-.11
Teachers' self-efficacy	.17	-.36**
F	8.83***	4.39***
R^2	.36	.22

Table 3 - Linear regression testing predictors of teachers' evaluation of distance learning and anxiety (*N* = 83).
Note. *$p < .05$. **$p < .01$. ***$p < .001$.

4. Discussion and Conclusions

The first part of our study descriptively investigated how e-learning has been implemented during the lockdown. It is worth noting that registered video-lessons and audio-lessons, that is the two modalities that require more planning and self-commitment by teachers, emerged as overlooked teaching modalities. Not surprisingly, the desktop is the less used device by both teachers and students, while the laptop is way preferred. Interestingly, while teachers prefer the tablet over the smartphone, the opposite tendency emerges among the students. Part of these differences may be due to the different use that teachers and students make of these devices (with teachers using them proactively to provide lessons, and students likely using them more passively). However, one may speculate a change in cultural use of these devices. Teachers prefer tablets probably because they have larger screens and keyboards, while students prefer smartphones because they are familiar with these tools, almost representing an extension of the self. In general, it is evident that portability and usability influenced the users and will certainly influence the choice of devices more and more in the future.

With respect to the students' perception of distance education and anxiety level experienced, we found that females felt higher anxiety during the distance learning experience, and that and students displayed a greater appreciation of distance learning when compared to teachers. In general, while students consider e-learning an innovative practice, they recognize that the extent of collaboration with other learners is critical, and that the e-learning environment promotes little exploration. These results suggest that students would like to participate in more interactive activities (research, projects, group activities), rather than following traditional lessons conveyed via digital tools.

Findings revealed that students' perceptions of the e-learning environments are critical in determining how students evaluate distance education. The explained variance was very high (81%). In addition, in a situation largely determined by the ongoing Covid-19 pandemic, the anxiety experienced is also a function of students' perceptions of the e-learning environment. In other words, appraisal of the e-learning environment contributes to well-being related to distance education, in addition to shaping how this is evaluated.

The teachers' level of metacognitive competence was generally rather high. This result suggests that the teachers have gained good pedagogical knowledge, but they have not achieved sufficient awareness of themselves. This result seems to be confirmed by the reported levels of self-efficacy: they perceive to have a good level of competence and control in classroom management, student engagement and the use of instructional strategies, however, they do not seem very satisfied with their job. Job satisfaction is a condition that is achieved more easily with a good awareness of oneself, of one's needs, objectives and desires. Interestingly, for teachers, the evaluation of distance learning and anxiety were a function of different predictors. Evaluation of distance learning was positively predicted by teachers' beliefs about ICTs, demonstrating the importance of promoting positive ICTs beliefs to motivate teachers in engaging in distance learning. In contrast, higher perceived self-efficacy was associated with lower levels of anxiety, showing the need to engage in training activities that would make teachers feel confident when using ICTs. Our results suggest that students would like to participate in more interactive activities during distance learning. This means that teachers should make every effort to transform "traditional" frontal teaching into practical activities. Teachers, on the other hand, reported low levels of self-awareness and low levels of job satisfaction when engaged in remote teaching activities. Taken together, these evidences suggest that during the remote teaching experience, teachers felt inadequate, without the necessary skills effectively deliver knowledge, which turned out to be little motivating and engaging for students. With this respect, one of the main strengths of our study is indeed to have considered both perspectives. We therefore derive that, if the distance education keeps proposing a transmissive teaching model, it is doomed to fail, as it leads to low involvement and motivation in students and high frustration in teachers. Therefore, it seems necessary to provide teachers with technical and pedagogical knowledge that allows them to exploit new technologies by taking advantages of the features that make them unique: tools capable of promoting an active role of the student, encouraging participation and peer collaboration.

In Italy, during the pandemic, one of the main problems has been the absence of central coordination: in most cases, teachers had to decide at the individual level (not even at the school level, with a few relevant exceptions) whether and how to use remote teaching. Without training and collective guidance, the introduction of ICTs is going to fail and support the expectations of the many who believe that it is not only useless but even potentially harmful. The situation caused by the pandemic should represent a stimulus to rethink teaching contexts by integrating new technologies in a more informed way to make students motivated, metacognitive, autonomous, and capable of self-regulation, all skills that support lifelong learning and that will be crucial for the citizens of the future.

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JOURNAL OF E-LEARNING AND KNOWLEDGE SOCIETY
Vol. 17, No. 1 (2021), pp. 90-100

E-Learning & decision making system for automate students assessment using remote laboratory and machine learning

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(submitted: 15/6/2020; accepted: 8/7/2021; published: 27/7/2021)

Abstract

This paper describes an implementation of a remote laboratory system for the practical works (PW) of electronics, this system make available to target and analysis the gaps, weaknesses and lack of scientific knowledge of students in the context of electric engineering through data mining algorithms and students' study behavior. Experimental work has traditionally been developed in laboratories. However, the increase in the number of higher education students in the last decades has put pressure on the physical structures and resources of laboratories. To overcome this, computational simulations and remote laboratories have been developed enabling the expansion of educational boundaries. this paper provides new opportunities to enhance the student's learning process. The results are presented and discussed according to two levels. The first is development a complete system of remote laboratory E@Slab and compare it with the related work. second level, we present an algorithms of Intelligence Artificial that automate evaluation and classify students in different groups attending to an assessment rubric. After this classification we compare the obtained results from algorithms of Intelligence Artificial with the levels obtained from interviews with the students and from the practical work review for to be a validation of sorts. Finally we compare the two results and we remark that algorithm classifies correctly the students with an accuracy of more than 90%.

KEYWORDS: E-Learning, Intelligence Artificial, Remote Laboratories, Embedded System, Behavioral Study, Online Practical Works, Automatic Evaluation, Data Mining Algorithms, Node Js.

DOI
https://doi.org/10.20368/1971-8829/1135285

CITE AS
Ouatik, F., Ouatik, F., Fadli, H., Elgorari, A., El Mohadab, M., Raoufi, M., Bouikhlene, B., & Skouri, M. (2021). E-Learning & decision making system for automate students assessment using remote laboratory and machine learning. *Journalof e-Learning and Knowledge Society, 17*(1), 90-100. https://doi.org/10.20368/1971-8829/1135285

1. Introduction

Assessment and evaluation [1] have a vital role to measure degree of transmission knowledge to the students and how students learn, and teachers teach. Evaluation has various purposes:

- Assessment informs teachers what students understand and allows them to plan and directed teaching by providing meaningful feedback to students.
- Assessment allows students to become aware of their learning methods for to adjusted and improved and advance their learning by assuming greater responsibility.
- The information gathered from the assessment allows students, teachers and parents, as well as the broader educational community, to be informed and to have idea about learning outcomes for to highlight successes, plan interventions and continue to foster success.

Within this framework E@Slab (Ouatik, 2017) integrate in these functionality a procedure allows the follow-up

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and the behavior study of each student during the online practical work in order to evaluate it, by a new approach using a feedback of an oral evaluation made to an sample students, the results of this evaluation we will be generalized for all students thanks to machine learning that use artificial intelligence by the exploitation of data mining that use a set of algorithms from various scientific disciplines such as statistics, probability and computing, for to build models from the data got from oral assessment, that is to say to find interesting structures or patterns according to criteria previously set, and to extract a maximum of knowledge for classified other structure. It helps to better understand the links between seemingly distinct phenomena and to anticipate trends that are not yet discernible.

In the following an overview of artificial intelligence methods used in adaptive education systems. AI approaches are considered valuable tools, as they have the capacity to develop and replicate the decision-making process adopted by the population (Barana, 2017; Cronin, 2018). Different artificial intelligence techniques have been used in adaptive education systems, such as fuzzy logic (FL), decision tree, Bayesian networks, neural networks, genetic algorithms and hidden Markov models.

Fuzzy logic was first introduced by Zadeh in (Ehlers, 2011) where it quickly became a popular and effective technique for user modeling, as it could mimic human reasoning (Hodgkinson-Williams, 2014). Fuzzy logic can be seen as an extension of traditional set theory, as statements can be partial truths, falling between absolute truth and absolute falsehood (Inamorato dos Santos, 2016).

The fuzzy logic system (FLS) consists of four stages:

fuzzifier, rule base, inference engine and defuzzifier (Knox, 2013). In addition, FL are commonly used to examine and assess learning and knowledge outcomes (Koseoglu, 2018).

Specifically, FL can be adopted to assess and review task objectives as well as multi-criteria assessments, as demonstrated in (Marchisio, 2019).

A decision tree is a tree in which each branch node represents a choice between several alternatives and each leaf node represents a decision (Marchisio, 2020). Decision trees are commonly used to obtain information in order to make the decision (Mayer, 2014).

Nascimbeni (2018) presented a system of personalized learning paths in which decision tree techniques inform the e-Learning system of the creativity of the learners. The author used the ID3 decision tree technique to explore the dataset containing learner data collected over a three-year period.

Neural networks are increasingly used to model human behavior and therefore to replicate human actions and responses (Marchisio, 2019) provide a good overview on neural networks and their functioning. Essentially, a neural network (NN) consists of a large number of neurons or intertwined components that work together to process information and solve problems. In reality, it is a system that collects and analyzes information very close to biological nervous systems, for example the brain. RNs do not require any information about a particular problem before solving it (Marchisio, 2019). They can process information and produce much more complex results than other information processing paradigms, making them a very influential way to model human behavior.

Bayesian networks are widely used methods for modeling learners in intelligent learning systems (Knox, 2013). A Bayesian network (BN) is a direct acyclic graph (DAG), that is, a graph that shows and explains the distribution of probability in such a way as to allow efficient diffusion of probability as well as accurate representation.

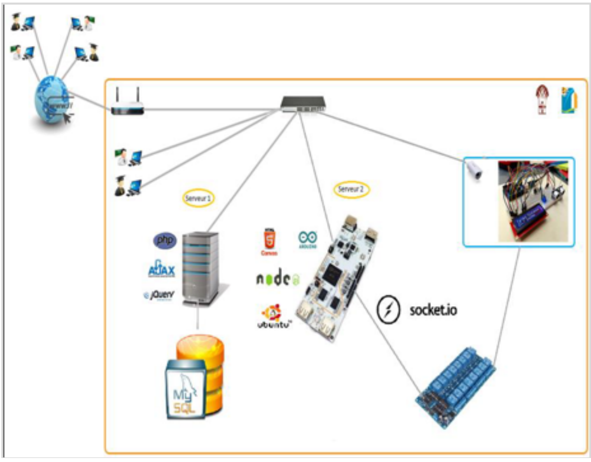


Figure 1 - Architecture and technology of E@Slab system.

1.1 Logical view

E@Slab is divided into 2 parts:
Admin Part is a web application where the administrator organizes the laboratory by the management of students, using a set of criteria (branch, group, module...), and creation appointments for practical work.

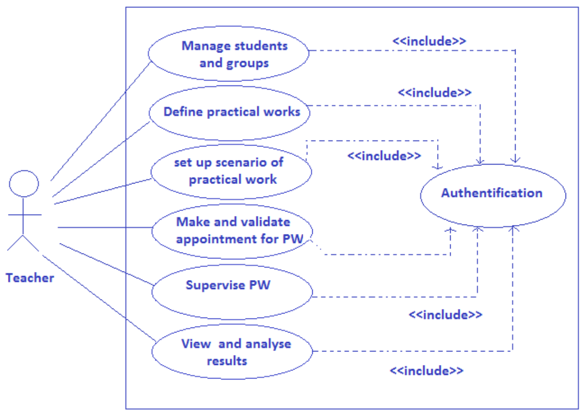


Figure 2 - Use case of Admin.

Actor: “Admin or Teacher”:

- Authentication: for to validate the legitimacy of access.
- Manage classes: allow teachers to manage classes, specialty and students.
- Define PW: allows teachers to implement the PW and theoretical part.
- Define the scenario: allows the teacher to define a practice scenario and question to students
- Make reservation: allows teachers to create appointments for each students to a specific practical work.

The second part concerns the student, after authentication in management platform, will see if he has an appointment for a manipulation; he will even know the date and time with which to start the PW. If the time comes, the link of the manipulation will appear and who will send towards the 2nd application that are the our electronic interface controller.

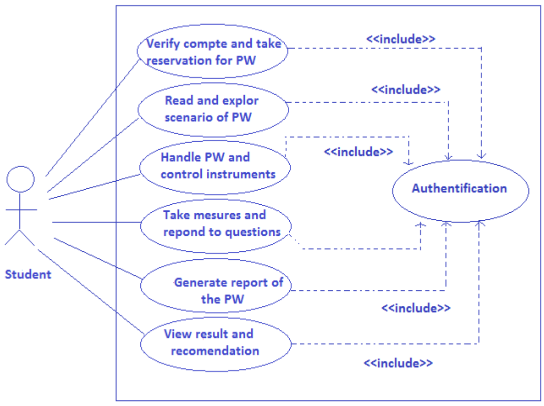


Figure 3 - Use case of student.

Actor: “Student”

- Authentication: for access authorization.
- Check there is a PW: allows students to check if they have an appointment to practical work.
- Gather information about the PW: allows the students to read a reminder about the theoretical notion.
- manipulate PW: Allows students to handle the practical work Using another application in server 2 (user interface for remote laboratory) but this will appear to students only when the reservation time is checked.

1.2 Physical view

Diagram of Figure 1 present two perimeters. The first is the web (Internet) and the second is the perimeter of the university (specifically the local school network LAN).

In the perimeter of LAN, we have two web servers, one containing the learning platform that represents the central university information system, where all information is found. The second server is a pcduino or raspebery that contains the application that will allow students to handle the practical work.

The process would work as follows.

Teacher connect either using the web or the local network; each teacher defines one or more PW, puts the theoretical part and the scenario after having made the PW reservation for all students.

On the other side, students connect using either the web. If student has an appointment for practical work, he consults and reads the scenario, then he checks the reservation. If the reservation time comme, he manipulates and remote the practical work; during this stage each reservation is destined and directed towards the server 2 (pcduino card). If the reservation time elapses, the PW ends and the material resources are released for a future reservation.

2. Evaluation And Make Decision About student gap

2.1 Logical vision: Why oral and interview assessment and difficulty

In this whole process our aims it’s not just the system and the technology used but our goal is learning, student must be understand the principle and aims of the courses and do practical work correctly. The classical methods to see their level of understanding is to do an assessment by feedback, test, report or exam, these methods are not efficient and not reflect the true level of the student and do not allow to target the gaps and problems that the student faces during the exam or test. For to properly assess the level of the students it is necessary to make an oral and interview based on precise and meaningful criteria, but that becomes very difficult in front of the big number of the students so the solution is to define a pedagogical and precise evaluation grid and criteria for assessment, then computerize and automate the evaluation but always keeping the benefits and advantages of the oral assessment that target the student gaps correctly, this is why this computerization is done thanks to Machine learning which uses the artificial intelligence algorithm and data mining.

Evaluation by oral and interview using data mining is usually done in 3 steps:

1. We take a sample of students who are going to do a practical work of analog electronics in front a teacher who will ask oral questions with each student for to analyze their behavior during practical work and to assess his level of understanding and mastered the theoretical and practical notions and noted all the problems that confront the student during this PW. For the results obtained for each student will be a class (trained data) that will used by data mining to evaluate the other student automatically.
2. Evaluated students automatically through the system E@slab which collects all reactions of the students from the user interface by JavaScript and their behavior during the PW online and it will evaluate them by datamining according to a set of

Criteria		Level unacceptable	Level insufficient	Level correct	Level excellent
A. KNOW-HOW: Relate to the involvement, the autonomy,	A-1 Anticipating the TP session	The student arrives without having done the preliminary work	The preliminary work is very incomplete	Preliminary work has been made seriously and drafted cleanly	The preliminary work is impeccable (complete, accurate and properly worded)
	A-2 Manage the TP session time	Some important parts of the TD were not addressed for lack of time	The pairs often wait to be relaunched by the teacher to move forward	The pair managed their time correctly (full work or appropriate reaction to a difficulty)	The binome benefits from its efficient management of time to deepen the subject
	A-3 Distributing work and helping each other within the binomial	The work is distributed unevenly among the students AND they do not cooperate	There is an imbalance in the distribution of work between the students OR they do not cooperate	The workload is fairly distributed AND the students cooperate so that everyone can master the overall work	Level and the student is able to help the other pairs at the time the teacher allows it .
	A-4 Working independently	The binomial does nothing without soliciting the teacher	Only the basic tasks are performed autonomously	The binomial answers the questions posed in the statement autonomously or asks the teacher wisely	Level and the pair poses pertinent questions for further discussion
B. EXPERIMENTAL KNOW-HOW: Relate to the ability to handle, compliance with a protocol, quality of measurements and recording of results	B-1 Using experimental equipment	The student uses the material in a hazardous or inappropriate manner (Possible damage)	The student uses the adapted material but he does not know how it works (unsuitable settings)	The student uses the material wisely and he knows how it works (settings Adapted)	Level and the student knows the limits of the equipment used
	B-2:Estimate measurement uncertainties	The binomial does not worry about the uncertainties	Uncertainty is poorly estimated or unjustified	Uncertainties are properly estimated and justified	Level and the binomial refines the experimental protocol to minimize them
	B-3:Record experimental results	Some important information is not readings	Results are uncoordinated (draft copy,...)	The student notes the results but he is the only one who can exploit his notes	The results can be easily a colleague
C. KNOW-HOW EDITORIALS: Are related to the exploitation and the analysis of the results, to the writing of a report including the capacity of synthesis, the taking of retreat	C-1 Write an introduction that specifies the context	No introduction	The introduction takes up exactly the text of the TP	The introduction is reworded, but it remains focused on the course of the session	The introduction is reworded with reference to the context and potential applications
	C-2 Establish a Scheme of the Experimental Device	No schematic	The schema is incompletely drafted, or remains inoperative for a reader not familiar with the system	The scheme is complete and exploitable but lacks care or rigor	The schematization is complete, exploitable, neat and rigorous
	C-3 Introduce the principle and the experimental protocol	The results are presented directly without the manipulation or associated principles being described	The principle and the protocol are copied without appropriation by the student	The experimental protocol is reformulated in a clear and justified way	Level and at least one proposed improvement of the protocol is formulated
	C 4. Draw a graph from measurements	The graph is very rough, the space is badly used (scale), it lacks the title, the label of the axes (magnitude represented • unit), graduations ...	The scale is adapted, the axes are graduated regularly, but badly denoted (absence of the magnitude represented unit), lack of title	The axes are labeled, the scale is adapted, the graph contains a title and a legend, the measurements are well reported with a trend curve	Level correct and error bars materialize uncertainties or annotations make it easier to interpret the results
	C-5 Establish a literal expression (including Uncertainties)	Literal expressions prior to numerical calculations are often Absent	The literal expressions are established, but often erroneous	The literal expressions are generally correct and the notations introduced by the student are explicit	The literal expressions are systematically correct and the notations explicit
	C-6 Present a finalized result	The results are presented in a Disordered	Units are missing or numeric values are false	The results are correct, with good results units, and with a number appropriate numbers significant	Level and an original presentation highlights important results
	C-7 Interpret the results, draw conclusions	No interpretation	The student discusses the results obtained in aVery superficial (repetitionof the speech of The teacher, ...)	Results are compared to expected values, and outliers are reported	Level and the conclusions put the results in a more general context in relation to the introduction

Table 1 - Criteria of evaluation.

parameters and according to the feedback from Trained Dataset.

3. Assessment criterion for practical work. We have defined 3 pedagogical criteria and each criterion contains a set of skills and competencies to be assessed it's well detailed in the grid it is a generic synthesis tool for the teacher and it offers 4 levels of evaluation and each level the condition that must fulfil.

2.2 Technical vision: Automatic and Computerize evaluation

Different steps are necessary to Computerize evaluation using datamining:

- Teacher prepares the practical work in the laboratory by realization the electrical circuit and related to the relay (Figure 7) which will be controlled by students.
- We choose a group of students to do the practical work really in laboratory ahead a teacher for to be a sample and datatest of datamining for prediction evaluation of all students.
- When student starts the practical work, teacher will record the note of their behavior, movements and answer and the way in which handled the practical work for to have additional information about their behavior.
- The same students who did the practical work, we will do them an interview depends on the practical work they did and we will try to find their level of understanding and target the gaps and problems that the student faces during the practical work.
- This sample group of students will become a exemplary and a model by which we will generalize the oral assessment for all students based on the principle of data mining, with this way we properly assess the level of the all students and target the gaps and problems that the student faces and met during the practical work automatically without doing the interview with all the students.
- For automated evaluation, we used the principle of data mining; that is to say evaluated the students by prediction of datamining algorithms by operating the interviews which made to the previous sample group based on a set of parameters.
- Our Organigramme system **S= {I, P, O}** can be modeled in the proposed system is represented in Figure 6 where:

  S = represent the proposed system

  P = {A, B, C} Where P=Processes: They Are the criteria that we have described in the table above figure and They are the criteria that our system must evaluate from the input parameter I.

  A = Know-how = $\{A_1, A_2, A_3, A_4\}$

  B = Experimental know-how = $\{B_1, B_2, B_3\}$

  C = Know-how editorials = $\{C_1, C_2, C_3, C_4, C_5, C_6, C_7\}$

  O = $\{O_1, O_2, O_3, O_4\}$ where O = output of our system and is the result of decision evaluation:

  O_1= Level unacceptable.

  O_2= Level insufficient.

  O_3= Level correct.

  O_4= Level excellent

I = inputs data to our system {I1, I2, … , In}

I_1: Last general note got by student.

I_2 : The note of the theoretical part of the PW

I_3: The note of the practical part of the PW

I_4: Number of absences in module.

I_5: Number of inscriptions in module.

I_6: Genre. The statistics we did on students behavior we noticed that there is a difference between girls and boys at the level of number of absences (3% for girls are absent in module and 11% for boys) and preparing practical work at home (90% for girls are preparing practical work at home and 70% for boys), for that we must take sex of students in consideration. On the other hand, when there is a phenomenon that we can't be modeled mathematically, in this moment we use artificial intelligence and dataminig algorithm which takes in consideration a set of parameters. These parameter, we have does not know is it affected on the phenomenon or not that is to say it is necessary to use all the parameters that we doubt have impact on the phenomenon. Concerning the input parameters I1, I4, I5, I6 are extracted directly from information system of the university and I2, I3 Are the notes of each practical work. Then the system uses these parameters to calculate the probability for the 4 levels O1, O2, O3, O4 for each Criteria then takes the level that has the high probability. The system repeats this method for all the criteria and for all students.

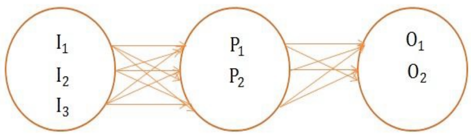


Figure 6 - Venn diagram of Proposed System.

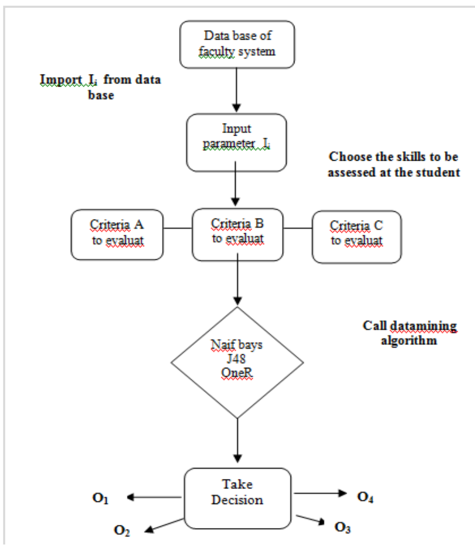


Figure 7 - Organizational chart of algorithms.

3. Application In Real Test And Results

3.1 Application

System test was done by 50 students of 2nd year university in physical science at the Semlalia science faculty of the cadi ayyad university and we followed the following steps:

- When we have completed the courses of the Analog Electronics module we have prepared a practical work of the operational amplifier in real laboratory for to be used by students from the web, Figure 7 describe instruments used.

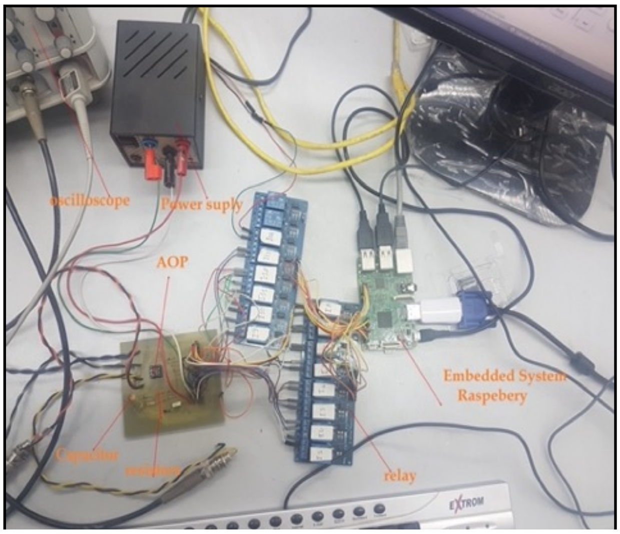


Figure 8 - Electronic Component in laboratory.

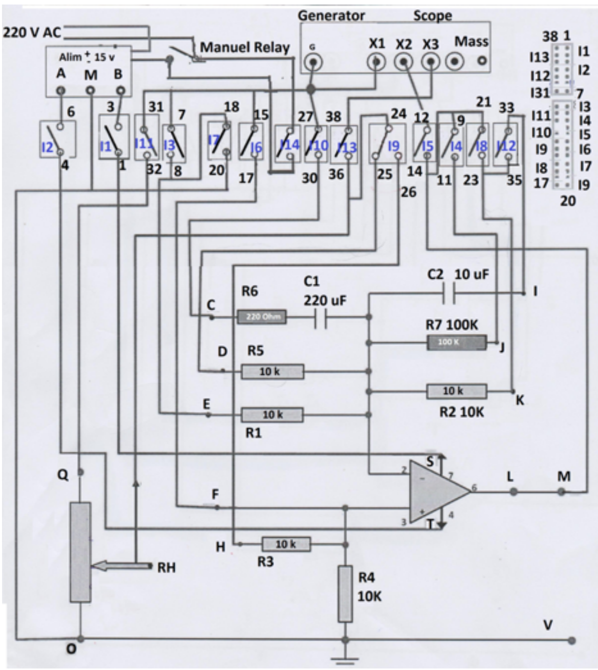


Figure 9 - Internal schema of practical work.

Practical work and Handling

Students see only the user interface displayed on the pc screen as it is indicated in figure 6 and from this interface they can control all instruments of laboratory.

Students are asked to do all the circuits of the operational amplifier with these flax diet and saturated according to the electronic component available on the screen of pc in Figure 10.a.

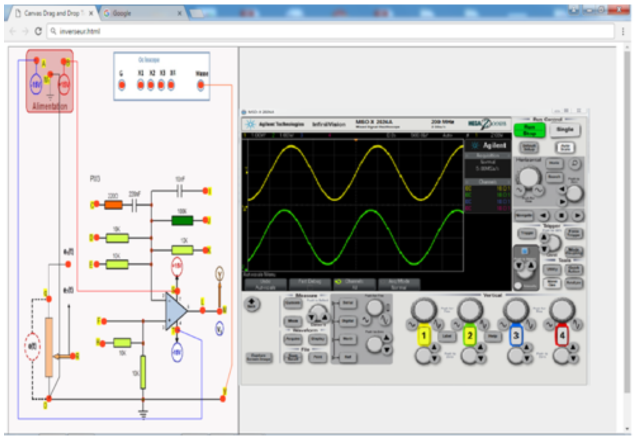


Figure 10.a - User interface student.

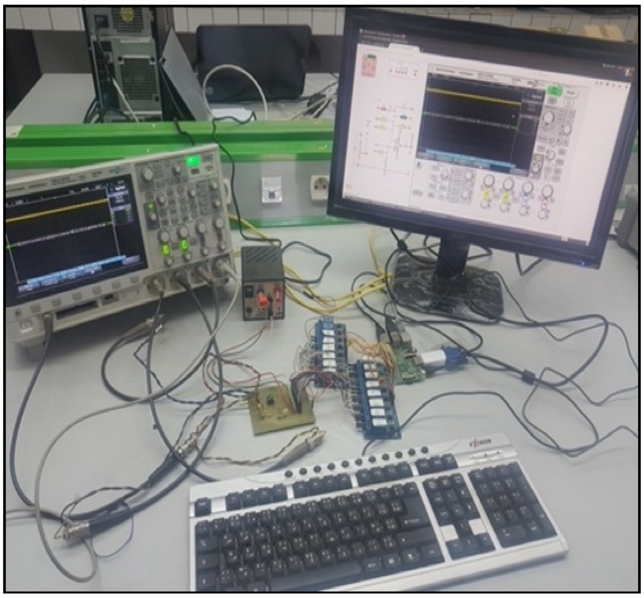
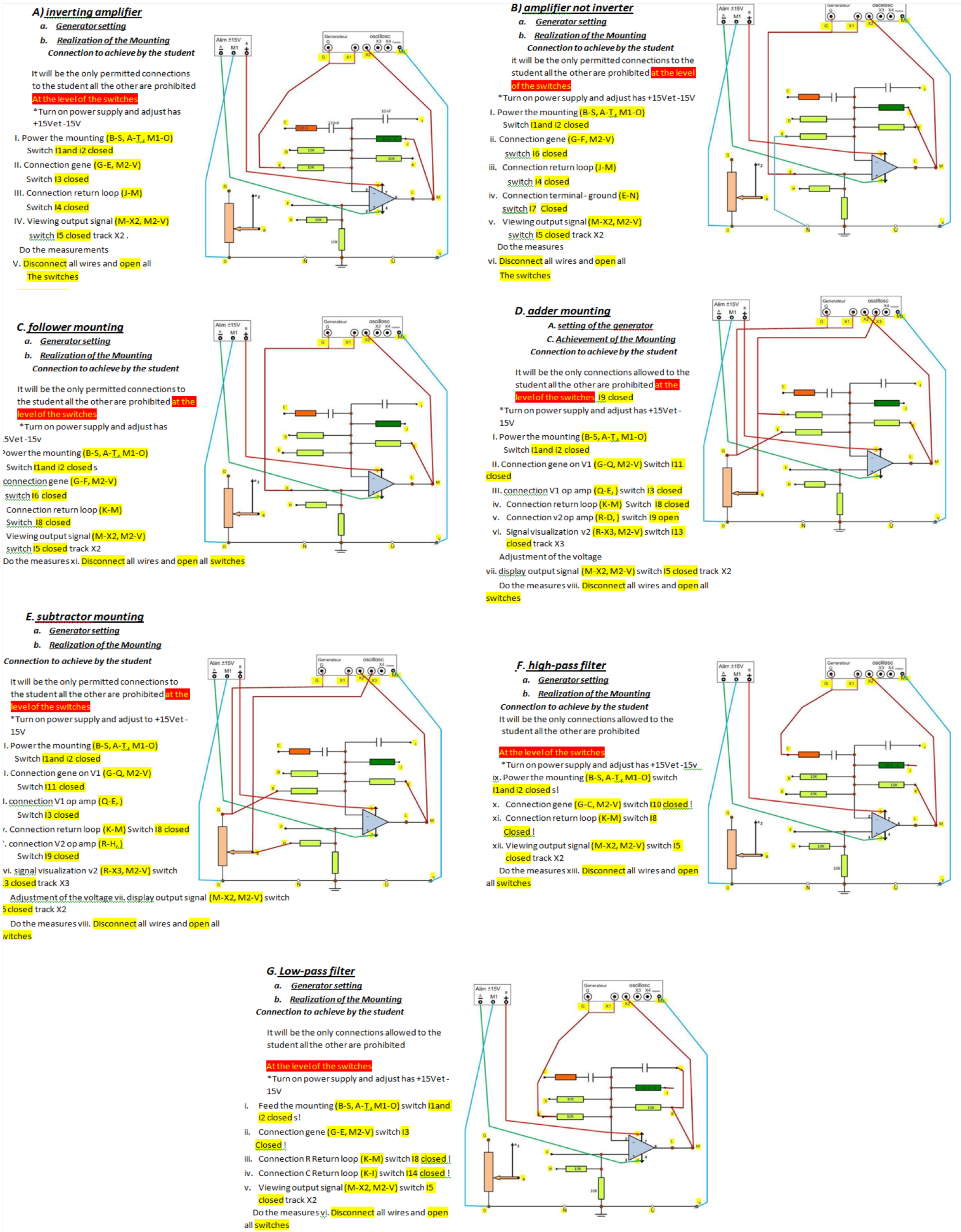


Figure 10.b - Real assembly in laboratory.

- Students have a week to read their homework and prepare the theoretical notion.
- At the day of the practical work. The students have subbed individual interviews front a professor in our physic lab before doing the practical work in front of their machine. in this interview the professors will evaluate in the student all the criteria described in the table above without given any sign or indication about response because we want to compare the results of the evaluation from an interview with the evaluation from algorithm of datamining.



- The teachers take their time to properly evaluate the students in the practical work proposed and have met the criteria explained in Table 1 and we found the results presented in Table 2: in this table we have given for each creature the percentage of each level among the 50 students.

Note: The role of this interview is to obtain the true level of the students of each criteria for to have a reference by which we will compare the performance of the 3 algorithms of datamining which will replace the interview for automate the assessment.

Criteria		Oral Interview Result
A	A-1	Level unacceptable 0% Level insufficient 25.47% Level correct 56.16% Level excellent 18.37%
	A-2	Level unacceptable 6.85% Level insufficient 30.27% Level correct 50.02% Level excellent 12.86%
	A-3	-- Individual interview with students
	A-4	Level unacceptable 0% Level insufficient 27.3% Level correct 67.2% Level excellent 5.5%
B	B-1	Level unacceptable 25.7% Level insufficient 34.8% Level correct 36% Level excellent 3.5%
	B-2	Level unacceptable 10.25% Level insufficient 33.45% Level correct 52.3% Level excellent 4%
	B-3	Level unacceptable 0% Level insufficient 25.5% Level correct 65.3% Level excellent 9.2%
C	C-1	Level unacceptable 0% Level insufficient 65.5% Level correct 27.3% Level excellent 7.2%
	C-2	Level unacceptable 25.32% Level insufficient 30.2% Level correct 40.58% Level excellent 3.90%
	C-3	Level unacceptable 10.25% Level insufficient 33.45% Level correct 54.3% Level excellent 2.00%
	C 4	Level unacceptable 23.54% Level insufficient 33.56% Level correct 41.70% Level excellent 1.20%
	C-5	Level unacceptable 0% Level insufficient 17.50% Level correct 77.50% Level excellent 5.00%
	C-6	Level unacceptable 0% Level insufficient 27.60% Level correct 56.47% Level excellent 15.93%
	C-7	Level unacceptable 24.64% Level insufficient 30.56 % Level correct 40.25% Level excellent 4.55%

Table 2 – Oral interview Results.

4.2 Result analyze and description

In our work, we choose to work with free software Weka for compare the performance of datamining algorithms for evaluate students, because it contains different classifiers in order to make decision for grants and funding. Firstly, we choose to work with Naïve Bayes classifier, decision trees classifier and OneR classifier. The three classifiers are highly efficient in evaluating a series of parameters to predict the forecast of an overall annual grant that the institution manages according to its needs.

Decision Tree classifier

The reasons for this choice are:

1. Classify correctly as much of the training sample as possible.
2. Generalize beyond the training sample so that unseen samples could be classified with as high accuracy as possible.
3. Be easy to update as more training samples become available.
4. Have as simple a structure as possible.

Naive Bayes classifier

The reasons for this choice are [11] :

1. For each hypothesis: we associate a probability observation of one or several instances may change this probability.
2. We can talk about the most hypothesis likely, based on the conditional probabilities and Bayes rule.
3. Forecasting the future from the past, while assume independence attributes.
4. Bayesian probability is the estimation of an event knowing a preliminary hypothesis is verified (knowledge).
5. The probabilistic model for a classifier is the conditional model: P (Oi | I1, I2, …. In) Where Oi is a dependent class variable whose instances or classes are few in number, conditioned by several variables I1, I2, ... In characteristics. Using the Bayes theorem, we write

$$P(Oi \mid I1, I2, \ldots In) = \frac{P(Oi)P(I1,I2,\ldots In \mid Oi)}{P(I1,I2,\ldots In)} \quad \textbf{(1)}$$

In practice, only the numerator interests us, since the denominator does not depend on Oi and the values of the characteristics Ii are given. The denominator is therefore constant. The numerator is subject to the probability law with several variables and can be factorized in the following way, using several times the definition of the conditional probability:

$$P (O_i)^* P (I_1 , I_2, I_n \mid O_i)$$
$$= P (O_i)P (I_1 \mid O_i) P (I_2,\ldots ,I_n \mid O_i ,I_1)$$
$$= P (O_i)P (I_1 \mid O_i) P (I_2 \mid O_i ,I_1) P (I_3,.. ,I_n \mid O_i ,I_1,I_2)$$
$$= P(O_i)P (I_1|O_i)P(I_2|O_i,I_1)P(I_3|O_i ,I_1, I_2)P(I_4, ,I_n|O_i ,I_1,I_2, I_3)$$

:

$$= P (O_i)P (I_1/O_i) \ldots\ldots\ldots P (I_n/ O_i ,I_1,I_2, I_3 \ldots\ldots I_{n-1})$$

(2)

This is where we apply the naive hypothesis: if each Ii is independent of the other characteristics Ij ≠ i, conditionally to Oi So $P (I_i / O_i , I_j) = P (I_i / O_i)$ **(3)**

For all j ≠ i, therefore the conditional probability can be written, hence the conditional probability can be written $P (I1 , I2, In/ Oi) = \prod_{i=1}^{n} P (Ii / O)$ **(4)**

$$P(Oi / I1 , I2, \ldots In) = \frac{1}{Z} P(Oi) \prod_{i=1}^{n} P (Ii / O) \quad \textbf{(5)}$$

The OneR Classifier

The reasons for this choice are:

1. For each attribute and each value of this attribute, create a rule**.**
2. Counts how many times each class appears, and finds the most frequent class.
3. Creates a rule: attribute-value-> class.
4. Calculates the error rate of the rule.
5. Chooses the rules with the lowest error rate.

Intelligence artificial tools are a type of application software designed to retrieve, analyze, transform and report data for business intelligence. The tools generally read data that have been previously stored, often, though not necessarily, in a data warehouse or data mart.
To analyze and measure the performance of scientific learning at the university, managers or policy makers need synthetic indicators that are cleverly grouped one indicator that can offer for the leaders necessary tools to improve scientific research in UCA University.

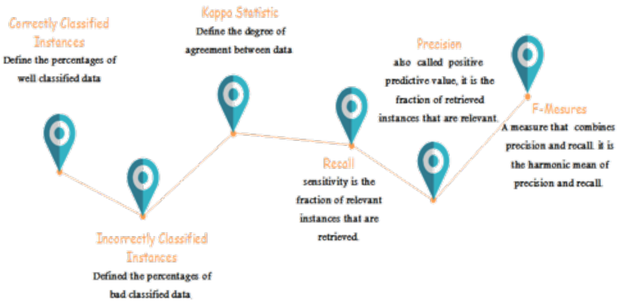


Figure 11 - The keys parameters.

We will start by defining some parameters for our analysis:

Root Mean Squad Error = $\sqrt{\dfrac{(p1-a1)^2+\cdots\ldots+(pn-an)^2}{n}}$

Mean Absolute Error = $\dfrac{|p1-a1|+\cdots+|pn-an|}{n}$

Relative Absolute Error = $\dfrac{|p1-a1|+\cdots+|pn-an|}{|a1-\overline{a1}|+\cdots+|an-\overline{an}|}$

Root Relative squad Error = $\sqrt{\dfrac{(p1-a1)^2+\cdots\ldots+(pn-an)^2}{(a1-\overline{a1})^2+\cdots+(an-\overline{an})^2}}$

Precision: also called positive predictive value, it is the fraction of retrieved instances that are relevant.

Recall: sensitivity is the fraction of relevant instances that are retrieved.

F-Measures: A measure that combines precision and recall; it is the harmonic mean of precision and recall.

After the application of the tree classifiers we got the following results:

- Application of J48 Algorithm

```
Classifier output

=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances          47               94      %
Incorrectly Classified Instances         3                6      %
Kappa statistic                          0.9101
Mean absolute error                      0.03
Root mean squared error                  0.1732
Relative absolute error                  8.9091 %
Root relative squared error             42.3059 %
Total Number of Instances               50

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     unacceptable
                 1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     insufficient
                 0.917    0.038    0.957      0.917    0.936      0.880    0.939     0.917     correct
                 0.923    0.054    0.857      0.923    0.889      0.849    0.935     0.811     excellent
Weighted Avg.    0.940    0.033    0.942      0.940    0.940      0.903    0.954     0.911

=== Confusion Matrix ===

  a  b  c  d   <-- classified as
  4  0  0  0 |  a = unacceptable
  0  9  0  0 |  b = insufficient
  0  0 22  2 |  c = correct
  0  0  1 12 |  d = excellent
```

- Application of Naïve Bayes Algorithm

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances          47               94      %
Incorrectly Classified Instances         3                6      %
Kappa statistic                          0.9087
Mean absolute error                      0.0355
Root mean squared error                  0.1695
Relative absolute error                 10.5462 %
Root relative squared error             41.4096 %
Total Number of Instances               50

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 1.000    0.000    1.000      1.000    1.000      1.000    1.000     1.000     unacceptable
                 0.889    0.000    1.000      0.889    0.941      0.932    0.930     0.917     insufficient
                 0.958    0.077    0.920      0.958    0.939      0.881    0.923     0.804     correct
                 0.923    0.027    0.923      0.923    0.923      0.896    0.946     0.949     excellent
Weighted Avg.    0.940    0.044    0.942      0.940    0.940      0.903    0.936     0.878

=== Confusion Matrix ===

  a  b  c  d   <-- classified as
  4  0  0  0 |  a = unacceptable
  0  8  1  0 |  b = insufficient
  0  0 23  1 |  c = correct
  0  0  1 12 |  d = excellent
```

- Application of OneR Algorithm

```
=== Stratified cross-validation ===
=== Summary ===

Correctly Classified Instances          44               88      %
Incorrectly Classified Instances         6               12      %
Kappa statistic                          0.8193
Mean absolute error                      0.06
Root mean squared error                  0.2449
Relative absolute error                 17.8182 %
Root relative squared error             59.8296 %
Total Number of Instances               50

=== Detailed Accuracy By Class ===

                 TP Rate  FP Rate  Precision  Recall   F-Measure  MCC      ROC Area  PRC Area  Class
                 0.000    0.000    0.000      0.000    0.000      0.000    0.500     0.080     unacceptable
                 1.000    0.098    0.692      1.000    0.818      0.790    0.951     0.692     insufficient
                 0.917    0.000    1.000      0.917    0.957      0.923    0.958     0.957     correct
                 1.000    0.054    0.867      1.000    0.929      0.905    0.973     0.867     excellent
Weighted Avg.    0.880    0.032    0.830      0.880    0.848      0.821    0.924     0.816

=== Confusion Matrix ===

  a  b  c  d   <-- classified as
  0  4  0  0 |  a = unacceptable
  0  9  0  0 |  b = insufficient
  0  0 22  2 |  c = correct
  0  0  0 13 |  d = excellent
```

	J48	**Naïve bayese**	**oneR**
Correctly Classified Instances	94%	94%	88
Incorrectly Classified Instances	6	6	12
Kapp static	0.9101	0.9087	0.8193
Mean absolute error	0.03	0.0355	0.06
Root Mean Squad Error	0.1732	0.1695	0.2449
Relative Absolute Error	8.9091	10.5462	17.8182
Root Relative squad Error	42.3059	41.4096	59.8296

Table 3 - Comparison performance of algorithms.

For define the algorithm which allows a good prediction, in this case the superior CCI (Correctly Classified Instances) is the CCI (J48 and Naïve Bayes)=94%. Furthermore, to have good results the error must be minimal; in this case Naïve Bayes is the only algorithm which satisfies this condition.

The algorithms by which we worked is naif bays, oner, j48. We don't used SVM because is need a big nember of trainedatest and in our lab we only trainedatatest just for one year university and the algorithms used mostly naif bayes give good result in the clasifcation even if datatest is not big.

E@Slab are not only to give students grades, but also to implement remote labs that can guide and lead students during the learning process and during the PW by predicting their behavior before their reaction as a recommended system. Even This system could guide students to different practical work to improve their knowledge in engineering electrical. Thanks to these algorithms, this recommendation will be individual, personalized. it gives the teachers statistics and information about the behavior of students and their reaction with the theoretical and practical courses, thanks to these recommendation statistics can be concluded by the teacher to know the effectiveness and the level of success of this course and their teaching method in order to adapt the aims of the course to the students' skills, And it's a novelty to define the Learning Circle.

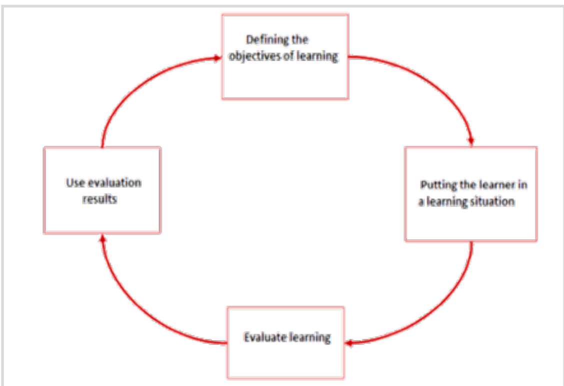


Figure 12 - Learning circle.

Conclusion

Thanks to this system, teacher will have statistics and a global vision of their working methodology for develop a syntactic strategy begins by defining the learning objectives, then put the learner in a learning situation then evaluate learning and use the results for defining new learning objectives, using the tools of artificial intelligence integrated in management education system of remote Laboratory and also the data of scientific research imported from the Presidency of the university.

We conclude that our new approach in the system evaluated student correctly, with any classification algorithm uses supervised learning.

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JOURNAL OF e-LEARNING AND KNOWLEDGE SOCIETY

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VOLUME 17 | ISSUE NO. 1 | JULY 2021

AN INTERNATIONAL AND OPEN ACCESS JOURNAL BY THE ITALIAN E-LEARNING ASSOCIATION (SIE-L)

www.sie-l.it

ISSN (online) 1971 - 8829 | ISSN (paper) 1826 - 6223