PROCEEDINGS OF THE INTERNATIONAL CONFERENCES

» Educational Technologies

» Sustainability, Technology and Education

» Internet Technologies & Society

» Applied Management Advances in the 21st Century

VIRTUAL, 14 - 16 December 2022

Edited by
Piet Kommers
Tomayess Issa
Adriana Backx Noronha Viana
Theodora Issa
Pedro Isaías

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international association for development of the information society

INTERNATIONAL CONFERENCES

ON

EDUCATIONAL TECHNOLOGIES 2022

SUSTAINABILITY, TECHNOLOGY AND EDUCATION 2022

INTERNET TECHNOLOGIES & SOCIETY 2022

AND

APPLIED MANAGEMENT ADVANCES IN THE 21ST CENTURY 2022

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14 – 16 DECEMBER, 2022

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Edited by Piet Kommers, Tomayess Issa, Adriana Backx Noronha Viana, Theodora Issa and Pedro Isaías

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FOREWORD

These proceedings contain the papers and posters of the International Conferences on: Educational Technologies 2022 (ICEduTech 2022), Sustainability, Technology and Education 2022 (STE 2022), Internet Technologies & Society 2022 (ITS 2022) and Applied Management Advances in the 21st Century 2022 (AMA21 2022) held virtually, from 14 to 16 December 2022 and organised by the International Association for Development of the Information Society.

The International Conference on Educational Technologies 2022 (ICEduTech 2022) is the scientific conference addressing the real topics as seen by teachers, students, parents and school leaders. Scientists, professionals and institutional leaders are invited to be informed by experts, sharpen the understanding what education needs and how to achieve it.

Topics for this conference were:

- **Education in Context:** Education in the Network Society, Educational Games, Social Media in Education, Home Schooling, Students' Rights, Parents' Rights, Teachers' Rights, Student-Safe Searching, School Violence, Education and Tolerance for Peace and Education in Developing Countries.
- **Education as Professional Field:** Teacher Education, Teachers' Professional Development, Teachers' Workload, Teacher Support for Grading, Time Tabling, Grading, Learning Tools, and Online Learning Software, Teachers' learning in Communities of Practice, Web-based Communities for Teacher Support, Teachers' Career Planning, Legal and Financial Issues, Conflict Resolution and Mediation, Governance and Servant Leadership and Educational Policies.
- **Curricular Evolution:** Problem-based Learning, Critical Thinking Skills, Creativity Skills, Learning Citizenship, Global Education, Media Literacy / Pedagogy, Multicultural Education and Alternative Assessment Methods.
- **Learner Orientation:** Student-Oriented Learning, Peer- and Collaborative Learning, Learning Strategies: Learn how to Learn, Motivating Students, Recognizing Students' Learning Styles and Special Education.
- **Integrating Educational Technologies:** Social Media and Social Networking, The Semantic Web 3.0, Podcasting for Broadcasting Video Lectures, Podcasting feedback to students, Wiki and blogs in Higher Education, Mobile, Virtual and Vicarious Learning and Simulations and Modeling.
- **International Higher Education:** Marketing Higher Education as a Business Case, Pitfalls and Solutions in Joint and Double Degree Programs, Enculturation and International Teacher Accreditation, Web-based, Mobile, Virtual Presence and Social Media to Overcome Student Mobility, Blended Learning and Student Assessment at a Distance, Student Mobility and Distance Education, New-Emerging Standards and Benchmarks for Higher Education, Education, Research, Exchange an Capacity Building, 21st Century Academic and Industrial Brain Exchange, Academic Salaries, Faculty Contracts, Residence Permits and Legal Issues, International Student Exchange Funding Programs: Erasmus Mundus, the U.S. Council on International Educational Student Exchange, and the Euro-American "Atlantis" program, Networks for International Higher Education in the Pacific, Australia, Europe, Asian and European countries and Higher Education, Cultural Diversity, Tolerance and Political Conflict.

The International Conference on Sustainability, Technology and Education 2022 (STE 2022) has the purpose to address the main issues which occur by evaluating the relationship between Sustainability, Education and Technology. The main areas of interest for this conference are: Sustainability and Leadership, Sustainability and Green IT, Sustainability and Education.

The International Conference on Internet Technologies & Society 2022 (ITS 2022) aims to address the main issues of concern within WWW/Internet as well as to assess the influence of Internet in the Information Society. Broad areas of interest are Internet Technologies, Information Management, e-Society and Digital Divide, e-Business / e-Commerce, e-Learning, New Media and e-Society, Digital Services in e-Society, e-Government / e-Governance and e-Health.

The International Conference on Applied Management Advances in the 21st Century 2022 (AMA21 2022) seeks to provide a unique forum for presentation and discussion of the last research developments and solutions for the current issues of the world economy. A global invitation was made to scholars, students, practitioners, organizations, government departments, policymakers and everyone interested in these subjects, to give their contribution. Its core areas of interest are: Managing with ICT, E-Marketing & Digital Communication, Digital Economy, Entrepreneurship & Innovation, Finances & Fintech and Teaching & Learning in Business.

These events received 114 submissions from more than 22 countries. Each submission was reviewed in a double-blind review process by an average of four independent reviewers to ensure quality and maintain high standards. Out of the papers submitted, 17 got blind referee ratings that published them as Full and Regular papers, which means that the acceptance rate was 15%. Some other submissions were published as Short and Concise papers, Reflection papers, and Posters/Demonstrations.

Selected papers from these conferences will be published as extended versions in the IADIS International Journal on WWW/Internet (IJWI) (ISSN 1645-7641), the IADIS International Journal on Computer Science and Information Systems (IJCSIS) (ISSN 1646-3692).

In addition to the papers' and posters' presentations, the conference program also includes two keynote presentations. We would like to express our gratitude to our keynote speakers: Dr. Tomayess Issa, Curtin University, Perth, Australia and Professor Pedro Isaias, Information Systems & Technology Management School, The University of New South Wales, Australia. These events also feature a special talk by Dr. Yaping Gao, EDD, Senior Academic Director, Member Services & Partnerships Quality Matters, USA, and a Tutorial presented by Cheri Flewell-Smith, Torrens University Australia.

A successful conference requires the effort of many individuals. We would like to thank the members of the Program Committee for their hard work in reviewing and selecting the papers that are included in this book. We are especially grateful to all authors who have submitted their papers to this conference and to the presenters who provided the substance of this meeting. We wish to thank all members of our organizing committee.

Last but not least, we hope that everybody enjoyed the presentations and we invite all participants for next year's editions.

Piet Kommers, University of Twente, The Netherlands
ICEduTech 2022 & ITS 2022 Conference Chair

Tomayess Issa, Curtin University, Perth, Australia
STE 2022 Conference and Program Co-Chair and ICEduTech 2022 & ITS 2022 Conference Program Co-Chair

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December 2022

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Yan Xu, Northwest University, China
Yousef Farhaoui, Moulay Ismail University, Morocco

KEYNOTE LECTURES

OUR SUSTAINABLE GREEN FUTURE

Dr. Tomayess Issa
Curtin University, Perth, Australia

ABSTRACT

Information and communications technology (ICT) use is increasing worldwide since ICT has become a significant mechanism for researching, searching, communication, entertainment, shopping, information, and more. However, recycling of ICT end-products is becoming a major dilemma for individuals and organizations. This is not simply a matter of being concerned about environmental damage or providing a solution to an environmental problem; it is a problem that should concern all of us. Indeed, a contemporary society should tackle and address such a problem and address it as a matter of urgency for the sake of the current and future stakeholders around the world. To address this problem, an online survey conducted in Australia, Brazil, China, Germany, India, Norway, Singapore, South Korea, Sweden, UK, and USA to examine sustainability awareness, and risk, sustainable design and introduce the New Participative Methodology for Sustainable Design (NPMSD). The survey outcomes confirmed the feasibility and value of the sustainable design step, and the online survey participants confirmed that through education and awareness, designers would learn more about sustainability and sustainable design. Finally, Human beings have been responsible for most of the damage done to the natural environment. The problems created by humans must be tackled immediately and effectively so that the seventh generation can enjoy the same lifestyle as we do. Unfortunately, there is no Plan B for our planet (Issa, Isaias 2022).

INNOVATIVE TECHNOLOGIES AND TRENDS IN THE DIGITAL SOCIETY

Professor Pedro Isaías
Information Systems & Technology Management School,
The University of New South Wales, Australia

ABSTRACT

As the digital society matures it is shaped by the unprecedented swiftness at which technology and innovation evolves and the ubiquitousness of digital technologies in all areas of society. The digitalisation of society is becoming more inclusive and more focused on sustainability to ensure that progress is all-encompassing and viable. As the benefits of an evolved digital society become more evident, concerns such as bridging the digital divide, creating awareness about misinformation/disinformation, ensuring the affordability of technology and promoting the development of digital skills assume an even greater importance. This talk will focus on the contribution that innovative technologies such as artificial intelligence, robotics, 3D printing, internet of things and 5G are making toward the advancement of the digitalisation of society, with a critical stance that examines the benefits as well as their challenges. In addition, it will discuss the current technological trends transforming key areas like smart cities, e-health, e-learning, digital marketing and e-government and reflect about inclusivity and the future of the digital society.

SPECIAL TALK

ESTABLISHING SOCIAL, COGNITIVE, AND TEACHING PRESENCE: KEY TO STUDENT ENGAGEMENT AND SUCCESS!

by
Yaping Gao, EDD
VP, Member Services & Global Partnerships
Quality Matters, USA

ABSTRACT

As a result of the COVID pandemic, institutions all over the world are making significant investments in digital transformation to be more resilient and better prepared for an unpredictable future. Study has shown again and again, however, that technology does not equal effective teaching in online education and digital learning. How do we effectively engage students to succeed in online or hybrid classes, synchronous or asynchronous in different combinations of modalities, and to meet the needs of increasingly diverse student populations?
This session will engage participants to review, examine, and reflect on how to engage students and help them succeed with the community of inquiry model by establishing cognitive presence, social presence and teaching presence.

TUTORIAL

MISSION MULTICULTURAL: HOW TO FOSTER DIVERSITY, EQUITY AND INCLUSION BEST PRACTICES FOR 21ST CENTURY LEARNERS

by
Cheri Flewell-Smith
Torrens University Australia
46-52 Mountain St, Ultimo NSW 2007

ABSTRACT

The aim of this tutorial is to share how the principles of diversity, equity, inclusion and belonging (DEIB) best practice can be embedded and deployed in online pedagogy using existing technologies and tools to foster a positive equitable, multicultural classroom experience for all—and ultimately enhance student engagement and outcomes. The workshop will discuss bias, what it is, and how unconscious bias can affect the decision-making processes. It will discuss actionable tools and tips that can be deployed in classrooms tomorrow, all grounded in a simple, easy to understand online facilitation framework employing design thinking methodologies.

KEYWORDS

Diversity, Equity, Inclusion, Belonging, Multicultural, Bias, Design Thinking

Full Papers

FINDINGS FROM A FIELD EXPERIMENT WITH A VR LEARNING UNIT

Thomas Keller, Stefan Botchkovoi and Elke Brucker-Kley
ZHAW Institute of Business Information Technology
Winterthur, Switzerland

ABSTRACT

The potential of using virtual reality in the school context is assessed heterogeneously from a scientific point of view. Especially the embedding in existing didactic approaches, the concrete design of the support system as well as the competence of the teachers are relevant. But it is undisputed that virtual reality opens up new possibilities to visit different out-of-school learning locations. However, it is not yet clear whether these opportunities have a significant impact on learning success. In this paper, three research questions about the learning effect and the essential criteria for the use of virtual reality are investigated in a qualitative field experiment with a virtual reality learning unit about our solar system. The field experiment follows a classical A/B testing approach with pre- and post-tests. The results show that virtual reality can contribute to students' knowledge transfer. However, this contribution does not show a higher learning success compared to a classical didactic approach. Another result shows that combining virtual reality learning applications with a traditional teaching approach can be very successful. However, as long as virtual reality is a new experience for most students, the use of VR goggles leads to cognitive overload.

KEYWORDS

Virtual Reality, Education, Field Experiment

1. INTRODUCTION

Digital media such as tablets or smartphones are already part of daily life for many children. They watch movies, play games or communicate with their friends. The children actively and self-determinedly participate in their digital world with their possibilities and competencies (Feierabend et al., 2019). Virtual worlds such as Minecraft are discovered by children in a self-determined and creative way (Baek et al., 2020; Callaghan, 2016). In these virtual worlds, children tackle challenges, experiment with virtual objects, or discover numerous phenomena (Cramariuc & Dan, 2021; Villena Taranilla et al., 2022). These are promising alternatives to initiate sustainable learning processes, provide children with appropriate experiential and learning opportunities in digital learning environments, and foster competencies in the digital environment (Best et al., 2019). But how can these virtual experiential and learning opportunities be designed in the subject classroom to provide children with guidance in their digital world? How can digital media be used to design new teaching and learning processes in a way that creates opportunities for individual competence development?

Extracurricular venues are particularly suitable for enabling students to experience a living world that is not accessible to them in everyday life (Brade, 2015). The use of virtual environments in primary education has been little researched so far. Various authors estimate the potential for successful learning as high (Buchner, 2022; Hellriegel & Čubela, 2018). Digital worlds enable a variety of experiential and learning opportunities that create new and inclusive support opportunities both outside and inside school (Bakenhus et al., 2022). In the context of technological development, virtual reality (VR) media can promote skills and constructivist learning beyond subject matter knowledge. VR technology is increasingly used in various learning environments to reduce complex teaching topics and present realities in a structured and immersive way (Radianti et al., 2020).

2. RESEARCH OBJECTIVE AND APPROACH

Immersive VR applications are not yet widely used in the school context (Pirker et al., 2020). A possible reason for this could be a lack of strategies and concepts for media development and integration of the technology into the teaching process (Martin-Gutierrez et al., 2017). Hellriegel & Čubela (2018) suggest that the rapid development of the technology is the reason for the low user rates. Therefore, there are a limited number of scientific publications dealing with virtual reality in education and its didactic use (Kröner et al., 2021). Little research has been done on how to integrate VR into curriculum and instruction, so collaboration between educators and game developers is needed for future studies (Martin-Gutierrez et al., 2017; Pirker et al., 2020).

From this, the following three research questions can be derived, which the literature research and field study documented here aims to answer:

RQ1: Can VR contribute to students' knowledge transfer?

RQ2: Can learning success be increased with the help of VR learning units compared to classic learning units?

RQ3: What criteria do you have to pay attention to when developing and using VR learning units in order to use the full potential of VR?

This scientific work is based on the Design Science approach according to Hevner et al. (2004). The basic principle of Design Science Research is that knowledge and understanding of a design problem and its solution are acquired through the creation and application of an artifact (VR Learning Unit). A systematic literature review will examine the topic of VR and how it relates to pedagogy and didactics. Specific content will be selected from the literature that deals with immersive VR in an educational context. In addition, further pedagogical, didactical requirements and content will be developed together with teachers in order to incorporate them into the optimization of the VR learning unit. The development and optimization of the artifact is oriented towards evolutionary prototyping (Bischofberger & Pomberger, 1992; Steinweg, 1995).

To determine the learning success of the VR learning unit, a qualitative field experiment with A/B testing (Döring & Bortz, 2016) will be conducted. The target group of the VR learning unit and the field experiment are middle school students of elementary and secondary schools. They are between nine and fifteen years old. The measurement of knowledge gain is implemented with the help of a pre- and post-survey. For this purpose, a questionnaire is designed, which is filled out by both groups before and after the completion of the learning unit.

3. STATE OF THE ART

The possibility of realizing convincing representations in VR initially leads to the assumption that these visualizations stimulate learning (Gerth & Kruse, 2020). However, as with any other medium, didactic considerations and learning activities are crucial for VR (Kerres, 2013; Kerres & Witt, 2003). According to Schwan & Buder (2002) and Dede (2009), there are the following learning-related action options for VR learning worlds:

1. **Exploratory worlds**: They aim to impart declarative knowledge and enable learners to engage with virtual environments independently and exploratively. Coupled with activating learning tasks, such as creating mind maps, such worlds can be effective in building new knowledge structures (Parong & Mayer, 2018).
2. **Experimental worlds**: In this way, the laws of physics can be suspended and causal relationships can be investigated (Schwan & Buder, 2002).
3. **Training worlds**: Here, learners practice and train skills and abilities that are not feasible in real environments, for example, because they are too dangerous, too expensive, or not feasible at all. Such worlds are already frequently used in vocational training, for example in the automotive industry or in the training of prospective painters (Zender et al., 2020).
4. **Construction worlds**: Learners can independently create their own objects or even entire virtual worlds in these worlds. They are still rarely used in education, partly because their production is particularly technically demanding (Radianti et al., 2020).

In summary, learning with VR is motivating, entertaining, and varied. Especially when actively participating and interacting with the virtual world, various studies show better cognitive experiences and enhanced learning effects (Freina & Ott, 2015; Jensen & Konradsen, 2018; Krokos et al., 2019; Maas & Hughes, 2020). The reason is that learning is more emotional and immersive, adding relevance to the content. Critical reservations nevertheless remain, as long-term studies and large-scale field studies in particular are lacking (Radianti et al., 2020).

VR applications have the potential to increase learning success and promote constructive learning (Chavez & Bayona, 2018; Hellriegel & Čubela, 2018; Parong & Mayer, 2018). Furthermore, with the help of VR, difficult and risky training experiences (e.g., in medical and military practice) can be learned virtually. As a result, the cost of training and the potential risk of the real physical situation can be reduced. Furthermore, students can experience places and situations in the world that they would not otherwise be able to experience, enriching their learning experience (Reynard, 2017; Zender et al., 2020).

Learning as a self-directed process

According to Arnold (2020), Reinmann-Rothmeier & Mandl (1997) and Shuell (1986), active participation of the learner is required. Without a self-directed share, sustainable learning growth cannot be achieved. Many teaching media and materials can only meet this requirement to a limited extent. VR applications basically allow more interaction or construction than classical media (Freina & Ott, 2015; Martin-Gutierrez et al., 2017; Schwan & Buder, 2002). From a constructivist-didactic perspective, virtual worlds become significant only when learners can move freely in the virtual worlds to explore the learning objects at their own pace and freely construct viewpoints. This has the advantage that different types of learners can be addressed equally (Hellriegel & Čubela, 2018; Schwan & Buder, 2002). Furthermore, VR can change the way a learner interacts with the learning material. VR assumes interaction. It encourages active participation rather than passivity. The learner who interacts with the virtual environment is encouraged to continue the interaction by seeing the results immediately (Pantelidis, 2009). Thus, high learning success can be achieved especially when learners can make their own decisions based on the results of their own actions to achieve the goals they set for themselves (Hellriegel & Čubela, 2018; Zender et al., 2018).

Learning as a productive and motivating process

Enthusiasm, motivation and emotions can be seen as important factors for learning success (Gieseke, 2003). However, in order to promote the intrinsic motivation of learners, it is necessary to tie in with the learners' lifeworld, interests, and individual initial situations (Siebert, 1991). In particular, the advantage of VR applications is that they address multiple sensory channels (Schwan & Buder, 2005), make complex issues tangible (Koehler et al., 2013), and can provide learners with freely selectable courses of action to ideally make self-directed decisions and explore virtual worlds (Martin-Gutierrez et al., 2017). In a meta-study, Freina & Ott (2015) point out that a clear link can be established between virtual technologies and the promotion of learner motivation. Martin-Gutierrez et al. (2017), Pantelidis (2009), and Vogel et al. (2006) also point to a relationship between VR and learner motivation (Hellriegel & Čubela, 2018).

Learning as a situational and practice-related process

Schüßler & Thurnes (2005) describe learning as a systematic, situational, and largely "self-organized appropriation process." Bailenson et al. (2008) highlight the potential of VR to address topics in the classroom that would be either too expensive or too dangerous in a real, physical environment. This expands the range of experiences that can be gained. Even complex and abstract relationships, as well as concepts and issues that are difficult to convey in normal settings, can be made vivid through VR. Schwan & Buder (2005) also speak of "metaphorical visualizations" in this context. The advantage of this visualization is that the learning object is given a concrete context, i.e., a concrete scenario, and authentically designed learning environments are created (Koehler et al., 2013). Learners can view complex subject matter from a first-person perspective and make concrete connections in a physical presence (Martin-Gutierrez et al., 2017). Similarly, they can feel present in a virtual body that is not their own body but can be perceived as such (Bailenson et al., 2008).

Learning as a social process

In schools, cooperative learning is often used to impart knowledge. In this interactive and structured form of learning, it is assumed that students learn more through interaction than through individual work (Fürstenau & Gomolla, 2009). Reinmann-Rothmeier & Mandl (1997), among others, refer to learning as a social process because it is an interactive exchange and is also subject to sociocultural influences.

Virtual environments offer the potential for interaction and collaboration among learners and foster discussion and feedback processes (Martin-Gutierrez et al., 2017; Youngblut, 1998). A virtual environment can also be set up for multiple real people. An example can be teachers as tutors who can monitor behavior and learning progress and provide immediate feedback (Schwan & Buder, 2005). However, the extent to which VR offerings can be used for social interaction and communication depends heavily on the didactic objective of the particular offering. A discussion in the group after the application or even during the application are further possibilities for interaction and collaboration between learners. Whether a joint VR unit is useful, however, depends on the didactic objective (Hellriegel & Čubela, 2018).

4. CHALLENGES

VR has a number of weaknesses from technological, organizational, and psychological perspectives (Velev & Zlateva, 2017). As a result, VR applications are currently used by educators with hesitation (Zender et al., 2018). For example, more powerful VR systems that also require a high-performance computer are costly (Zender et al., 2018).

Another challenge is the implementation effort. The implementation of VR applications is demanding. Increasingly complex program logics and support for different end devices complicate application development (Velev & Zlateva, 2017). Implementation cannot be done by teachers or computer scientists alone, as knowledge in programming, graphic design, pedagogy, and educational psychology is required (Liu et al., 2017; Pantelić & Plantak Vukovac, 2017).

The current generation of VR still offers much potential for development (Zender et al., 2018). A major shortcoming of VR is the lack of haptic feedback generation, which makes it impossible to simulate resistance, elasticity, structure, and temperature (LaValle, 2016).

VR input and output devices usually appear with their own SDKs, which are strongly tied to the corresponding hardware. These vendor-specific solutions make integration into existing systems and switching to other end devices difficult (Velev & Zlateva, 2017). Open standards such as VRPN or OSVR have not yet been able to establish themselves. However, often at least the most common development environments such as Unity or Unreal are supported, which have already proven themselves as leading development environments for VR and AR (augmented reality) (Anthes et al., 2016).

In addition to the aforementioned technical and organizational challenges, it is important to consider the challenges specific to education. The enthusiasm for VR learning applications is currently boosted by a large novelty effect. However, this will decline and is subsequently insignificant for the actual effectiveness of learning tools (Kerres, 2003).

One of the main challenges of VR learning applications is the currently scarce conceptual didactic basis (Zender et al., 2018). Many standard works on media didactics lack explicit treatment of VR (Kerres, 2018; Rey, 2010). Furthermore, Akçayır & Akçayır (2017) point out the following additional challenges that limit learning experiences using VR: high time requirements, unsuitable for large groups, and possible cognitive overload of learners and misdirected attentional focus (Akçayır & Akçayır, 2017).

The use of VR requires media competence from teachers and learners (Zender et al., 2018). Learners must first master the use of the medium. The acquisition of these competencies is currently still severely hampered by the variety of devices, bulky head-mounted displays as well as counterintuitive user interfaces and insufficient assistance in connection with hardly binding standards (Akçayır & Akçayır, 2017). Teachers must also be able to operate the learning media and deal with error messages (Castellanos & Pérez Sancho, 2017).

Other factors hindering the use of VR applications in education include health concerns such as nausea, dizziness, and eye pain, which can be especially prevalent when using VR (LaViola et al., 2017). This can be attributed to conflicting sensory impressions (Keshavarz et al., 2014). Furthermore, immersive VR can create intense illusions, the physiological and psychological effects of which are difficult to assess (Zender et al., 2018).

5. FIELD EXPERIMENT AND RESULTS

The development and optimization of the artifact will not be discussed further in this paper. All documentation for this as well as the executables for Android-based (Quest2) and Windows-based systems (HTC Vive) are available at https://osf.io/t4sxj/.

The qualitative field experiment took three school days to complete. The qualitative field experiment was conducted with one class each at a secondary school and an elementary school. The participating subjects were randomly divided into two subject groups. One group of subjects received the teaching content by means of the VR learning unit and the other group of subjects by means of a classical frontal teaching, in which the teachers were allowed to choose the teaching form and techniques freely. The raw data of the survey are also available at https://osf.io/t4sxj/,

The data collected from the pre- and post-measurement are analyzed and considered separately due to the different performance levels of the school classes (Figure 1 and 2). A total of 31 participants took part in the field experiment. Of these, 8 participants were from the Realschule (secondary school), shown in Figure 1, and 23 from the Primarschule (elementary school), shown in Figure 2.

For both schools, an increase in knowledge can be seen for each group. It can be stated that in both cases the increase in knowledge was greater for the control group than for the VR group. This result is also consistent with the authors' experience from previous field experiments (Brucker, Keller). A hypothesis for this is that the unfamiliar learning environment overloads the subjects' cognitive resources with the VR challenges. Repeated use of VR as a learning medium would alleviate this situation.

The implementation of the VR learning unit as well as the frontal teaching were observed and recorded in order to gain further, primarily qualitative insights into the use of VR in an educational context. At the elementary school, eleven subjects were randomly assigned to conduct the VR learning unit. Before beginning the VR learning unit, subjects were asked questions in advance about their feelings and prior knowledge regarding VR and gaming. It was interesting to note that five of the eleven subjects had already played with VR sets more than once. One subject even plays with VR sets on a regular basis. All participating subjects received instruction. Subjects who already have regular contact with VR sets were quickly familiar with the controls and did not need any assistance. They used teleportation and additionally moved around using the movement buttons. Full attention could be paid to exploring the VR environment and working through the learning and task stations. Subjects who had no previous experience with VR used either only teleportation or only walking in the first scene. Combining both was too challenging for the subjects. Throughout the execution of the VR learning session, VR-inexperienced subjects were highly focused on the controls and somewhat less focused on the content. All subjects were able to complete the learning station and tasks independently. Subjects particularly enjoyed the throwing stations in the Earth and Moon scene. The learning content in the Journey to the Moon scene caused amazement, especially when the subjects saw the size relationships of the sun, earth, and moon. One subject perceived the VR learning unit more as a game and focused more on the playful aspect. Little attention was paid to the learning and task stations. All subjects were able to immerse themselves in the VR learning unit. A sense of presence was felt, which can be attributed to the immersive nature of the VR learning unit. In places, it was not possible to converse with the subjects during the execution because they were too shielded from the real world. The two youngest subjects, aged 9, had severe problems with their coordination. This resulted in wobbly legs and near falls. To continue the VR learning session, the subjects were given a chair to sit on. This measure minimized the coordination problems and even prevented them completely after a certain period of time. One of the affected subjects discontinued the VR learning session due to the occurrence of dizziness and nausea. The subject who regularly plays with VR sets devoted his full attention to the VR learning unit. In the pre-test, 25.5 points were already achieved. In the post-test, the subject achieved 31.5 out of 34 points.

After the field experiment was completed, the students from the control group were also allowed to play the VR learning unit to reward their use. It was observed that the students experienced an "aha effect". This means that the test subjects subsequently understood what they had previously learned from the frontal instruction. When asked, the students were able to confirm that they were able to better comprehend the size ratio of the sun, earth and moon in particular and gained an idea of the dimensions.

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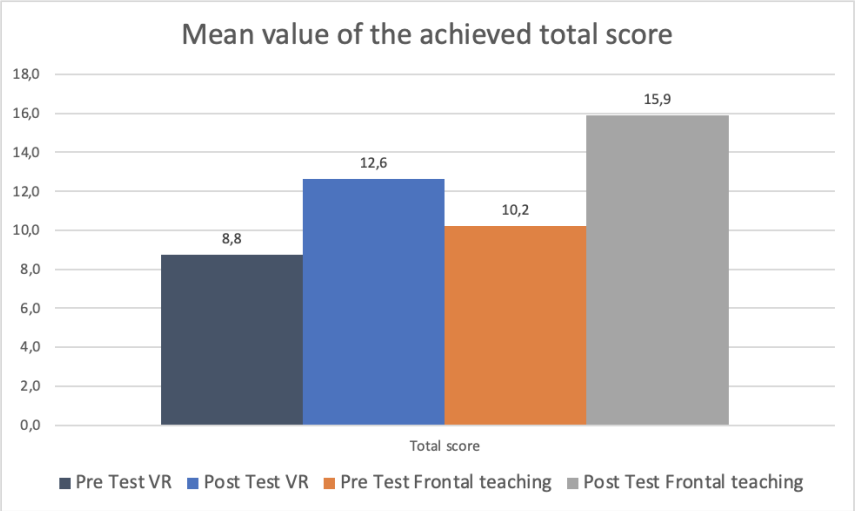

Figure 1. Average score for Realschule

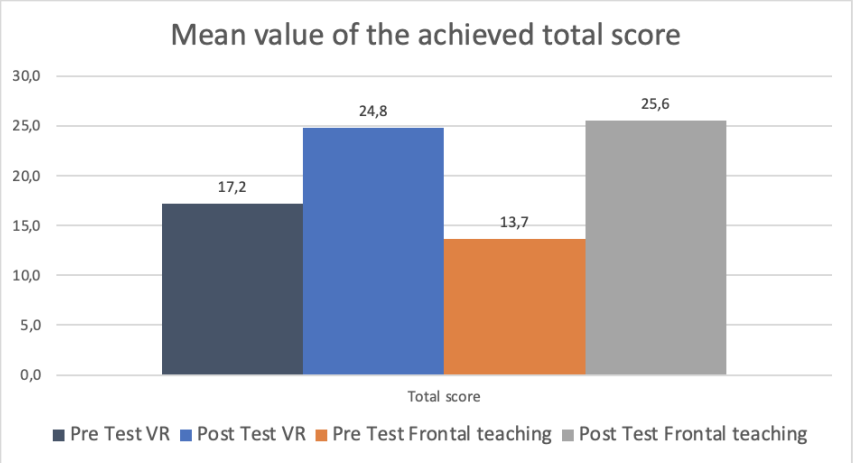

Figure 2. Average score for elementary school

6. CONCLUSION

The evaluation and interpretation of the data from the field experiment show that an increase in knowledge was achieved in all subjects of subject group VR (RQ1). This is shown by the key figures of the achieved score per question, the achieved total score and the percentage knowledge increase per question. These conclusions can be drawn for all subjects of the VR group when comparing the individual performances.

A direct comparison of the groups of test subjects shows that the control group performed better at both schools (RQ2). This is shown by the evaluation of the achieved total score of the test groups of the Realschule as well as of the Primarschule. Abstract questions about contents that are difficult to comprehend (questions 1-5), which could be presented vividly by means of VR, could not be answered more successfully by the subjects of the subject group VR of both schools than by the control groups. It should be noted that small subject groups, as at the Realschule, can cause biases, for example, due to the personal attitude and motivation of individual subjects towards learning and the field experiment. With such small subject groups, this confounding variable cannot be reduced or eliminated by randomization. No robust conclusions about learning success through VR can be drawn from the collected elementary school data and findings alone. For this, further field experiments would have to be conducted at several schools and with larger subject groups, which

is why the second research question cannot be answered conclusively. Nevertheless, the results show the tendency that the learning success with the help of VR learning units cannot be increased compared to classical learning units.

The third research question can be answered with the findings from the literature review and the collected evidence from the observations of the qualitative field experiment. Compelling representations in VR related to immersion and presence stimulate students to learn and increase motivation. The assumption that presence in a VR learning environment enhances memory processes cannot be clearly confirmed by means of the collected data. Immersion in VR environments is associated with a high cognitive load. This was observed in the two youngest participating subjects (nine years old). Going through the VR learning unit caused severe coordination problems for the subjects. This was noticeable by trembling legs, which led to near falls. The cognitive load can be reduced by instruction in the correct use of VR and further assistance, such as a seat and orientation aids by the teacher. Furthermore, the high cognitive load leads to learners concentrating too much on the controls and the didactic learning content being pushed into the background. To counteract this, the learners must be trained in advance in the use of the interaction possibilities. The observations show that learners who frequently play computer games in their free time do not have any advantages in dealing with VR. For learners with little or no VR experience, there is a risk of motion sickness in the form of nausea and dizziness. Again, the risk of motion sickness can be mitigated by providing guidance in the use of VR glasses and using them regularly. The possible occurrence of eye pain was not noted, which can be attributed to the high resolution of the HMD. Learners with a fundamental VR experience can devote their concentration to the learning content to be taught. Nevertheless, care must be taken with experienced learners to direct their attention to the essentials, the learning content, as they tend to focus on the playful aspect of the technology. From the observations, VR-experienced learners are not prone to health impairments such as motion sickness.

VR learning content must build on existing knowledge. Further observations showed that learners with existing prior knowledge were better able to comprehend the size relationships and interrelationships of the solar system after completing the VR learning unit. The VR learning unit deepened the prior knowledge. VR technology can be used as a supplementary medium in the school day. Learners must be familiarized with the technology before conducting VR learning units and practice using it regularly to avoid health impairments and excessive cognitive load. The VR learning unit must build on existing knowledge and learners' attention must be directed to the essentials. Learners must be provided with guidance, both in and out of the VR environment. Outside of the learning unit, assistance can be provided by teachers or the fading in and out of information within the VR learning unit. Based on the results of this work, it is recommended to follow the instructional design according to Mulders et al. (2020) for the use of VR technology as a learning opportunity.

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TRAINING CT WITH AUGMENTED REALITY-BASED RESOURCES – AN EXPERIMENT IN A CLASSROOM

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ABSTRACT

The challenges in learning and teaching computer programming relate to everyone who needs to prepare others for the digital world. Learning and teaching computer programming is a challenge because it requires persistence and dedication. Nowadays, Computational Thinking is understood as an essential skill to overcome those challenges. In this paper, we propose an Augmented Reality (AR) environment that creates representations of complex programming constructs displaying engaging and playful activities that can be promptly done and do not require a heavy mental load. Such exercises are intended to be used as Learning Resources to train people in CT. The artifact enables people to explore CT concepts and several problem-solving approaches subtly. The artifact includes a simple AR-based activity, which is easy to handle and visualize based on "see-through video." We argue that users can develop CT problem-solving skills by interacting with this artifact. These learning activities supported by AR provide visual representations and interactivity to engage students while training CT. We also describe an experiment to test this artifact. The experiment was performed with 59 participants of the same age and educational level. The results of the feedback collected were positive.

KEYWORDS

Augmented Reality, Learning Resources, Active Learning, Mobile, Computational Thinking, Experiment

1. INTRODUCTION

Researcher Jeannette Wing consolidated the term CT (Computational Thinking) in her work (Wing, 2008), which states that developing skills related to PC concepts is essential to solving complex problems better.

An algorithm is a correct sequence of instructions for solving a problem. It is possible to build an algorithm by combining abstraction, decomposition, and pattern recognition abilities with logical reasoning. After successfully creating the algorithm, instructions must be translated into a programming language to achieve the problem solution. After running the program, it is important to analyze the output and the process and, if necessary, revisit the previous steps to improve the proposed solution.

However, training those abilities is difficult and requires appropriate resources. The author (Azuma, 1997) defines AR as virtual information integrated into a real environment in real time.

The author (Billinghurst et al., 2015) defines types of AR Display Technology, which depends on the proximity of display mediums. Handheld AR is a common method that uses smartphones and tablets to show AR content. Another technique is using headsets classified as optical see-through and video see-through like Hololens. The latter, nonetheless, although highly effective, is an expensive technology considering it would be used in public schools. The challenge of the activity is to create a virtual hero by following a sequence of steps. This resource supports a Plugged Activity using mobile devices guided with audio instructions.

This paper describes, in Section 2, some works related to our project; Section 3 discusses the ideas and motivations that led to the project; Section 4 presents the artifact developed; before the conclusion in Section 6, we discuss in Section 5 the results achieved in an experiment conducted after the development of the two pedagogical tools.

2. RELATED WORKS

Since the popularization of AR technology, society has been interested in developing new teaching methods. J. Wing (Wing, 2008) said that CT would influence all fields of action, thus raising the educational challenge of our society. We have to consider and develop the idea of creating new teaching/learning tools appropriate for training CT. The author also shows how social media has introduced a new industry segment to our economy, investing in Virtual and AR technologies.

Regarding the evolution of technologies, (Teng et al., 2018) presents an augmented reality (AR)-enhanced learning system that offers visual representation and interactivity to help students learn how to program 3D applications. The author demonstrates in his work's results that, using AR, students had a higher learning efficiency than using the traditional system. Furthermore, the author's work claims that, by using AR, students have a better perception of usability, flow, and usage.

In two recent works by (Schez-Sobrino et al., 2020b) and (Schez-Sobrino et al., 2020a) with RoboTIC, different components integrated into the RoboTIC architecture are provided thanks to the use of AR and game mechanics designed to motivate students. The presented system, however, has high-cost wearable equipment. The works by ("Gardeli and Vosinakis, 2020) and (Gardeli and Vosinakis, 2019) suggest how to use RoboTIC in the classroom, first explaining the concept of programming and then letting students play the related game level to check if they really understand this concept.

It is possible to reduce the challenges of learning programming by using tools and graphical representations associating real-world elements with specific programming concepts. Thus, the main idea is to convert those complex programming concepts and associate them with metaphors easily created by AR. It is important to highlight that the future work suggested in the mentioned papers confirms that we are on the right path. The authors pointed out the need to work on a fundamental axis, which is the exploration of AR environments on mobile devices with current technologies, such as ARCore, ARKit, Vuforia, etc.

Following the related works, we identified gaps that align Augmented Reality and ontology to guide the development of activities that impact programming learning. Students find it hard to assemble mental models to solve ordinary problems. Feedback from previous work by (Araújo et al., 2019) describing an ontology model for teaching CT in schools and other works by (Lima et al., 2020) that present this idea motivated us to keep researching the impact of AR on CT training. In the next section, we will show how we associate the artifact's activities with the skills to be developed in the CT.

3. PROJECTING AN AR ARTIFACT TO TRAIN CT

The learning activities projected and discussed in this paper require that students use CT key concepts. To limit the scope of this work, the artifacts developed and presented here were built using Handheld AR techniques, as illustrated in the general architecture depiction shown in Figure 1.

The idea is to plan activities in which the user will have to make choices and come to decisions according to a strategy resorting to mechanisms such as abstraction, decomposition, logic reasoning, pattern recognition, etc. Thus, it is possible to improve the quality of the reached solution in a loop until developing an effective final artifact.

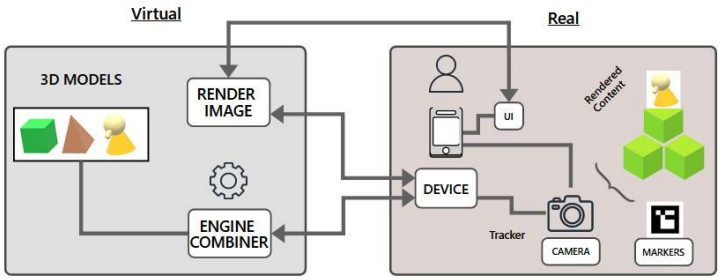

Figure 1. Artifact's architecture

We developed an application called "Make Your Hero in AR," which was designed to perform learning activities based on the leading characteristics of CT. The artifact allows students to create several 3D heroes and change their attributes using Markers as cards. In the App, AR is used to display information and is also the environment used for interactions. The user plays with cards to interact and choose the character's attributes. The created heroes can be saved and then exported as a QR-Code to be imported later into a different device. Aiming to reduce energy consumption, we chose not to use wireless technologies to exchange information between devices. This approach was made possible by saving the information gathered as a JSON format file and then using this information to create a QR-Code to be read by another device.

It is important to notice that the activities use a Camcorder and consume more power from the device.

The QR-Code is generated with the information the user has customized using the markers. The option to use the camera to read the data of another device is only available when the camera is turned on. After reading a valid QR-Code, this routine is suspended so that scripts that use the camera do not consume power. By using interactive menus with buttons before the activity, we diminish the camera usage, reducing power consumption and using the camera in only two moments: in the Learning Activity with AR and the QR-code reading.

To implement the ideas, we used Unity 3-D® v.2018.4. The tool is useful when it comes to building AR systems supported by the Vuforia® library version 9.8. To create JSON files, we used the Newton soft library, and to exchange information between applications, we used QR-Code from the ZWING library. The technologies chosen make it possible to create scripts using the C# language to operate in the interface layer produced by Unity 3-D, and they also enable the use of libraries capable of generating visual information through QR-Codes. The following sections present a thorough discussion regarding the artifacts created to fit the concepts of CT using AR.

4. LEARNING RESOURCES TO TRAIN CT

CT is based on key concepts such as *Logical Reasoning*, *Algorithm Design*, *Decomposition*, *Pattern Recognition*, *Abstraction*, and *Evaluation*. As our goal is to train CT skills using a Learning Activity, the idea is to focus on the thought processes. With this activity, users will experience and explore an AR Activity aiming at customizing, recreating, or creating characters randomly. The key concepts associated with CT can be explored and improved while playing "Make Your Hero," as it will be later explained. **Pattern Recognition**: Players will begin to recognize patterns by interacting with the cards. **Decomposition**: The challenge is to create a hero with some attributes, such as *choosing a hero, size, special effects*, and *color*. **Algorithm**: The activity's goal is to follow the settled steps and use the modifier cards to customize a character, like in an algorithm, performing a sequence of elementary instructions; **Abstraction**: It is crucial to abstract how make the cards interact. Furthermore, the perspective view provided by AR to visualize the character from all angles gives the user a sense of analysis.

With the game, it is possible to create several characters with different effects, colors and sizes using six cards. Then, the students must save their characters to compare them with those created by other users. Finally, students must use the QR-Code to export/read the generated characters. It is possible to perform the activity in two ways: create a custom hero or select a randomly generated character. When creating a character, users are free to choose and customize their hero. We present a system designed as an appropriate system for training CT concepts using AR for mobile devices and cards as tangible objects. To use the system, it is necessary to print the Markers so that students can interact with them. There are six Markers in total. The printed Markers serve as Game Cards that will be used as an interaction tool in a routine that guides the users through the information displayed on the screen.

The activity of creating a character has five steps: Place the Player 1 and/or Player 2 card; place the Skin card and choose one of the available characters; place the Skill card to choose which effect will be displayed; place the Size card to change size and display; place the Color card to change RGB colors. The sequence of letters for interacting with the AR environment was fixed, relating to the concept of algorithm flow sequence. Users can create and save two characters at the same time. After choosing the character's characteristics, they can export their character using a QR-Code, and the character information will be loaded on another device. The system only shows panels for changing the character's attributes when the Player cards are combined with the modifier cards (character, size, color, and skill). Users can choose between four sizes, 19 characters, and ten different skills (effects), and they can even choose between ten colors to create other combinations.

Figure 2. List of basic Heroes available and Panel to customize the character

Figure 3 shows two screens of Make Your Hero during different occasions in the game.

When the user presses the button, the system responsible for the randomization functions generates information about all the customizable attributes of the activity. The textual information is presented for each attribute generated, allowing us to explore the abstraction concept.

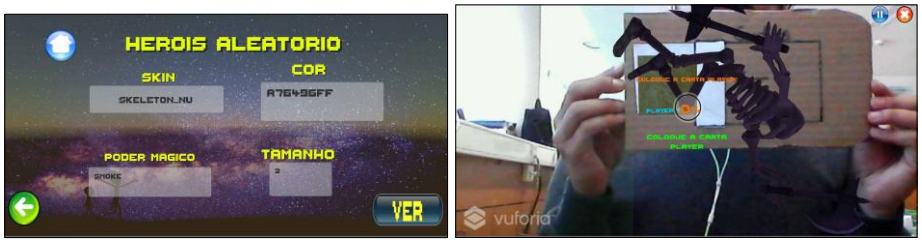

Figure 3. Screen shown when users press the "randomize hero" button and an example of the screen shown when we choose to randomize attributes

This plugged Learning Activity, which uses CT concepts, demonstrates that we can create numerous character customization options by using a few printed Markers for AR interaction. Furthermore, the application can export information in QR-code format, and students can exchange characters between devices.

The activity can also be used to create stories and use custom characters as their protagonists, combining it with other educational subjects. For instance, it can be used in subjects such as History, where the teacher and the students can create scenarios and replicate historical moments using mobile devices with cameras and printed markers.

5. THE EXPERIMENT, ITS RESULTS, AND FURTHER DISCUSSIONS

The experiment's presentation was given in a classroom with two groups of high school students in the first period in the morning. Because of this, some students were still sleepy during the presentation of concepts, but when the instructions and images of the proposed activities were shown, students woke up and identified an exercise different from the usual. A total of 59 students from ages 14 to 16 participated in the experiment, of which 23 were girls and 36 were boys. Students of the Computer Technician course, beginners in Logic programming. After showing the concepts related to Computational Thinking and how LR-AR works, a second teacher observed and recorded data collected from the experiment. Then, a link was shared to download the activity. The system was developed for a younger audience, but the objective is to test the motivation and usability of handling the system. Figure 4 shows the students' motivation in exploring the Learning Resource.

Figure 4. The figure shows the engagement of all students in the activity

Students were advised to work in pairs to solve some device compatibility issues. After installing the software, students were given 15 minutes to work on the activity so that the teachers could check if the students absorbed the given instructions. Then, the teachers met each group to present two other activities. Some students could not install the app because of parental control systems or because their device was of a brand that was incompatible with the system.

Figure 5. The figure shows that, after a few minutes, the students had completed the task

Figure 5 shows the sequence of completed tasks using the Handheld resource.

The first activity was to create a custom character and make notes of the chosen characteristics. The second activity proposed that students create a hero using fixed characteristics so that everyone could create the same character. At the end of the experiment and the two exercises, students were asked to complete the Evaluation of a Mobile Augmented Reality Game Application as an Outdoor Learning Tool questionnaire (Pombo et al., 2022). Four evaluation factors are defined for the MAREEA evaluation model: usability, engagement, motivation, and active learning. Students were motivated by the technology and way of operating the Learning Resource. At the school the experiment was carried out, students with special needs are not separated from other students. In the two referred groups, five students had autism spectrum disorder (ASD). They created custom characters and a specific hero following instructions, saving them with custom names. After creating it, the teacher passed it to another device, and students generated a QR code of the customized character and transferred such information to be used.

Ten answers were highlighted when considering both positive and negative reviews. A couple of students realized what the activity was for and enjoyed trying Augmented Reality, saying, "It is a great way for you to experience VR. I thought the app was cool, but it was hard to use it on old cellphones." The other student said, "I liked it because it has different characters, but I found it difficult to use the cards." Another student suggested

"further information in the interface," showing us that not all information was clear in the system. Some comments were completely positive: "Everything, I loved it!" and "I liked everything in the app." Some students reported system errors, stating, "There could be a more practical access and a better way to access the QR codes" and "The letters were not focused on the cellphone." Two constructive criticisms stood out as teenage students understood design and human-machine interface: "the font color (yellow), besides being tiring, doesn't look good visually" and "I loved the game, but I would like to interact with my friends' heroes." There were also suggestions for future work, such as creating an online combat arena where battles with the custom characters would take place.

There was much praise, and students with autism spectrum disorder (ASD) were highly motivated and created custom characters. In this case, the students took the interaction cards home to show other customized characters later.

6. CLOSING REMARKS

The artifact presented in this paper trains the key concepts of Computational Thinking that we believe to be crucial in programming. The research and tests done to collect and analyze data and feedback regarding user experience while they played with our Resources showed that the overall opinion given was distinctly positive and encouraging. The concepts presented by the Make Your Hero app evidence the students' interest and its development potential to be largely used as a learning tool. The follow-up during the experiment allowed us to learn how people's interactions differ from one another. Participants used the system from different perspectives. Some participants moved the marker around to see the 3D environment and solve the problem, while others logically tested the presented tools' behavior patterns.

Summing up, we demonstrated that creating adequate AR-based tools to train CT helps to understand a problem better, analyze it, and produce solutions in a digital society. To overcome the existing challenges, users perform actions that rely on skills related to CT, such as *abstraction,* in which unnecessary details are removed to understand problems better. CT skills are currently considered essential to face those challenges. After abstracting the problem's essence, participants must apply the *decomposition* skill, dividing a problem into smaller parts to decrease its complexity. Then, they must use *pattern recognition*, which is the ability to recognize similarities among known problems, a skill to be used in reusing solutions. Another characteristic identified in the experiments is the light mental load to perform the activity. When using the artifact, users get smoothly involved in the game, easily performing the proposed actions. The activity was designed to be short, i.g. they can be completed without much effort and do not require a great amount of time to be completed., avoiding time-consuming and complex tasks that would lead to disinterest. The problem of identifying touches on the marker represents a feature that the AR library used to program the artifact needs to improve. For that purpose, new artifacts based on Augmented Reality technology using concepts of CT will be developed.

ACKNOWLEDGMENT

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MOBILE TECHNOLOGIES REINVENTING TEACHER PREPARATION FOR EDUCATION 4.0 OUTCOMES IN MARGINALISED COMMUNITIES

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ABSTRACT

Mobile technology is a promising area of research post COVID-19 and helps the realisation of education 4.0 The purpose of this paper is to conceptualise mobile learning in Education 4.0 paradigm in the South African context. This descriptive study used a questionnaire made in a google form and distributed amongst pre-service teachers at a faculty of education. The survey questionnaire explored perspectives, ownership and use of mobile technologies by pre-service teachers. The data was analysed using the frequencies of the answers to the questionnaire. The findings establish the need for all stakeholders to holistically invest in the technical and capacity building of mobile technologies for learning purposes and help realise and develop the education sector to partake of the Education 4.0 opportunities. The study recommends the need for further studies that will explore additional knowledge on effective mobile technologies that make learning mobile aligning with the fourth industrial revolution innovations.

KEYWORDS

Mobile Learning, Mobile Technologies, Smartphones, Pre-Service Teachers, Education 4.0, 4IR

1. INTRODUCTION

The unprecedented revolution of the digitalised world is disrupting every sector of our society. The shifts are enabled by the advancements in technologies. The disruptive effects of Fourth Industrial Revolution (4IR) are transformative and reveal a broad repertoire of superhuman performance. Therefore, higher education institutions (HEIs) must innovate to prepare students to work alongside smart machines, hence the need for a transformative approach to education. An introspect into the current education systems, needlessly to say the current education serves to prepare students to take on tasks of traditional jobs. The danger of an unreformed curriculum is producing students whose roles will be easily replaced by automation. Educators and stakeholders must note that the purpose of education evolves on the needs of society. The World Economic Forum (WEF) reports aptly the digital skills gap (WEF, 2018). Mobile technologies have evolved and become powerful and can help bring transformation in education, hence raising the quality of teaching and learning.

The onset of the COVID-19 pandemic disrupted the normal operation of all sectors of society through restrictive protocols that encouraged virtual meetings. This transitioning opened a pandemonium and challenges specifically in education, due to their unpreparedness for such eventualities. Most institutions were reluctant to explore the integration of technologies afforded by the third industrial revolution into their practices, maintaining their traditional teaching and learning strategies. Nevertheless, this article conceptualizing the use of mobile technologies in teaching and learning that lines up with the 21st-century lenses within the Education 4.0 phenomenon.

Mobile technology refers to all technologies both hardware and software, that typically goes where the user goes (Kukulska-Hulme & Shield, 2008). They consist of network-enabled internet technology that connects them globally. For example, technologies are smartphones, tablets and watches that operate under android, iOS, and Applications. For this study the term, mobile technology is used to refer to the device's hardware and software.

Education 4.0 is about transforming the current and future of learning that aligns with the 4IR using advanced technologies. The 21st century advocated for a new skill set that challenges the status quo of traditional strategies that promote lectures and memorization (Education 1.0), Internet Enabled Learning (Education 2.0), and Knowledge-based education (Education 3.0) is not enough. Teacher preparation institutions must focus on innovation-based education (Education 4.0). The 4Cs skills are the foundation of Education 4.0 Therefore, the need to transform the educational curriculum to equip pre-service teachers with Education 4.0 skills. Today, the emphasis is on applying the knowledge (available freely on networked devices), translating that knowledge to solve the problem is more important than having the knowledge without applying it. It is the result or product that is more important in making a difference in society. Consider the unlimited possibilities of having billions of people connected by mobile devices, giving rise to unprecedented processing power, storage capabilities and knowledge access.

The use of mobile technology in teaching and learning has focused on facilitating interactions, however, few have engaged with other facets of mobile learning, such as human learning capacities and pedagogical issues in learning. Several models have been developed to help in-depth knowledge generation of mobile learning. Koole (2009) designed a FRAME that assists in implementing mobile learning in both formal and informal learning settings. The FRAME incorporates concepts that highlight technical characteristics of mobile technology and social and individual aspects of learning. Koole's (2009) FRAME model is founded on Vygotsky's Cultural Historical Activity Theory (CHAT), instituted on constructivism principles, whereby every element of the mobile learning process plays an active role. The FRAME was originally developed to understand the process of mobile learning. This framework resonates very well with the current Another framework is the TRIPLE E whose goal is to measure the effectiveness of a technology to help meet the learning outcome. The application of this model could help guide educators tap into the 4IR revolutionizes teaching and learning. The 4IR is rooted in the integration of networked technologies that facilitate the application of knowledge automation.

Most mobile learning studies have explored the theoretical aspects of mobile learning. However, is the initial phase of a longitudinal study that is exploring mobile learning technology use in marginalized communities. The project aims to highlight the real application of mobile learning in teaching and learning relevant for 4IR, Education 4.0 The following questions are guiding phase one of fact-finding,

The question used to explore this study

1. What should be the focus areas for teacher training institutions in pre-service teacher preparation foreducation 4.0?
2. How can teacher training institutions transform their curriculum to harness education 4.0?

2. REVIEW OF LITERATURE

The COVID-19 pandemic brought the popularity and rise of mobile technology use, many learners used mobile technologies for their learning (Karim et al., 2020). The advancements of the smartphone revolution have made it easier and brought major changes in how people do business and learn. This development indicates that mobile technology is no longer a want but a need to succeed in today's digital world.

2.1 Mobile Learning

The popularity of mobile technologies is growing fast and powerful with each innovation. Today's young generations that were born and bred during the 1990s rely heavily on technology and are skilled hunters of finding digital resources. Of the current university students 97% have access to smartphones and other mobile technologies (Statistica, 2021). In a study, Clayton (2016) noticed that students lacked the skills of using their mobile technologies for classroom learning activities, such as downloading or forwarding a voice memo of a class lecture, they could not set calendars to keep track of their progress or access tutorials in their subject disciplines.

The use of mobile technology for teaching and learning is ubiquitous, students use them for researching, collaboration, social interaction etc. The flexible learning afforded by eLearning initiated mobile learning (m- learning). Three concepts of m-learning are mobility of the learner, mobility of the learning and mobility

of the learning (Kukulska-Hulme & Shield, 2008). Mobile technologies are interconnected and becoming smarter, disrupting geographic boundaries, and opening more students' study options. During the COVID-19 pandemic, mobile technologies foresaw a significant growth in their acceptance in the educational sphere of influence. Most students are using mobile technology for their learning and mobile technology accounts for digital technology (Karim et al., 2020). Many studies have observed that mobile devices have an exceptional potential to replace other e-learning devices in the Education 4.0 learning setting (Karim et al., 2018, 2020). (Karim et al., 2020) administered a questionnaire to 120 HEIs students, and the results indicated that all students used their smartphones in their studies. Studies further revealed students use mobile technology for downloading learning materials, watching content-related videos, participating in the discussion on social media, WhatsApp and for searching for content online. Therefore, implying that mobile technologies are used effectively in HEIs.

2.2 Fourth Industrial Revolution and Education 4.0

Technological innovations and human creativity have made it possible to disrupt traditional business models and ceded power to smaller innovative businesses in a very short span of time. Given the imminent technological-driven changes, HEIs' traditional strategies require transformation, regular reviews and updates. According to WEF (2018), white paper, education is expected to produce graduates with skills for the unknown future.

HEIs are mandated to produce agile, multi-skilled, independent, adaptive, and lifelong graduates. HEIs' strategic plan grapple with such questions as 'how to remain relevant and sustainable for the success of current students, graduates and alumni.' The future of 4IR in developing nations has lower barriers than the first revolutions. Similarly, Education 4.0 technology solutions should be efficient, innovative, and lower costs. Education 4.0 comments under the 4IR embracing advancements in technology that align the physical with the biological realm (Karim et al., 2020). It is in response to the current development and needs of society. The Education

4.0 paradigm cultivates educational innovation-producing processes. This aligns with Jean Piaget's constructivist theory which states that students create knowledge through the interaction between experience and idea (Bhattacharjee, 2015), which is then translated into applied knowledge to solve societal problems.

The current generations are already living this 4IR life, hence transforming educational institutions is better than it was some decades ago. This generation is already exposed to the drivers of 4IR technologies and skills, namely cloud computing, the internet of Things (IoT), virtual reality (VR) / augmented reality (AR), Artificial Intelligent (AI), Big data, and Robotics (Cobots). It was critical for educational institutions to create an environment and resources

that help students to learn the tools that make them stand out in the 4IR. Education 4.0 adaption is never determined by institutions' readiness per se, teacher preparation institutions need to explore and incline towards foundational elements of 4IR technologies.

2.3 Linking Mobile Learning to Education 4.0

The education 4.0 characteristic is to harness the opportunities interconnected devices bring into the learning arena. Mobile technology is highly connected and is getting smarter and more powerful, this means it is highly connected to Education 4.0 qualities. Mobile technologies provide a wider variety of opportunities for finding and sharing information. A study by Shahroom and Hussin (2018) confirmed that mobile technology is a feasible device that supports education 4.0 learning outcomes. The ubiquitous nature of mobile technology innovation using devices like smartphones, tablets, and iPads supports anytime, anywhere access to learning (Mafenya, 2014). Mlearning has become the mainstream of educational technology. Mobile applications provide diverse access to quality educational content. The adoption of a learning management system (LMS) built using the responsive theme that can scale across all devices.

Internet of things (IoT) has the potential to transform teaching and learning as both educators and students have better access to teaching and learning materials, are better connected and collaborate and communicate in real-time using mobile technologies (Islam et al., 2020). For example, the use of learning management systems creates a connected environment that keeps all stakeholders with events and attendance updates in real-time.

Most sectors in society have benefited from robotics – manufacturing, transportation, medicine etc. Educational Studies explored the potential of robotics in education, e.g., educational, assistive, and social robotics with the aim of enhancing teaching and learning (Bhattacharjee, 2015). However, studies reveal the adoption of social and assistive robots has greater potential, but more effort is needed to evaluate educational robots (Scaradozzi et al., 2019). Empirical studies are still exploring how best to exploit the benefits of new 4IR innovations in teaching and learning.

Gamification in Education 4.0 is a concept of designing a learning environment that motivates learning a skill or behavior. The user experience influences engagement amongst students, henceforth increasing learning output (Urh et al., 2015). Artificial intelligence (AI) is used for various parts of the game and aspects of nonplayer characters. AI is applied in behavior modelling aspects such as situation analysis, target selection, resource allocation, learning, and simulated perception. Smartphones offer more practical, easy access, and are easy to carry anywhere. Mobile devices allow learners to play mobile games anywhere at any time.

Virtual reality (VR) and Augmented Reality (AR) intend to increase learners' satisfaction, enjoyment, creativity, audio, and graphics quality. VR and AR pedagogical process that creates authentic learning using 3D models (Lubega et al., 2014). The student actively experiences rather than receives passive information. VR and AR immersive student thereby building their emotional intelligence, and critical thinking and boosting creativity (Shahroom & Hussin, 2018). AR is used to create events that could be dangerous to explore like observing a tornado or veldfires, which in turn helps understand these natural disasters and help think of solutions and testing them virtually (Potkonjak et al., 2016; Shahroom & Hussin, 2018). Experts argue VR and AR catapult us from the information age to the knowledge age (Shahroom & Hussin, 2018). VR and AR afford students to learn, feel, remember, and process new ideas more experientially and deeply.

Artificial Intelligent in education is a technology that enables the machine to simulate human behavior, solving complex using mathematical models to learn and improve themselves with no program in this regard. Machine learning (ML) is the ability for applications to learn and adapt without following explicit instructions. The applications use algorithms and statistical models to analyze and draw inferences from patterns to accurately predict outcomes using historical data input.

Machine learning (ML) has the capability to transform education and fundamentally changing teaching, learning, and research. ML is used by internet search engines, email filters to sort out spam, websites to make personalized recommendations, application to detect unusual execution, GSP systems, and lots of apps on our phones (Chhaya et al., 2020). ML in education can help educators to easily identify struggling students earlier and take action to improve success and retention. ML further brings personalization in education to a new level (Kuleto et al., 2021). Importantly, ML derives meaning from all the data generated by the student and tailor the system to meet their needs. Consequently, a student doesn't lose motivation and the retention rates remain high (Hussain & Khan, 2021). The innovation of smart technology is promising to transform education by opening a new world of learning that is not bound in physical spaces. Students has access to diverse subject experts, collaborate beyond their classroom, and importantly self-paced and self-regulated learning.

3. METHODOLOGY

The purpose of this paper is to conceptualize mobile learning in Education 4.0 paradigm in the South African context. This is the initial phase of a longitudinal study that is exploring mobile learning technology use in marginalized communities. The study engages with quantitative data using descriptive statistics.

All respondents were given information about the purpose of the study and the anonymous processing of their data, A Google form link was shared with all (Foundation Phase (FP) (Grade R to 3), Intermediate Phase (IP) (Grades 4 to 6), Senior Phase (SP) - (Grades 7 to 9), Further Education and Training (FET) – Grade 10 - 12) pre-service teachers. the form could not start before consenting or not consenting and the form would close thanking the participant. The pre-service teachers, 256 voluntarily consented, the next page of the survey questions would open. The survey used close-ended multiple choice and multiple answers scale questions with open-ended options on every question. The questions were used (learning/teaching) of mobile technologies, duration spent using mobile devices, Mobile Apps used, and pre-service teachers' willingness to learn Apps for teaching and learning.

Data were analyzed using SPSS analysis. The data was presented in tables and bar graphs to visualize checking for patterns and outliers. Permission to conduct this study was obtained from the Research Ethics Committee in the institution at the onset of the longitudinal study. Privacy and confidentiality concerns were always given the deserved consideration.

4. RESULTS AND DISCUSSION

4.1 Demographic Data of the Participants

The pre-service demographic data was examined in terms of gender, age, teaching phase; FP/IP/SP/FET across all the academic years, 1st year to 4th years. To understand mobile learning the study designed a survey in the google form and shared it with all pre-service teachers, 226 pre- service teachers voluntarily completed the form. 160 (70.8%) were females, 64 (28.3%) were males and 2 (0.9%) preferred not to say their gender. Most students are between 20 – 25 years of age. Most pre-service participants came from the SP-FET phase, with none coming from the FP phase.

Table 1. Participating Pre-service teachers' demographic data

	Classification	Frequency	Percentage (%)
Gender	Female	160	70.8
	Male	64	28.3
	Prefer not to say	2	0.9
Age	18 to 19 years	71	31.4
	20 – 25 years	126	55.8
	26 – 35 years	27	11.9
	36 – 40 years	1	0.4
	Above 40 years	0	0
Phase	FP	0	0
	IP	20	8.8
	SP-FET	175	77.4
	PGCE	30	13.3

Most participating pre-service teachers were females. Most of the students 56% were aged between 20-25 years, and none of the participants was above 40years. Global indicators reveal that majority of Smartphone users are younger people termed Generation Z, born in the 1990s. Generation Z has unique characteristics, especially its dependence on mobile technologies. In terms of the phases, the SP-FET had the highest number of participants who volunteered.

In a study on mobile phone usage among university students in Kenya, Ogutu, Mariita, Nyakerario, Wanekeya and Akoth (2014) reported that female student rated higher in terms of mobile technology usage for academic purposes. This entail that gender is significantly related to mobile technology usage in university settings. Similarly, a Pew research on mobile usage fact sheet, shows that there is an insignificant difference between males and females (Vogels, 2021). However, in this study, demographic data is unlikely impacting on the usage of mobile technology in teaching and learning (Vogels, 2021).

4.2 Availability of Digital Devices amongst Pre-Service Teachers

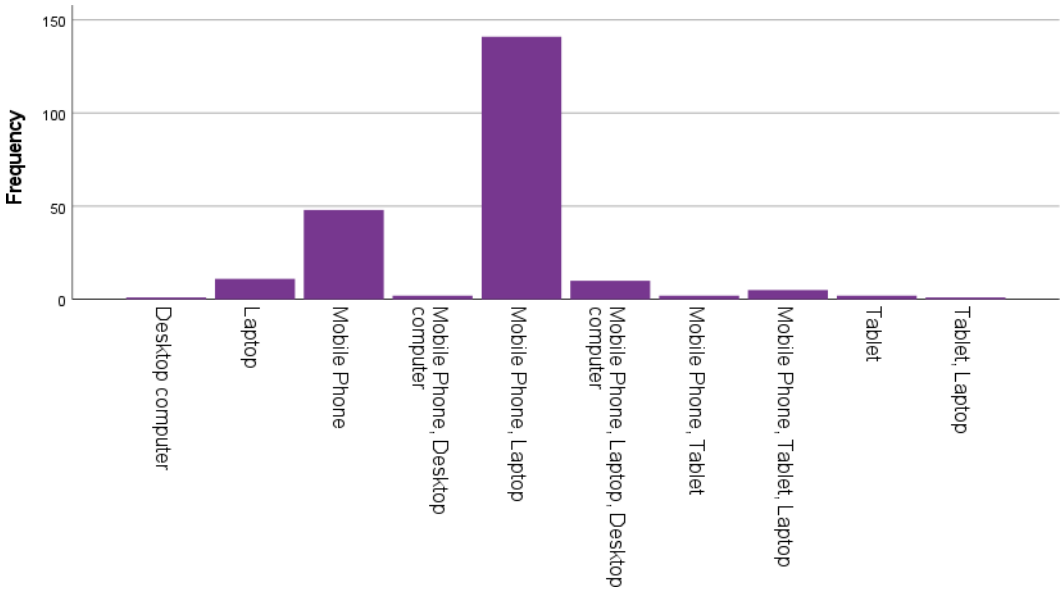

Figure 1. Digital Technological Devices pre-service have access

Figure 1 below, shows the frequency of devices at the disposal for students to use. Most students have access to both mobile phones and laptops. It is interesting to note that frequency of students having mobile phones only are fewer than those who have a mobile phone and a laptop. Mobile phones and laptops maybe the most owned digital devices because the probably portable and use applications that are tailored for student specific needs.

According to (Aheto & Cronje, 2018), noted the increased support for technology integration from organization and institutions. Since mobile phones and Laptops allow for multiple communications, easy access information, therefore students have found educational use for them. Students choose not to own tablets and Desktop computers, implies that mobile phones and laptops perform all functionalities that are needed (Aheto & Cronje, 2018). This further implies that students could be seeing mobile phones and laptop as portable and transformative tools in education.

4.3 Using Mobile Phones Technology for Learning and Teaching Purposes

The pre-service teachers spend time at university learning the art and concepts for professional teaching and get to go on teaching practice under the mentorship of a qualified and experienced teacher. During their teaching practice, they are also assessed on the application knowledge as they are taught at university. 65.5% mentioned that they always use smartphones in teaching, 13.7% mentioned that they sometimes use and 20.8% never use their smartphones for teaching. The results reveal that most the pre-service teachers use technology for both learning in their learning and teaching practice. Studies have demonstrated that using mobile technologies in teaching and teaching purposes (Chaka, 2022; Karim et al., 2018; North et al., 2014). The number of pre-service teachers using mobile technology learning is more flexible and easily used to access information (North et al., 2014). Using mobile phones promotes multitasking and flexibility, this is consistent with (Wasiaya et al., 2021) findings. Therefore, this implies that mobile phones are appropriate for teaching and learning.

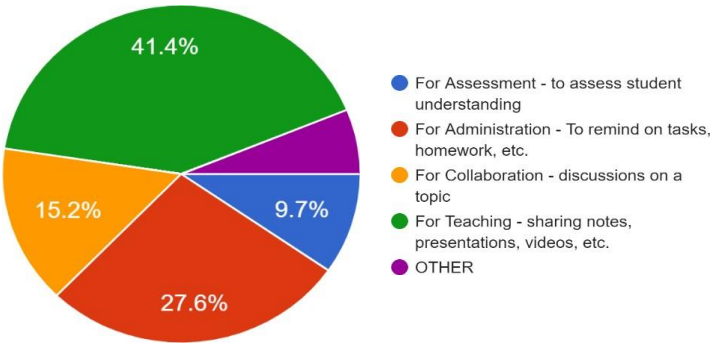

Figure 2. How pre-service use smartphones in teaching practice

Figure 2 shows the responses on when and how they use mobile technology, 41% use smartphones for teaching, 28% for administration, 15% for collaboration 10% for assessment and the 6% selected other. The functionality of Smartphones is on one hand increasing rapidly, on the other, the cost of these devices is decreasing, therefore making them more affordable than any other mobile technology.

The pre-service teachers used mobile applications for teaching and learning. Studies highlight mobile technologies have a greater influence on the teaching and learning experiences (North et al., 2014; Wasiaya et al., 2021). However, studies have also raised questions on the appropriate use of mobile technology in teaching and learning (Ally & Tsinakos, 2014). Pre-service emphasized that mobile technology can easily access online content and share links with others on social media. Mobile technology is becoming a mainstream technology, as devices come pre-loaded with search engines i.e., Google, for Android and Safari, for iOS smartphones.

4.4 Mobile Application Explored by Pre-Service Teachers

The study explored mobile applications that pre-service were using. The pre-service teachers indicated that 71.7% use Google Classroom app, and 37.6% use Quizlet in their teaching practice. The pre-service teachers specified other Apps they used besides the listed ones were blogs, google scholar, Vodacom e-school, wikis, Padlet, MS Teams, eBooks, Socrative, Content creation, and Chegg study. According to Burden and Kearney (2017), pre-service teachers are engaging in using these Apps authentic and with real experts. Furthermore, Burden, Kearney, Schuck, and Hall (2019), observed that students controlled what Apps they use and what connections they made through these Apps to tailor their preferred ways of learning and communication on more customized closed networks.

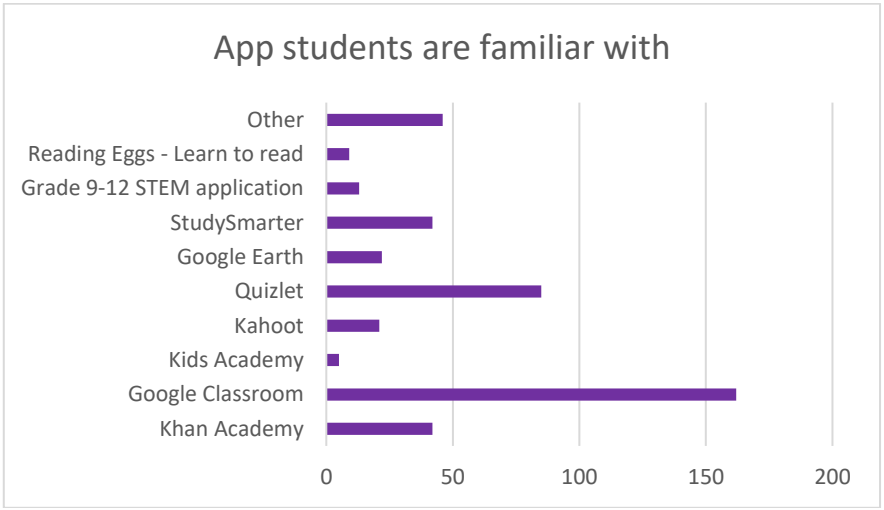

Figure 3. Teaching and Applications pre-service are using

The apps are not limited to independent one, it was interesting to observe that students mentioned Microsoft educational apps as well under other.

4.5 Pre-Service Interest to Learn More on a Mobile App for Teaching and Learning

The study observed that pre-service teachers appreciate and can identify with applications they can use for for teaching and learning.

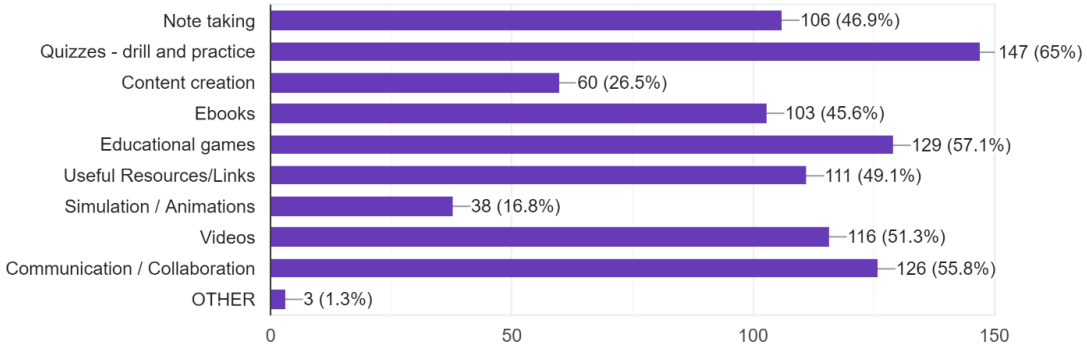

Figure 4. Pre-service Apps of interest to learn

Figure 4 shows pre-service teachers' interest to learn on how to use a variety of mobile apps to enhance teaching and learning. The result indicates most pre-service teachers require professional training on how to use mobile applications for quizzes (65%), educational games (57%), communication & collaboration (56%), use videos (51%), notetaking apps (47%), using eBooks (46%) etc. The finding reveals mobile technology has gotten mainstream offering more applications and functionalities (Chifamba, 2013). A study (Serdyukov, 2017) highlights that mobile technologies have positively impacted education making them essential technologies to support teaching and learning. Interesting to note that most mobile apps are changing the learning landscape that is bringing acrobatic invention. It is interesting to note that students understood various application that support the achievement of learning outcomes.

4.6 Mobile Technology is Highly Connected to Education 4.0

Mobile technology holds great potential in transforming teaching and learning. The results have shown that pre- service teachers have already revolutionized their individual learning capacity and even applied mobile technologies in their teaching practice. 110 students indicated that they always use their mobile devices for learning purposes. 148 students use their mobile devices to teach and assess students' understanding using real-time applications that will give students immediate feedback and help keep track of results. Reinventing education using the reality of 4IR into Education 4.0 is promising to make learning fun, interactive as well as experiential. Cloud computing, software as a Service (SaaS) system architecture serves education on licenses, hardware, and maintenance cost. The amalgamation of cloud computing and mobile learning is promising to transform conventional educational strategies with Education 4.0 strategies.

5. CONCLUSION

In conclusion, the advancement in mobile technology propagates Education 4.0 paradigm as a student-centered instruction and takes advantage of the limitless opportunities 4IR has created. The study provides teacher educators and researchers with what Mobile Learning Apps that pre-service teachers are using and how they are using them. The study then relates mobile technology to the current development in 4IR in turn to Education 4.0 The study additionally highlights the need for research into the design of a mobile learning curriculum in pre-service teacher preparation in line with the Education 4.0 contexts.

However, the limitation of tapping into the Education 4.0 is the lack of curriculum in preparing pre-service teachers. Educators are unprepared to exploit mobile learning opportunities and dynamics. It is recommended, for researchers to explore issues to deal with Education 4.0 developments in the conventional education setups.

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ORCHESTRATING AN UBIQUITOUS LEARNING SITUATION TO IMPLEMENT EFFECTIVE AND EQUAL LEARNING IN PANDEMIC TIMES: CASE STUDY OF MARGINALIZED REGION IN NORTH AFRICA

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ABSTRACT

The COVID-19 has impacted education all over the world, especially many African countries where the experience of the pandemic has been distressing. While the need for distance learning was clear from the outset of the pandemic, achieving effective reach to learners was more complex, multifaceted and challenging task, facing to many issues: Closing equity and adapting and using technologies for hybrid learning that engages pupils. Early childhood and primary level students are seen to be most likely to be disadvantaged by the crisis and least likely to be able to access the technologies required for learning. These problems faced governments worldwide but has been particularly severe in most African countries where there is a wide disparity in technology use and access for the 'elite and for less advantaged pupils mostly in rural areas. his paper describes the first stage of a study that aims to characterize the ubiquitous learning scenario for marginalized regions and challenges brought by the COVID-19 pandemic to the Tunisian primary education context. This scenario aims to enhance learners to embrace change, learn, and keep attached to the learning process by interactive SMS based game. This scenario has been tested on the second level of science education in six Tunisian elementary schools in a rural region. A preliminary analysis showed that the proposed learning activities motivate Tunisian pupils who become more closer to learning than before. The experience should be generalized in the other Tunisian regions and classrooms.

KEYWORDS

Ubiquitous Learning, Pedagogical Continuity, Marginalized Region, Equitable Education

1. INTRODUCTION

As technological development facilitated the access to information, ubiquitous learning - technologically mediated learning that occurs regardless of time and space - provides learning able to overcome geographical barriers and to level the field for students generally disadvantaged in access to education.

In this sense, creative solutions implementing ubiquitous technologies and techniques have emerged to provide learners (students or pupils) and their ecosystem (parents, teachers, etc.) with the facilities and resources needed to engage in and successfully complete the learning process.

These ubiquitous scenarios enhance interaction and provide effective learning to pupils anywhere and anytime Yahya, et al., (2010) across ubiquitous communication channels and tools such as cell / smart phone, closed-circuit television etc.

However, the needs and contexts of educational agents – teachers, learners, and parents and their access to technology, Internet, and digital literacy, may have a major impact on the processes of going digital, and therefore cannot be ignored.

In fact, during the COVID-19 pandemic, Tunisian transition to distance learning has not been the same in different primary and secondary schools. In fact, online learning has required adjustment at different levels by both teachers and learners to adapt to new learning styles with focus on active learning and technological support required for delivery of teaching.

Many extensive problems remain, including the lack of internet connectivity in some locations, especially rural ones, and the competing needs among family members for the use of home technology.

According to the investigation done in eLearning Africa & EdTech Hub (2020), Educational TV and radio are seen as the most important technologies for sustaining learning for learners at the primary level in these countries. However, it was quickly clear that, for most learners, these unidirectional communications approaches were not always the answer. They couldn't interact and evaluate their achievement.

In this sense, to ensure continuous learning during ongoing crisis or long holidays, this paper provides a reflection on the challenges fostered by ubiquitous learning and the permeability of contexts, faced by learners in rural region during the COVID-19 confinement. It describes a mixed learning scenario which combines educational radio program with the use of cell phones to respond to SMS – Quiz game. This scenario has been tested on the second level of six Tunisian primary schools in a rural region. A preliminary analysis showed that the proposed learning activities motivate Tunisian pupils who become more closer to learning than before. The experience should be generalized in the other Tunisian regions and classrooms.

This paper will be structured as follows. Section 2 gives an overview of ubiquitous and online learning scenario in time crisis related works. Game based ubiquitous learning scenario for competencies' enhancement description and a conceptual supporting framework are given in section 3. Section 4 presents the research context and methodology adopted in this article. We describe and discuss different experimentation and results in section 5. Finally, conclusion and perspectives are given in section 6.

2. BACKGROUND AND THEORETICAL FOUNDATION: UBIQUITOUS AND ONLINE LEARNING IN TIMES OF COVID 19

Ubiquitous learning, also known as Context-aware Ubiquitous Learning, integrates wireless communication, sensing, and mobile technologies which ensure learners across real, digital, and gamified activities to be more attached to the learning process Guettala, et al., (2021).

According to Mishra, et al., (2013), Ubiquitous learning process is characterized by:

- **Permanency:** The learning process remains continually until the learners purposely eliminate it.
- **Accessibility:** The learning process should be available whenever the learners need to apply it.
- **Immediacy:** The learning process should be retrieved by the learners whenever needed.
- **Interactivity:** The learners should have the possibilities to interact with peers, teachers, and experts efficiently and effectively through various types of media.
- **Context-awareness:** The environment had to be adaptive to the learners' context.

In the literature, several proposals have been advanced to deploy ubiquitous learning paradigms, especially during crisis time.

The authors in Simoes, et al., (2021) propose adaptation to virtual learning in the introductory course of biological engineering. These adaptations involve several changes to enhance interaction and learners' engagement. Due to technological disparities, synchronizing and interacting with learners were complicated. In several courses, a pre-class Question-Answer session was conducted, which initiated group discussions between the students and professors.

Siripongdee, (2020) defines a smart Blended Learning with IoT-based framework as a new normal of educational technology especially in time crisis. Therefore, this study proposes to consider 2 types of contexts:

- The classroom context with important parameters that can be detected by IoT devices.
- The personal context with personal parameters that can be detected by personal devices or wearable devices which are able to be identified, to collect and process personal data to report and track the students' status and learning processes.

A critical study is presented by Hassan, et al., (2020) that discuss Indian teacher's perspective about this mode of learning, challenges and issues faced by them in migration to online platform, experience about online tools/platforms used for instructional delivery and their suggestions to improve the process for effective teaching. Several issues such as connectivity coverage, learning motivation, teachers' competencies (ICT competencies required to teaching-learning design, social competencies, ability to accept teaching process' changes) etc. are discussed. Professional support and guidance to educators and enhancing learning context and infrastructure are the most relevant recommendations proposed by the authors.

García-Alberti, et al. (2021) demonstrates the impact of the sudden shift in the teaching-learning strategies in time of the global health emergency in higher education. This study concludes that online learning could be beneficial in some aspects and difficult in deployment in other aspects, especially students' engagement and motivation. discuss the adequate forms of evaluation.

By studying different proposals of ubiquitous learning, we can conclude that these ubiquitous learning scenarios couldn't be deployed in the African context particularly in the Tunisian's Context due to wide disparity in technology use and access for the 'elite and for less advantaged pupils mostly in rural areas. In the other hand, educational radio is seen as the most important technology for sustaining learning for learners at the primary level. However, it was quickly clear that, for most learners, these unidirectional communications approaches were not always the answer. They couldn't interact and evaluate their achievement.

For this reason, we propose, in the following section, a game based ubiquitous learning for competencies' enhancement, a novel form for the classical scenario adopted in African countries.

3. GAME BASED UBIQUITOUS LEARNING SCENARIO FOR COMPETENCIES' ENHANCEMENT

3.1 The Ubiquitous Learning Scenarios Design

A pupil is learning, when he is acquiring knowledge through interaction and through active participation not through passive recipient.

Based on this hypothesis, we need to allow learners to be in active environment which should be adapted to their learning context and constraint (internet and network coverage, level of competencies). That's why we hybridize educational radio channel with SMS-Quiz game (with parent cell phone) to ensure interaction.

The aim of the learning situation was to enhance scientific reasoning competencies, as well as communication competency. That's why we choose Arabic and Mathematics lessons to be aired on a national radio station.

The learning situation was planned during 4 months (from the February to May 2022). Involved teachers deliver gamified structured lessons on selected disciplines which target approximately 300 children in the rural region. Radio lessons for pupils à 4th level primary education was planned three times in a week. SMS Quiz were sent to pupils daily to keep them attached. Pupils should send the number of correct answers. The SMS Server was developed to indicate whether the pupil's response is correct or not. An intelligent repetitive remediation was planned to low progress learners. The scenario design is depicted in Figure 1.

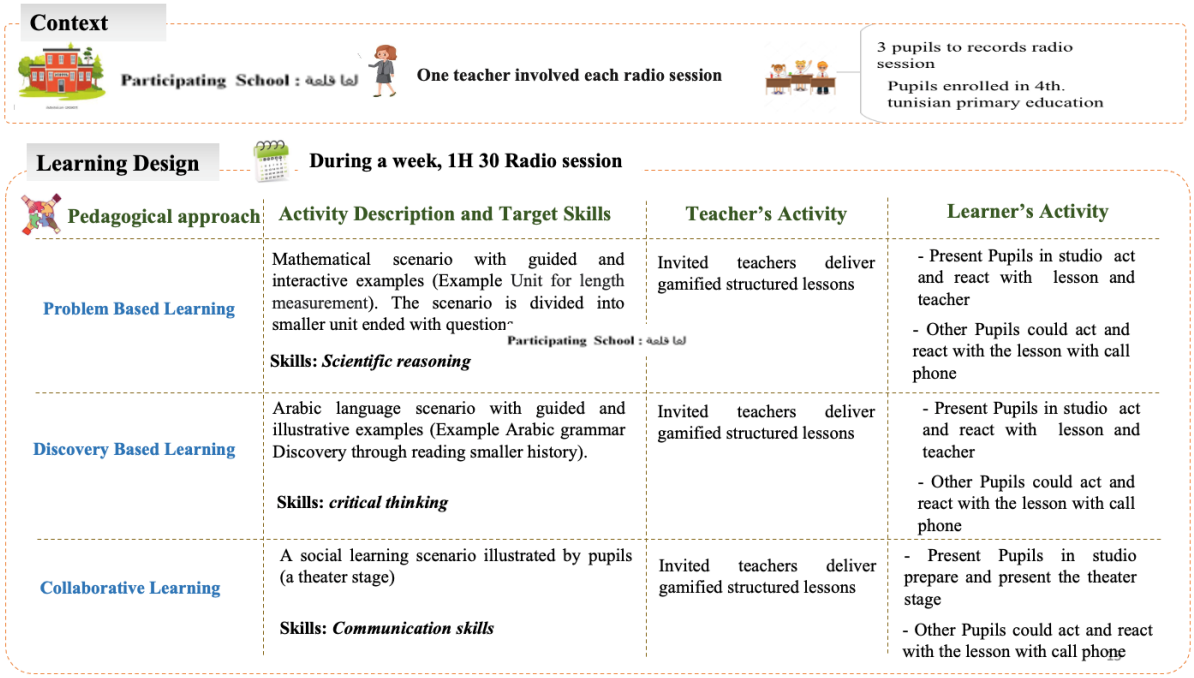

Figure 1. Graphical depiction of the ubiquitous learning scenarios design

We organized various stakeholder meetings as part of planning for introduction of the distance learning initiative. We also organized discussion platforms on Radio and social media to engage the general public.

3.2 Conceptual Learning Analytics Framework

We conceive and orchestrate various elements together in an integrative conceptual framework for ubiquitous learning environment (see Figure 2) to provide a structure for analysis to recommend strategically enhancements, a common language to stimulate further engagement.

In this project, the study of collected data produced by the interaction of pupils and teachers with the proposed learning scenario, interests not only learners and educators themselves as decision-makers, but also researchers, analysts, designers, administrators, and policy makers and so forth.

As we are dealing with a wide range of contexts and we are aware of how important to fully explore the user's requirements throughout the process of designing contextual based recommendation, the study of the variety of users, their different learning problems, and their intended purposes take a prominent place among our research challenges.

To answer different stockholders' needs, we propose a multi objective and contextual framework which corporates three basic components. The first component is the intelligent SMS server which stores pupils' response and provides them adequate replay and remediation.

The second component is the explainable recommendation across intelligent dashboard which enables a dynamic production of different effective recommendation to explain integrated visualization needs expressed by each user in a wide variety of contexts.

To add semantic information, qualitative (questionnaire survey and interviews) and quantitative data (SMS response) are gathered and integrated together to generate visualization components, user descriptions and different data/indicators.

Hence, each generated dashboard should provide, on the one hand, a set of indicators gathering that facilitates the links between the data and the visualization objective.

On the other hand, it should provide adequate visualization components to maximize the value of this relevant set of data to be visualized at the right time.

These set of dashboard components (chart, user description etc.) will act as a semantic framework for storing contextual information required for generating an adaptive and explainable recommendation.

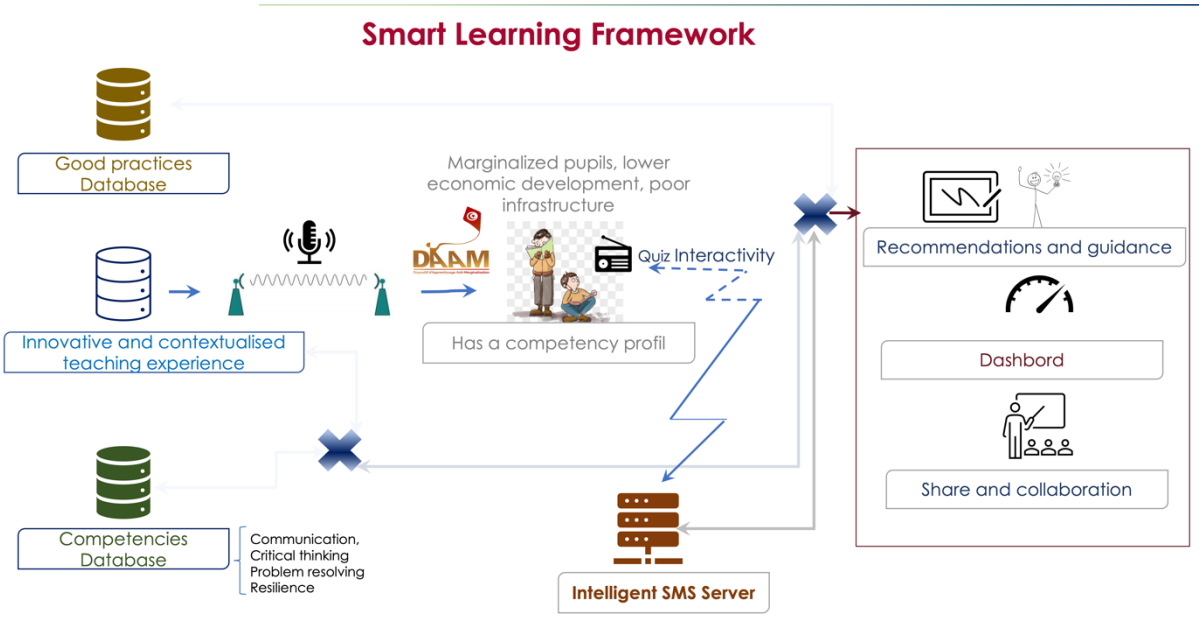

Figure 2. Conceptual Learning analytics Framework overview

4. RESEARCH CONTEXT AND METHODOLOGY

This case study was carried out in public primary-education schools located in marginalized Tunisian region (North of Nabeul, Tunisia, North Africa). This region is rural with limited internet and network coverage and poor economic infrastructure. In these regions, the lack of continuous supervision and guidance after school are highlighted and the dropout rate is higher.

4.1 Research Context

- **Participants:** A purposive sample of courses was chosen to provide rich insights. Courses were chosen based on being those that are most adequate to enhance the development of scientific reasoning competencies. Pupils enrolled in 4th primary year have been invited to participate. Academics teachers working different schools and contributing to the above courses have been kindly asked to collaborate in the study as depicted in Figure 3. The total number of participants is around 400 participants (100 teachers and 300 pupils) for 6 months.
- **Study Duration:** The study is proposed over 06 months from January 2022 till June 2022. The study duration has been proposed based on the duration of the AUF Covid 19.2 project and based on the assumption that pupils enrolled in 4th primary years are likely to succeed to the next level at the beginning of September 2022
- **Ethics**: Ethical approval for this study has been obtained from:

- National educational ministry to conduct pilot learning experience
- Pupils 'parent to allow them to participate in the ubiquitous learning experience. An explanatory statement will be provided and written consent to participate will be obtained from all parents who their pupils participate in the ubiquitous learning experience

Figure 3. Different stockholders working on the ubiquitous learning scenarios

4.2 Methodological Approach

A convergent mixed methods research design Creswell, et al., (2007) is employed using both quantitative (Response to SMS-quiz) and qualitative data (Pupils and educators' feedback through open ended questions in the survey Pupils and educators' interviews), which will be collected longitudinally analyzed and interpreted together. Figure 4 depicted the research methodology.

The aim of this study is to evaluate the impact of the change to teaching and learning approaches, including online education and changes to work-integrated learning, during the COVID-19 pandemic. More specifically the study will answer the following research questions:

- *How have the teaching and learning approaches been received by pupils*?
- *How effectively did teachers adapt to the transitioning teaching approaches and what factors influenced their adaptability*?

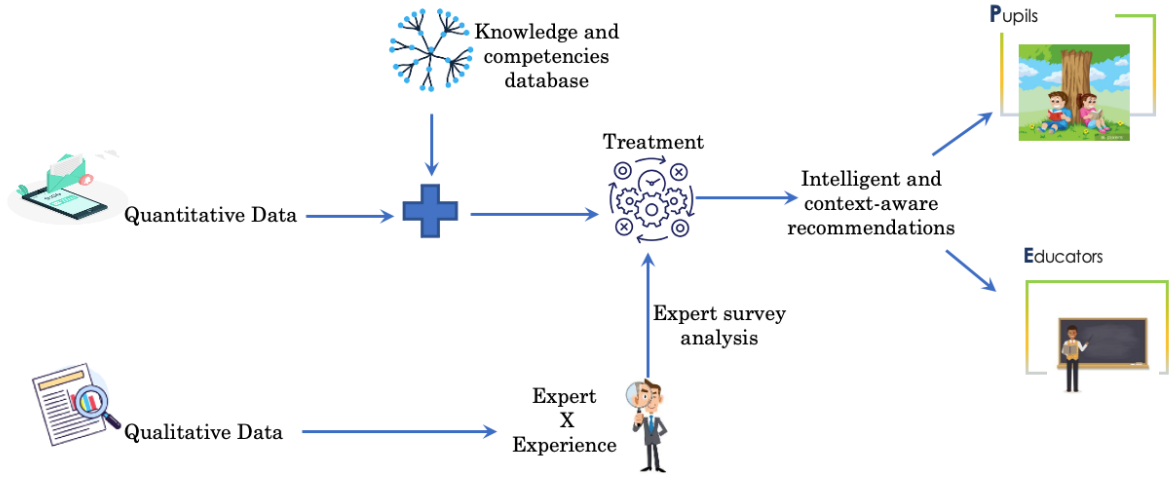

Figure 4. Methodological approach

5. RESULTS AND DISCUSSION

The learning situation was successfully carried out. The first part in DAAM project was achieved. The field investigation is in progress. Thus, we present, in the following section, preliminary quantitative analysis.

5.1 Preliminary Analysis and Results

To assess the learning outcomes achieved through ubiquitous learning scenario, quantitative data relating to pupils' performance and engagement, is summarized, and presented using descriptive statistics.

Effectiveness and efficiency related to the learning scenario deployment were deduced from pupils' interaction with the SMS- Quiz extracted from the server database.

The enactment measures used for the assessment of pupils' involvement are as follows:

- To evaluate effectiveness: we used the completion rate percentage (complete %)
- To evaluate efficiency: we used the average time and the average score (for quizzes)

Table 1. Pupils'performance and engagement result deduced from their response and interactivity to SMS-Quiz

	Easy Level SMS (30 questions)	Medium Level SMS (30 questions)	High Level SMS (30 questions)
Number of evaluated learners	287		
Completed (%)	90%	70%	30%
Avg. Score	15,5	10	NA
Min Score	2/30	4/30	3/30
Higher Score	30/30	29/30	25/30

5.2 Discussion

The results of this experience and involved teachers' interviews indicate that pupils are more motivated and engaged in learning process.

As perspective to this project, generalizing learning experience through intelligent learning platform is proposed. Teachers are motivated to be trained in IT technologies and active pedagogy strategies to remediate to their technical difficulties in using online platforms and delivery of instruction as well as in creating e-content adapted to limited internet coverage.

Based on this research study and after considering the challenges faced by teachers, there are some recommendations that can help in effective ubiquitous teaching. We conclude that there is need for professional training of teachers with emphasis on the deployment of active pedagogies methods and on the use of ICT tools in creating, sharing, disseminating content and use of online modes of teaching learning process.

6. CONCLUSION AND FUTURE DIRECTIONS

During Pandemic proliferation, many Tunisian children, as well as African ones, do not have fairly access to the technologies needed for home-based learning and often have limited means to continue their education.

In rural regions, quality of education remains poor with a higher rate of dropout and a fewer rate of children demonstrating developed life skills and 21st century competencies. Therefore, keeping learners, especially pupils, positively engaged with learning has been critical during and after the time of COVID-19.

Mitigate the impact of the pandemic on learning is the main objective of the ubiquitous learning scenario through a radio program and gamified learning activities for children to ensure continued learning during ongoing crisis or long holidays.

This article describes the first stage of a DAAM project that aims to deploy an ubiquitous learning scenario for marginalized regions with limited internet and network coverage to the Tunisian primary education context. This scenario aims to enhance pupils and teachers to embrace change in teaching-learning process by keeping pupils attached to the learning process by interactive SMS based game and enhancing educators to adopt active learning pedagogies.

This scenario has been tested on the second level of science education in six Tunisian elementary schools in a rural region. A preliminary analysis showed that the proposed learning activities motivate Tunisian pupils who become more closer to learning than before. Teachers are open to ICT and pedagogical training. As future direction, qualitative data will be semantically integrated to the recommendation system to enrich recommendation.

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Revealing the genius of the scientific Francophonie throughout the world, the AUF, an international non-profit organization, is also a label that carries a vision for a better development of educational and university systems: "to think globally about the scientific Francophonie and to act regionally while respecting diversity".

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STUDENT-GENERATED VIDEOS IN A MANAGEMENT INFORMATION SYSTEMS COURSE – FEASIBILITY, STUDENT ACCEPTANCE, AND GUIDELINES FOR TEACHERS

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ABSTRACT

As lessons were forced to switch to online or hybrid mode during COVID-19, educators need to apply tools to foster engagement inside and outside the classroom. Screencasting software enables teachers to evaluate students' learning outcomes in compensation for the lack of face-to-face interactions. This study investigated the use of student-generated videos to replace written reports in an information technology subject involving hands-on skills. The SGV can prevent plagiarism as it requires showing steps with verbal explanations. The multiple benefits of getting students to create their own content using video were supported by pedagogical theories such as multimedia learning theory (Mayer, 1997), VARK model (Fleming, 2001), and dual coding theory (Paivio & Clark, 2006). Furthermore, it can encourage students to practise their presentation skills and gain experience in video editing, which may also be helpful for their future careers. This research aimed to explore the feasibility of applying SGV in an information technology subject, and students' perception towards the assignment format, and provide some guidelines for teachers. This qualitative study involved 39 Hong Kong students. Their opinions were collected in a focus group after the subject had finished. We found that even though making SGV may require more time and effort, the students in the focus group agreed that SGV can better evaluate their understanding of subject knowledge. Based on the empirical findings, guidelines for teachers who want to use SGV in formative assessment were provided.

KEYWORDS

Computer Programming, Student Acceptance, Screencast, Student-Generated Videos, Teacher Guidelines

1. INTRODUCTION

Due to COVID-19, many lessons were conducted online, and many teachers were forced to adopt online teaching upon short notice, asynchronous communication is commonplace during remote instruction (Grieger & Leontyev, 2020). Many of them had no choice but to migrate their teaching face-to-face (f2f) strategies to a virtual environment. In reality, even when the format of examinations and tests must be changed so that students can do them at home, the content of many teaching activities and assessments remain the same as those for face-to-face classrooms. In either f2f or online mode of instruction, student assignments take up a significant part of the teaching and learning activities. In fact, the role of student assignments has become more important when students and teachers can only interact virtually. That is because in f2f teaching, teachers can get clues about students' understanding of the materials by looking at their facial expressions and observing their reactions during lessons. However, in most online teaching environments, the teacher cannot see and hear the responses of the students. The widespread use of technologies by students and teachers at home means that they can complete assignment tasks in ways that were not feasible before. In particular, student-generated video (SGV) is one of the emerging multimodal learning approach with students demonstrating their learning or perceived knowledge by submitting video assignments (Campbell et al., 2020). The following student-generated materials has been identified from literature:

Table 1. Terminology of student-generated materials mentioned in literature

Terminology	**Citations**
student-generated video	Balija (2020); Box et al. (2017); Doyle et al. (2020); Gelman & Tosone (2006); Grieger & Leontyev (2020); Omar et al. (2013); Pereira et al. (2014); Pirhonen and Rasi (2017)
student-created video	Benedict & Pence (2012); Campbell et al. (2019); Campbell et al. (2020); Cowie & Sakui (2020); Marley (2014)
student-authored video	Campbell & Cox (2018)
student-produced video	Hubbard et al. (2017)
learner-generated video	Orús et al. (2016)
learner-generated content	Lee & McLoughlin (2007); Snowball & McKenna (2017)

Video is an effective multimedia tool to promote student engagement in asynchronous learning settings. Apart from viewing instructional videos provided by the teacher, students could also share videos that contain useful information with the class (Bledsoe & Simmerok, 2013). SGVs have the potential to better ensure students' submission is their own work, and therefore, fairness in grading. Conventionally, teachers asked students to submit assignments in form of printed or electronic documents containing text and images. Ideally, after submitting assignments, students can get formative feedback to improve their work. Teachers who mark with pens preferred paper to electronic documents, yet the process of submitting and returning assignments inevitably required extra effort. Even with automated plagiarism detectors such as Turnitin™, it may not completely prevent internet-facilitated plagiarism. With online machine translation website such as Google Translate and DeepL, students can cheat the system through back-translation, such that both computer software and teachers can hardly identify (Jones & Sheridan, 2015). In an age where wide-range of digital content is easily available, students are tempted to borrow online materials without comprehension, which has become a universal problem. SGV may address this "Paste-without-understanding Syndrome", because the individualized process of show and tell involves attentive engagement. After all, true understanding is hard to guarantee, as in written reports, paraphrasing mostly reflects students' language ability. Computer programming requires hands-on demonstration instead of mere description, therefore, SGV can be an effective assessment format.

2. LITERATURE REVIEW

2.1 Benefits of using SGVs

The taxonomy of educational objectives proposed by Bloom (1956) was mentioned in SGV papers (Arruabarrena et al., 2019; Frenzel et al., 2013; Marley, 2014). The revised Bloom's taxonomy consist of six levels, namely remember, understand, apply, analyze, evaluate, and create (Krathwohl, 2002). Marley (2014) found that SGV not only reinforces lower levels of learning such as memory and comprehension, but also enables the highest level through producing original videos on new topics. Furthermore, the SAMR technology-enhanced learning framework by Puentedura (2010) examined the degree which technology create added value to a teaching approach. **S**ubstitution refers to technology acts as a direct tool substitute with no functional change. **A**ugmentation stands for substitute with functional improvement. **M**odification takes place when technology allows for significant task redesign. **R**edefinition involves the creation of new tasks which is previously inconceivable (Hamilton et al., 2016). This research involves redesigning traditional computer programming assignments which was previously inconceivable. It is because traditional computer programming assignments only submitted the programs and related output as text only. With digital technology available at every students' home, it is now possible to ask students to show the steps of their work at the computer, the process of using for official information on the Internet, and their own explanations of the steps that they were taking.

According to multimedia learning theory, multi-sensory learning design of SGV can generate better outcomes (Mayer, 1997). In dual coding theory, language (logogens) and a nonverbal stimulus processed differently by the brain; multimodal messages could enhance memory, comprehension, and deeper learning (Paivio & Clark, 2006). In the VARK model proposed by Fleming (2001), individuals receive information through sensory modalities and have preferences over the four perceptual modes of visual (V), aural (A), read/write (R), and kinesthetic (K). Traditional assessments rely on the single modes of read/write(R). On the other hand, SGVs covers the visual (V) and kinesthetic (K) modes. It may reduce the difficulty level of completing coursework for students who are less confident in written assignments.

2.2 Turn Students from Consumers into Prosumers of Videos

Millennials are characterized by digitally-oriented and fluent in multimedia, students nowadays are on the receiving end of live or recorded videos. Videos offer a faster, easier, and more digestible medium to convey a message to a large audience than written assignments (Thomas & Marks, 2014). There is limited evidence of learning-by-doing, which is based on the theory of constructivism for teaching and learning. Open digital content is widely accessible nowadays, students perceive low value in the rote learning of factual information, the true value of education is to empower students to become a "prosumers", who not only passively receive pre-packaged authoritative content, but also be able to engage in social processes of knowledge construction through guided learning materials, or even actively create their own content (Lee & McLoughlin, 2007).

Students can learn more if they create content. SGV creates situation of active learning, which is associated with the constructivist approach of learning by doing, which requires activities that challenge the learners to perform tasks to engage in their own learning (Bonwell & Eison, 1991). By involving behavioral, affective, and cognitive engagement, this approach could renew students' interest in a previously learned topic, inspire higher-level independent thinking, and motivate students to reflect on their personal learning experiences (Quinn & Chu, 2017; Winstone & Millward, 2012).

Some SGVs featuring students and other actors, or even in the form of mini-documentaries or role plays, could be effortful as it required a script, storyboard and post-production (Benedict & Pence, 2012; Frenzel et al., 2013; Gelman & Tosone, 2006; Marley, 2014; Ng & Nicholas, 2015; Pirhonen & Rasi, 2017). Negative feedbacks from students were mainly complaints about SGV assignments needed longer preparation time, in which they need to pick up skill unrelated to the subject (Omar et al., 2013). Video editing can be a time consuming and tedious process, for some students, it was even more challenging than the subject content itself (Campbell et al., 2020; Feijóo-García & Gardner-McCune, 2020; Quinn & Chu, 2017). Therefore, teachers may hesitate in asking students to submit videos as assignments, because they are uncertain if the students have the skills to create SGVs, and even if they can, it is uncertain whether students would perceive them positively. On the other hand, teachers cannot be sure if the schools' LMS can handle the submission of videos, and if they can view and mark the videos efficiently and effectively. Making videos with storylines contribute very little to technical disciplines such as computer programming. Screen capture could be a preferable option to remove such skill barrier, which may reduce the cognitive load required from students to produce SGVs (Rasi & Poikela, 2016).

2.3 Discipline-Specific Application of SGV

SGV can be applied in a wide range of subjects related empirical study, commonly found in the discipline of pure science, such as physics (Douglas et al., 2017), chemistry (e.g. Jordan et al., 2016), and biology (Pirhonen & Rasi, 2017). Multiple findings show that, by doing video lab reports, students were able to complete labs in less time and less dependent on the explanations from instructor and teaching assistant (Benedict & Pence, 2012; Box et al., 2017; Jordan et al., 2016). Campbell & Cox (2018) proposed the ICSDR model to guide the design of SGV assignments, the framework contains procedures of **I**dentify, **C**onceptualize/**C**onnect, **S**toryboard, **D**evelop, **R**eview/**R**eflect /**R**evise. The ICSDR method was applied by Campbell et al. (2020), in which video drafts were review and revise multiple times before the videos are finalized for publish, the experiment found improvement in students' self-efficacy in STEM content and cross-curricular technology skills.

In human-oriented subjects such as education, SGVs foster meaningful, assistive, and therapeutic discussions among student teachers. In healthcare subjects such as pharmacy (Frenzel et al., 2013), psychology (Gelman & Tosone, 2006), and social work (Quinn & Chu, 2017; Thomas & Marks, 2014). SGV usually incorporate the element of role play. Sharing of individual stories with a group of peers was found beneficial for alleviating pre-service teachers' emotional pressure (Ng & Nicholas, 2015). There were studies in Asian regions on SGV in English as a Second Language (ESL) courses in Japan (Cowie & Sakui, 2020) and Taiwan (Hung, 2016). Through producing speech video clips and oral feedback, students can improve their fluency and accuracy with frequent practices. Even when applied in non-language subject, Omar et al. (2013) experiment in Malaysia shows that SGV can improve students' communication and presentation skills in ESL context.

2.4 Research Gap

SGV is an emerging research topic, with most articles are published during the past 5 years, mainly examined the effectiveness of SGV to enhance the effectiveness of teaching at universities. Although SGV has the vast potential as an effective tool for enhancing learning effectiveness, there is a lack of sufficient research in this area. In particular, we found that most of the past research was mainly in the disciplines of science, the application of SGV in computer programming is under-researched, which Arruabarrena et al. (2019) from Spain is the only related publication in Q1 and Q2 journals.

It is obvious that the more video assignments are used, the more benefit they can bring to students. However, previous researchers did not always indicate the number of video assignments used. Only certain studies clearly stated the SGV being a one-off assignment (Balija, 2020; Campbell et al., 2019; Campbell et al., 2020; Frenzel et al., 2013; Omar et al., 2013; Orús et al., 2016; Pereira et al., 2014; Snowball & McKenna, 2017; Willmott, 2015). The use of one-off exercise limits the opportunity for the student to receive teacher feedback and reflect on their own work.

When using SGV as an assessment tool, teachers should create shared objectives with clear, achievable and valuable perspectives for students (Arruabarrena et al., 2019), instructions could be provided to students for reminding them about the purpose of SGVs (Thomas & Marks, 2014). At the initial stage, teachers may have to spend time to instruct students and motivate them to participate in the activity and supervising their progress. However, millenniums undergraduate students are "digital natives", in general, they familiarize with technology quicker than the older generations who are "digital migrants" (Ryan, 2013).

3. RESEARCH QUESTIONS AND METHODOLOGY

3.1 Research Questions

The research questions for this study are listed below.

1. Is it feasible to use SGVs to teach an IT subject?
2. What are the student perceptions on SGVs?
3. What are the guidelines that can help teachers to use SGVs in their course?

3.2 Sample

The student in this research were studying in a university during their final year of study. They were taking a subject called Management Information System from September 2020 to November 2020. The class was planned as a face-to-face course, but it was forced to turn into hybrid lessons due to COVID-19 pandemic. There were 40 students at the beginning of the course, but 1 of them dropped out, so only 39 students finished the course. The duration of the course was 13 weeks. Students were required to submit two SGVs.

3.3 Methodology

Lessons were delivered in a hybrid format, meaning that students may choose to take the lesson in face-to-face mode on campus, or virtually using Microsoft Teams. All lessons were recorded as videos and available for students to review. There was an examination component which accounts for 30% of the subject grade.It was changed to an extra assignment, in which students had to provide written essays to answer some questions. There were 2 SGVs which accounted for 5% of the students' grades in the subject. The students were required to submit 2 SGVs in week 4 and week 11 on two programming tasks. Task 1 required students to submit a video of their programming using Visual C# in 2 minutes or less. Task 2 required students to submit a video of their programming using Python in 3 minutes or less.

Due to the exploratory nature of this study and small sample size, we use a qualitative approach. After students completed the course, and received their grades, they were invited to join a focus group discussion. They were informed that, their participation were voluntary and their responses will not affect their grades. The focus group was conducted in December 2020. Four students participated in the focus group discussion. The discussions were transcribed and sent to students for their confirmation.

4. FINDINGS AND DISCUSSIONS

4.1 Feasibility

We found that SGV as a form of assignment for programming tasks was technically feasible. For Task 1, the submission rate was 95%. Two of the 39 students did not submitted the assignment, and only 1 student missed the deadline by 42 minutes. One student submitted an image file only. For Task 2, the submission rate was 82%. All files submitted were videos. Seven of the 39 students submitted the assignment, and two student missed the deadline. Both students missed the deadline by about 4 hours. The submission rates and punctuality ratio were similar to the other assignments. Furthermore, less than half of the students used the screen capturing software demonstrated by the teacher. No students reported problems about creation or submission of the videos.

Table 2. Summary of Student Submissions of Video Assignments (m = minute, s = second)

SGV Topic	**Video Length Limit**	**Submitted Video Lengths**	**File Size**	**% of Students who did not use Screen Capturing Software Provided by Teacher**
Programming Task 1 – Visual C#	2 minutes	Longest: 3m56s Shortest: : 10s Average: 1m	Largest: 103 MB Smallest: 0.49 MB Total:541 MB	31%
Programming Task 2 - Python	3 minutes	Longest: 3m24s Shortest: : 16s Average: 1m10s	Largest: 105 MB Smallest: 0.41 MB Total:547 MB	13%

While these results show that using SGVs as assignments is technically feasible, there are some drawbacks as well. Moodle, which was the learning management system, and the students themselves, had no issues with the submission of videos. Many students even used screen capturing software that were not taught by the teacher. However, we found that some SGVs were low-resolution, silent, or too short. This shows that clear instructions must be given to students about the submission requirements. Also, it requires more effort from the teacher to grade the SGVs. These will be covered in the "Findings & Discussions" section below.

4.2 Student Perceptions

The transcriptions were read and re-read carefully by the investigator. It was found that the students had both positive and negative views about the use of SGVs to replace traditional written reports. The following are positive comments made by students:

1. *It is interesting and innovative.*
2. *It is better than writing a report on programming.*
3. *I must understand the program in order to explain it in the video.*
4. *I learnt a new skill of creating videos using screen capture software.*

The following is negative feedback from students:

1. *It is time consuming to retake the video when I said something wrong.*
2. *It is hard to find a quiet environment.*
3. *There are no good video examples to follow.*
4. *I need to put effort in picking up a new skill of video editing.*

All the students managed to complete the two videos. It showed that creating screen capture videos is not difficult for the students. However, the students in this study were all IT major students. That cannot be generalized to students from other disciplines. Furthermore, the need to learn the new skill of producing screen capture videos has both pros and cons. Overall, the students' acceptance was high, and because there were no problems reported and the anonymous course-end evaluation was at the same level as the previous class in which no SGVs was used.

4.3 Guidelines for Teachers

Based on the findings, the following are suggested guidelines for teachers who want to adopt SGVs as assignments in their lessons.

- Assignment Design:
  - The assignment should state clearly the purpose of video is to let them assessed in the most appropriate way. When students understand the purpose, they acceptance should be increased.
  - Students should demonstrate correcting common mistakes such as syntax errors.
  - Students should show the search for relevant information from official websites.
  - Students should show a list of the major steps. This will improve their organization skills.
  - Ask students to their program and program output side-by-side.
  - Set a time limit so that the SGVs received would not be too short or too long.
  - Set a limit on the submission file format and size.
  - Indicate clearly if the student should explain using their own voice.
- Student Support
  - Provide a sample video to show what an SGV submission should look like.
  - Give a checklist for students to review their recordings before submission.
- Feedback
  - Use rubric to show how SGVs will be marked.
  - State clearly if voice explanation is required.
  - State clearly if text explanation is required.
  - Produce sample videos that show good practices for students to follow.

5. CONCLUSIONS & SUGGESTIONS FOR FURTHER RESEARCH

We found that it is feasible to use SGVs to teach an IT subject. The students' perceptions on SGVs in this research were generally good as reflected in the focus group and post-course evaluations. There could be guidelines for teachers who want to adopt SGVs in their lessons. SGV can bridge the gap of students from

diversified background by addressing discipline-specific skills and content from understanding of theoretical concepts to practical application (Hubbard et al., 2017). With feasibility proven, teachers should consider using SGVs as one of the tools to enable blended learning.

We have the following suggestions for future research. Firstly, it is worthwhile to find out if the student performances correlate with their language grades. It would be unfair if a student's grade in a computer programming assessment is significantly affected by the student's language skills. Secondly, there should be study to investigate the use of peer review of SGVs. Vygotsky's, as in Jaramillo(1996), sociocultural theory stated that competent peers were learning facilitators. Besides, social interactions between peers elicit different perspectives about a problem (Jaramillo, 1996). However, the teacher must consider if students should show their names or speak during video. Also, the computer desktop of a student in his/her video may cause privacy concerns. Thirdly, as the marking of SGVs involves more effort than traditional assignments, it is suggested that artificial intelligence (AI) be used to "view" the SGVs to help spot problems and misconducts. Finally, although the technical feasibility is confirmed, the workload on the teacher and the gain in student performance needs to be further investigated.

There are certain limitations in this study. The dataset was relatively small, and the sample is limited to students who were IT majors. Students from other disciplines may encounter other difficulties in creating SGVs. Therefore, future studies should be repeated using larger sample size and involving students who are non-IT majors. Furthermore, the need to learn the new skill of producing screen capture videos has both pros and cons.

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RESEARCH ON THE EVALUATION OF TEACHERS' TEACHING QUALITY BASED ON △S EQUATION

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ABSTRACT

The teaching quality evaluation of college teachers is an important indicator of school evaluation, performance assessment and teacher promotion. However, the existing evaluation methods are only limited to the formal evaluation of teaching behavior, and have not achieved objective, reasonable and scientific evaluation results. The purpose of this paper is to propose a △S equation of the state of the teaching system from the point of view of the teaching system's operation process. On this basis, a Markov process evaluation method for teachers' teaching quality is established. The research results show that the application of the △S equation of the teaching system to the evaluation of teaching behavior and teaching effect has its own characteristics, and the key lies in the reasonable selection of the △S equation and the the combination of Markov analysis can effectively achieve the evaluation goal of teachers' teaching quality.

KEYWORDS

Teaching Quality Evaluation, △S Equation, Markov Analysis

1. INTRODUCTION

The evaluation of teachers' teaching quality is an important task of teaching management in colleges and universities. Teaching quality is the main work quality of teachers in colleges and universities, and it is also one of the important indicators to evaluate the quality of running schools in colleges and universities. It plays an important role in college evaluation, teacher work evaluation, and teacher promotion. For a long time, in the formulation of various educational policy documents and school education and teaching management systems, the quality of teachers' teaching has been placed in an important position. However, in the actual management and evaluation implementation, the rationality, objectivity and scientificity of teachers' teaching evaluation have not been fundamentally resolved, which results in that the evaluation of teachers' teaching quality is limited to formalized management modes such as workload statistics (Sun,2011). With the continuous deepening of information technology in teaching management in colleges and universities, the management and evaluation of teachers' teaching quality have been networked and digitalized. At present, various types of network teaching management systems have been developed, and some teaching quality management software has been put into practice (Zhang, 2014). However, a prominent problem is that the existing teaching quality evaluation is either based on the evaluation of students, peers and leaders, or the evaluation results of students' test scores, ignoring the process management of teaching quality, and failing to achieve teaching quality evaluation the real purpose (Fan, 2005).

Therefore, how to evaluate the teaching quality of teachers in colleges and universities, so as to build a reasonable and scientific management system of college teaching quality, is an urgent problem to be solved in college education and teaching management. Teaching quality management of college teachers is a systems engineering. Usually, a mathematical model of teaching evaluation is constructed in the network teaching management system. The existing research is to establish an evaluation model based on multiple teaching factors (Zhang, 2011). The function of this comprehensive evaluation teaching quality model is to reveal the activity law of the teaching quality system. However, in the specific implementation, it is found that only the calculation method of weighted summation cannot achieve the purpose of teaching management and evaluation (Si, 2008). Because teaching quality is affected by variousfactors inside and outside the teaching system, teaching quality management and evaluation need to link various factors and establish a

mathematical model to reveal the quantitative relationship between them (Wang, 2008). As the researchers argue: "No matter what system is studied, no quantitative analysis is possible until a mathematical model describes the relationship between the physical system and external inputs."(Wang, 2004). In fact, not only is this the case with physical systems, but teaching, as an artificial system, cannot do in-depth quantitative analysis without revealing the mathematical relationship between the internal factors of teaching activities and the external environment, and it is impossible to reveal any mechanism of teaching activities. Of course, teaching, as a behavioral interaction system between teachers and students, is much more complex than the general physical system, and there is also a lack of necessary data accumulation in education and teaching management. Therefore, we try to establish the relationship between the variables of the teaching system in a very definite form. It is difficult to describe. However, according to the actual situation of the teaching information management system in colleges and universities, a teaching quality big data analysis system can be established. Based on the collection, processing, diagnosis and evaluation of teachers' teaching quality data, the process quality of teachers' teaching is evaluated by selecting an effective mathematical model. This is also the original intention and purpose of this study.

2. METHODS OF EVALUATING THE QUALITY OF TEACHERS' TEACHING WORK

The evaluation of the quality of teachers' teaching work is usually called teaching evaluation, which is different from the evaluation of the comprehensive teaching quality of a school. Generally speaking, the network assessment of comprehensive teaching quality of college teachers adopts the following methods:

$$K_m = \sum_{i=1}^{n} a_i k_i \tag{1}$$

In the formula (1), K_m represents the comprehensive teaching quality level; k_i represents the ratio of the hours of each course and various teaching links to the total number of hours; a_i is the weighting coefficient. The evaluation of the quality of teachers' teaching work is different from this. It focuses on teaching activities, and is an evaluation of teachers' behaviors and the resulting effects in actual teaching activities. Its purpose is to help teachers overcome weak links and continuously improve their teaching level. Generally speaking, the basic form of teaching quality evaluation is to divide according to the direct object of evaluation, namely behavior evaluation method and effect evaluation method.

2.1 Teaching Behavior Evaluation Method

Teaching behavior evaluation method is a widely used teaching quality evaluation method in colleges and universities. Teaching behavior evaluation method takes teachers' behavior in teaching activities as the direct evaluation object. Teachers' teaching behavior is usually determined by teaching attitude, teaching ability, teaching method and so on. Teaching behavior evaluation method can be divided into: ①Student evaluation; ②Peer evaluation; ③Leader evaluation; ④Self-evaluation and other methods (Zhang, 2008). There have been many research results in the evaluation of teaching behavior, and many successful experiences have been widely used in the practice of education and teaching management. However, there are certain limitations in the quality of teachers' teaching based on teaching behavior: first, it is difficult to quantify teachers' teaching behavior; second, there are constraints of human feelings and competitive environment, so it is difficult to realize the objectivity, rationality and scientificity of teaching evaluation.

2.2 Teaching Effectiveness Evaluation Method

The effect evaluation method of the quality of teaching work takes the final effect of the teaching work, that is, the students' academic performance as the information source, and takes the students' behavior change, ability growth, and learning level improvement as the quality level of teaching work after a stage of learning. It is a method of evaluating teachers' teaching work through the effect of teaching.

2.3 The Relationship between the Two Evaluation Method

The teaching behavior evaluation method directly takes the teacher's work as the evaluation object, and the effect evaluation method evaluates the teacher's teaching work from the students' learning effect. It can be considered that the evaluation method of teaching quality effect is an indirect method. However, in the teaching process, students' learning is under the guidance of teachers, and students' gain and improvement through course learning is the most direct and authoritative basis for reflecting the teaching effect. Although some indicators can be established around teaching work to judge the quality of teachers' behavior, the most fundamental criteria for establishing these indicators are how to promote students' learning and the teaching effect. Therefore, in this sense, it can be considered that the teaching effect method is a direct method, and the behavior method is an indirect method.

There are still some technical difficulties in evaluating the quality of teachers' teaching work from the learning effect of students. Mainly, student learning outcomes are determined by multiple factors. As mentioned earlier, in addition to the teacher's work, the quality of management, internal and external environmental influences, and the student's learning base all have an impact on the final outcome of learning. In addition, it is also a question whether the students' performance based on the teaching evaluation can reflect the real level of the students. The existence of these difficulties hinders the application of the effect method, but some researchers believe that "students' learning effect can fully reflect the teaching effect" (Wei, 2009). Because the evaluation method of teaching behavior often exists that the benevolent sees benevolence, the wise sees wisdom, and lacks objectivity, and the effect evaluation method has its unique advantages in this respect. Therefore, it is the real meaning of college teachers' teaching quality evaluation to seek appropriate ways, overcome the above difficulties, and constantly improve the effect evaluation method of teaching quality so that it can be used in actual teaching management. This paper solves this problem by establishing the △S equation of the teaching system.

3. MATHEMATICAL MODEL OF TEACHER TEACHING PROCESS EVALUATION

3.1 △S Equations for Teaching Systems

In the network system of teaching management and evaluation in colleges and universities, the state change of the teaching system is an important information, which is related to the quality of teachers' teaching work, the quality of teaching management, and the internal and external environment (conditions) of the teaching system. The mathematical expression for this relationship is as follows:

$$S = f(T, M, C) \tag{2}$$

In formula (2), S : the macroscopic state vector of the teaching system; T : teaching; M : management; C : teaching conditions. Formula (2) indicates that the macro state of the teaching system is related to the above three factors and is a function of these three factors. Taking the total differential on both sides of formula (2), we have:

$$dS = (\frac{\partial f}{\partial T})_{M.C}\, dT + (\frac{\partial f}{\partial M})_{T.C}\, dM + (\frac{\partial f}{\partial C})_{T.M}\, dC \tag{3}$$

If there is no significant change in teaching conditions and management quality within a short period of time, it can be approximated that m and c remain constant during this period of time. This approximate condition is expressed as:

$$D_m = D_c = 0$$

Under this approximate condition, equation (3) can be simplified as:

$$dS = (\frac{\partial f}{\partial T})_{M.C}\, dT \tag{4}$$

Integrate equation (4), and make:

$$F_{M.C}(T) = \int \left(\frac{\partial f}{\partial T} \right)_{M.C} dT \tag{5}$$

Thus we get

$$F(T) = \Delta S = S_1 - S_0$$

Suppose the macro state vector of the teaching system is $S = f(x_1, x_2, \cdots, x_n)$, We have

$$F(T) = \Delta S = (x_1^1, x_2^1, \cdots x_n^1) - (x_1^0, x_2^0, \cdots, x_n^0)$$

Similarly, if in a short period of time, approximately consider that T , L lare unchanged, or T , M are unchanged, after similar processing, we can also get the functions are:

$$F(M) = \Delta S, F(C) = \Delta S$$

These are simplified teaching system equations, which may not necessarily be precise, but they enable us to obtain the possibility of teacher work quality or management quality from changes in the macroscopic state of students. We call this formula is the ΔS (incremental) equation of the teaching system. This paper uses this ΔS equation to discuss the evaluation of teachers' teaching quality.

3.2 Effect Evaluation Method Based on ΔS Equation

If the teaching process is regarded as a control system, Figure 1 shows the input and output of the teaching system.

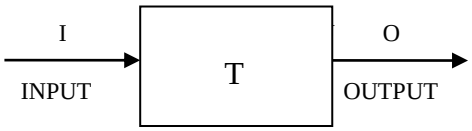

Figure 1. Schematic diagram of the input and output of the teaching system

In Figure 1, T represents the teaching system, I represents the input of the system, and O represents the output of the system. If a teaching system only knows its input value and output value, but its internal structure is unknown, we call it the "black box" of the teaching system. According to the control mechanism of the teaching system: "Only by observing the output reflection caused by the input change, the behavioral characteristics of the system can also be deduced." When the internal structure of the teaching system is uncertain, the function of the system can be analyzed according to the input and output of the system, identify the behavior of the system. In the expression of the ΔS equation, if we regard S_0 as the input value of the teaching system and S_1 as the output value of the teaching system, then the practical significance of using the d equation to evaluate the teaching quality is: according to the input and output data to analyze teaching system behavior.

4. APPLICATION OF ΔS EQUATIONS

According to the ΔS equation of the teaching system, the state vector S of the teaching system is described by the macroscopic description method. In practical applications, according to the content of the macroscopic state vector S, the effect analysis of teachers' teaching quality can be divided into XE analysis, Markov process analysis and comprehensive analysis.

4.1 ΔS Equation and the XE Analysis Method of Teaching Quality

The XE analysis method of teachers' teaching quality is to use the average X of the students' academic performance in each class and the degree of deviation E of the students in the class from the average as the indicators of the effect of teaching quality, that is,

$$\bar{X} = \frac{1}{n}\sum X_i \ , \ E = \frac{1}{n}\sum \left| X_i - \bar{X} \right|$$

Then, we examine X and E in two different periods, and make different evaluations of teaching work according to their changes. In fact, taking X and E as independent variables of the state vector, we have

$$\Delta S = (X_1 - E_1) - (X_0 - E_0)$$

Obtain X and E, and then evaluate the teaching quality according to the content of Table 1. The evaluation of teachers' teaching quality is divided into 9 grades: excellent, better, good, poorly, general, poorly, poor, very poor and worst.

Table 1. XE Evaluation form

ΔX	ΔE	Teaching quality
>0	>0	Excellent
>0	=0	Better
>0	<0	Good
=0	>0	poorly
=0	=0	general
=0	<0	poorly
<0	>0	poor
<0	=0	very poor
<0	<0	worst

4.2 ΔS Equation Combined with Markov Analysis

The XE analysis method of teachers' teaching quality has the advantages of being simple, clear and suitable for application, but it has its shortcomings. First, the final evaluation criteria are subjective. For example, there is no convincing proof why an increase in E must be better than a decrease in E. Secondly, this method of analysis loses a lot of information, and it is impossible to give more guidance to actual teaching activities. Therefore, some researchers have introduced the Markov process analysis method of teaching quality.

The Russian mathematician Markov once pointed out that there is a class of things in nature and society whose changes are related to their recent state (. The influence of the past state of things on their changes is all reflected in their recent state, that is, the state of things at time T depends on the state at time $T-1$, and its state at time $T+1$ depends on the state at time T. Moreover, Markov made a mathematical analysis of the process with this property. For this reason, a process with this property was later called a Markov process. This method of analyzing the Markov process using a dynamic stochastic mathematical model is called

Markov analysis. Markov process analysis of teacher teaching quality is a statistical analysis method. It takes a group (Lv, 2012). a class or a grade) the proportion of students who have obtained excellent, good, medium, passing and failing grades to the total number of students as a state variable, and represents it with a state vector $S(t)$ (Yuan, 2021).

$$S(t) = (X_1(t) \quad X_2(t) \quad X_3(t) \quad X_4(t) \quad X_5(t)$$

We use an example to verify the effect of combining the△S equation with Markov analysis.

4.3 Examples and Discussions

For example, after an exam, among the 50 students in a class, there are 9 outstanding students, 18 good students, 15 average students, 6 passing students, and 2 failed students, so the state vector is can be written as:

$$S(2) = (9/50, 18/50, 15/50, 6/50, 2/50) = (0.18, 0.36, 0.30, 0.12, 0.40)$$

We know that the △S equation of the teaching system is determined by the changes between two states at different times. If after the second test, 6 of the 9 students who originally got excellent grades will continue to be excellent, 2 will drop to good, and 1 will drop to medium. Therefore, we can get the transfer of the 9 students who got excellent grades in the first exam: $(6/9, 2/9, 1/9, 0, 0)$.

Because of the original 18 students who got good grades, in the second test, 3 students rose to excellent, 9 students remained good, 6 students fell to average, and 0 students were below average. The transfer of grades can be expressed as: $(3/18, 9/18, 6/18, 0, 0)$.

Using the same method, we can obtain the changes in the performance status of the remaining students: $(1/15, 3/15, 6/15, 4/15, 1/15)$, $(0, 1/6, 1/6, 3/6, 1/6)$, $(0, 0, 0, 1/2, 1/2)$. The matrix of the above changes is expressed as:

$$G = \begin{bmatrix} 6/9 & 2/9 & 2/9 & 0 & 0 \\ 3/18 & 9/18 & 6/18 & 0 & 0 \\ 1/15 & 3/15 & 6/15 & 4/15 & 1/15 \\ 0 & 1/6 & 1/6 & 3/6 & 1/6 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{bmatrix}$$

And the following equation holds between $S(2)$ and $S(1)$:

$$S(2) = S(1) \cdot G$$

Obtained by matrix operation:

$$S(2) = (0.18, 0.36, 0.30, 0.12, 0.14) \begin{bmatrix} 6/9 & 2/9 & 2/9 & 0 & 0 \\ 3/18 & 9/18 & 6/18 & 0 & 0 \\ 1/15 & 3/15 & 6/15 & 4/15 & 1/15 \\ 0 & 1/6 & 1/6 & 3/6 & 1/6 \\ 0 & 0 & 0 & 1/2 & 1/2 \end{bmatrix}$$

$$= (0.20, 0.30, 0.28, 0.16, 0.06)$$

The general expression for this relationship is:

$$S(t+1) = S(t) \cdot G$$

The above relationship determines that the ΔS equation of the Markov process teaching system is a matrix equation:

$$\Delta S = S(t+1) - S(t) = S(t) \cdot G - S(t) \quad = [G - I]S(t)$$

In Equation 9, I is the identity matrix, that is:

$$\begin{pmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{pmatrix}$$

In a Markov process, G is called the transition matrix. According to the nature of the Markov process, it is possible to infer what will happen next exam.

$$S(t+2) = S(t+1) \cdot G = S(t) \cdot G \cdot G = S(t) \cdot G^2$$

From a mathematical point of view, the transition matrix has an important property: if $S(0)$ is the initial vector, then there is K under the action of G, the state can reach an equilibrium state after K transitions, that is, the state no longer changes on the macroscopic level, We have

$$S(K) = S(K+1) = S \quad \text{（equilibrium）}$$

Of course, it should be pointed out that in the equilibrium state, the micro-changes among the personnel of each part of the system still exist, but the relative proportion of the personnel of each part no longer changes. This equilibrium state is generally referred to as the limit state. It is especially important that if G is not block-diagonal (here, it means that personnel at each level can move to any level), then the limit state of the teaching evaluation system has nothing to do with the initial state of the system, that is, it has no relationship with $S(0)$. It is only related to the transition matrix G, that is to say, the teaching quality evaluation is completely determined by G.

The above analysis shows that this property of the Markov process transition matrix is very meaningful in the evaluation of teaching quality. The change of students' academic performance reflects the teaching effect of teachers. Therefore, the transition matrix is a reflection of factors such as teaching quality and certain teaching conditions. The limit states of the Markov process show how far students are generally possible under these conditions if these factors are stable. This possible degree is independent of the student's learning base. Therefore, the limit distribution of Markov process can be used as an evaluation method of teaching quality, and the influence of students' basic differences can be solved when evaluating teaching quality by using students' grades.

5. CONCLUSION

Study shows that the digital teaching quality management is the key to establish a mathematical model of the teacher's teaching, that is to say, only the formal teaching activities, teaching quality data analysis can be realized, thus established on the basis of algorithm and data analysis of teachers' teaching evaluation in order to achieve the objective, the rationalization and scientific requirements. By combining △S equation with the two methods, the results show that the Markov teaching process evaluation method based on △S is ideal and can be applied to the real teaching quality evaluation of teachers.

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THE CONSTRUCTION AND APPLICATION OF A TEACHERS' PROFESSIONAL DEVELOPMENT PLATFORM UNDER THE CONCEPT OF SELF-DIRECTED LEARNING

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ABSTRACT

Teachers' professional development is an important factor to improve the quality of teaching in colleges and universities. At present, teachers' professional development in colleges and universities mainly focuses on teacher training and consultation, lacking personalized attention to teachers' professional development. With the development of technology, the construction of a professional development platform for teachers based on the concept of self-directed learning provides a new perspective on teachers' professional development. This paper first analyzes the design ideas of A University's teacher professional development platform, and systematically describes how to integrate teachers' learning resources, build teaching portfolios and build online communication communities under the guidance of the self-oriented concept from the perspective of different sessions of data aggregation, self-development and teaching promotion. Then, after analyzing the application of the platform, the results show that the construction of a professional development platform based on the concept of self-directed learning plays an important role in supporting teachers' personalized development paths, promoting teachers' reflection on teaching, and building learning communities.

KEYWORDS

Self-Directed Learning, Teacher Professional Development, Portfolios, Portraits, Community

1. TEACHERS' PROFESSIONAL DEVELOPMENT AND SELF-DIRECTED LEARNING

The connotation of teachers' professional development was put forward one after another in the 1970s, and Jerry Gaff's definition of professional development for university teachers was widely recognized. He believed that teachers' professional development refers to teachers' improvement of teaching design, teaching evaluation, teaching activities, and continuous improvement of teaching effectiveness, etc(Gaff, 1975). Chinese scholars have interpreted teachers' professional development with Chinese characteristics. They believe that teachers' professional development is a process in which teachers improve their professional awareness, knowledge and spirit through continuous professional learning, reflection on teaching practice, curriculum development and inquiry into the ways of teaching, so as to ultimately achieve excellent teaching that promote students' effective learning and their own life values. It is a process of professional growth in which the social environment, cultural and personal characteristics influence each other continuously (Su, 2015). The two major ways for teachers' professional development are school promotion and self-development. The former includes improving professional development system, setting up teacher's professional development institutions, implementing professional development programs, and improving teaching training (Yao, 2018).

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In the field of teacher professional development, self-directed learning theory has attracted increasing attention, and there is a general awareness that teacher professional development cannot only rely on conventional training programs and one-way indoctrination, but requires teachers' initiative, purpose, planning and systematic practice, as a result, teachers acquire knowledge, develop competencies and form values in practice. Self-directed learning was developed from adult education theory. Knowles, a leading adult educator, defines self-directed learning as "a personal spontaneously process with or without help of others, in which learners determine learning needs, form learning goals, identify human and physical learning resources, select and implement appropriate learning strategies, and finally assessment learning outcomes.". Self-directed learning transcends the limitations of traditional self-learning in terms of concept, meaning, approach, and process by integrating the external characteristics of being a teaching and learning process with the internal characteristics of being a learner who actively assuming responsibility for learning, combining independent learning with external support (Li, 2005). Self-directed learning emphasizes learners' development, implementation, evaluation and responsibility for learning programs, and it is important for promoting teachers' professional development.

At the same time, with the development of information technology, technology has become massively employed in teaching and learning in schools. There are more channels of access to teaching resources and more timely and convenient communication, which facilitates teachers' self-directed development. In the new era, how to promote teachers' self-needed, active and conscious development behaviors based on the concept of self-directed learning through information technology has important practical and theoretical values for promoting teachers' professional development and improving the quality of the teaching force. Therefore, this study discusses how faculty professional development platforms can support teachers' self-directed professional development through the construction and practice of a professional development support platform for teachers at A University.

2. DESIGN OF A SUPPORT PLATFORM FOR FACULTY PROFESSIONAL DEVELOPMENT AT A UNIVERSITY

Many colleges and universities at home and abroad have set up teachers' professional development centers, which are especially responsible for teachers’ professional development in their own universities and play an important role in strengthening teachers' awareness of professional development, enriching teaching knowledge and improving teaching ability, etc. However, the professional development of teachers in most colleges and universities still focuses on teaching training and consultation, lacking personalized attention to teachers' growth (Yan, 2019). At the same time, relating to the design and construction of the teacher professional development platform, the core idea is also to provide training courses for teachers, and promote teachers' professional development by providing them with online training courses. In addition, some universities build faculty information management systems to save, record, organize and analyze faculty information, and manage it scientifically (Tan, 2022), these kinds of platforms are often combined with teacher evaluations. However, these platforms, which singularly provide training courses for teachers or manage their teaching information, lack individualized attention to teacher growth and do not give full play to the potential of teachers' self-development.

Guided by the theory of self-directed learning, there are three key elements in the design of the professional development support platform for teachers at A University: First, it is teacher-oriented and respects the autonomy of teacher development. Unlike the fixed training program paradigm, the A University Teacher Professional Development Support Platform not only provides teachers with diverse teacher training programs, but also learning resources and materials for teachers’ professional development, opportunities for peer exchange and collaboration, and exploration of teaching laws. In addition to this, teachers have the right to choose their own matching resources and freely select their development path. Second, it emphasizes teachers' awareness and ability to self-reflect. Reflection is an inevitable requirement and a fundamental prerequisite for teachers' professional development. Teachers' self-directed learning is often directed at specific problems encountered in teaching practice, but the contextual nature, complexity, uncertainty, instability, and conflicting values of teaching practice make it impossible for teachers to solve practical problems directly by relying on or applying ready-made theory or book knowledge. They need to learn to critique pedagogical ideas, concepts and methods, to criticize and reflect on their own and others' theories, beliefs, words and practices, to remove

prejudices, limitations and barriers, and to explore and grasp the essence and methods of teaching and learning in order to effectively solve problems and make progress in learning (Li & Qin, 2006). The teacher's teaching portfolio is an important tool for teachers to reflect on their teaching. Therefore, in the design of A University platform, teachers' teaching reflection is promoted through the construction of teaching portfolios. Third, focus on collaborative peer development. Self-directed learning does not mean learning by oneself alone; it is one of the important ways of teachers' professional development and does not exclude collaborative learning and action research. Self-directed learning emphasizes the learner's flexibility, initiative and motivation to determine learning goals, content and methods according to his or her actual needs and time and conditions, but it also requires help, tutoring and support of others and the effective use of necessary human and material learning resources(Wang, 2009). The construction of an online community and the sharing and discussion of teaching portfolios have both facilitated and provided space for the collaborative development of faculty peers.

In summary, the A University teaching professional development support platform emphasizes teachers' independent choice, active reflection, personality development, and peer cooperation. The design framework is shown in Figure 1.

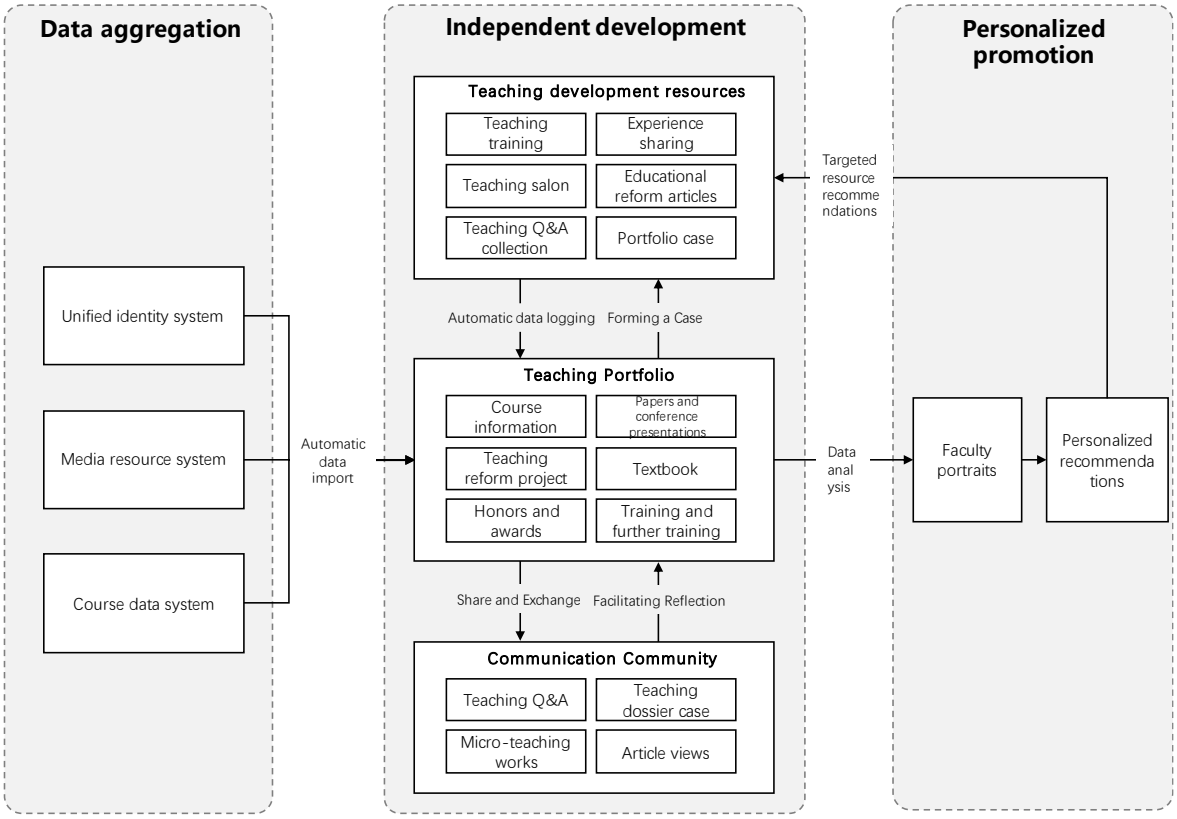

Figure 1. A teacher professional development platform design framework based on the theory of self-directed learning

1. Data aggregation

The data aggregation session involves multiple systems, mainly including:

1) the unified identity authentication system of A University, which is a management system for the basic personnel information and system authority of the whole school, including the teacher's job number, position, contact information, authority, etc., used for the information construction and management of the school.

2) The media resource system, in which there are instructional video recordings of all teachers in the school, as well as some featured courses, open courses and other video resources of some teachers. It is an important material reflecting teachers' teaching, and also the basic content of teachers' teaching portfolio.

3) Course data system, which contains the information of the whole faculty, including the time, location, target audience, and number of lectures offered. Through the data connection to these platforms, A University Professional Development Support Platform allows teachers to log in to the platform using unified identity authentication without registration, and for the automatic import of course information and media resource

information, it lays the data foundation for teachers' teaching portfolio construction and professional development activities.

2. Independent development

The independent development session is the core of the professional development support platform of A University, which mainly has three modules.

1) Professional development resources. In this module, the platform provides various teaching training projects for teachers' professional development, such as digital teaching & learning. At the same time, there are collections of teaching questions and answers, teaching experience sharing, teaching reform articles, and portfolio cases, etc. Of particular importance is that teachers' learning data from these resources on the platform are automatically recorded and become important data in the teaching portfolios.

2) Teaching Portfolio. Teaching portfolios can guide teachers to visually see their personal growth and progress and effectively promote their personal reflection (Yu & Feng, 2020). In the construction of the platform, the contents of the teaching portfolio include course information, papers and conference reports, teaching reform projects, teaching materials, honors and awards, training and further training, etc. Teaching portfolios play a vital role in teachers' professional development. They not only help teachers integrate teaching resources and record professional development data, but also serve as a basis for teachers' teaching reflection and peer exchange. Teachers can edit and share their teaching portfolios in the platform.

3) Communication Community. The teaching communication community provides online communication and sharing opportunities for teachers' professional development. According to teachers' learning needs, the columns in the platform community are divided into: teaching Q&A, teaching dossier cases, micro-teaching works, article views, etc. And the columns are adjusted and supplemented in real time according to the focus of teachers' attention.

3. Personalized recommendations

The personalized facilitation session is a support platform providing personalized services for teachers' personalized development. In this session, artificial intelligence algorithms such as machine learning need to be used to analyze teachers' professional development paths, which is one of the important application scenarios of educational artificial intelligence (Yang & Ren, 2021). By supporting teachers, the teacher professional development platform can collect and analyze various aspects of teacher development data, such as basic user data, topic preference data, learning path data, activity level data, interaction data, etc., thus building a multi-dimensional labeling system of teacher professional development portrait. This enables precise and effective support and services for teachers' professional development, such as recommending resources and activities that are of interest to teachers.

3. THE PRACTICE AND APPLICATION OF PROFESSIONAL DEVELOPMENT SUPPORT PLATFORM FOR TEACHERS AT A UNIVERSITY

The professional development platform of A University has features such as "aggregating teaching data, promoting teaching reflection, and forming a communication community" to support teachers' entire professional development process. In this way, we support teachers' self-directed learning by providing instructional development courses and resources, building teaching portfolios, and creating opportunities for peer collaboration, and provide personalized support for teachers' instructional development by painting a portrait of their professional development through big data analysis. Since the platform began to be built in 2022, in two years, the platform has made useful practices and achieved initial results in integrating faculty professional development programs, building teaching portfolios, and building online communities.

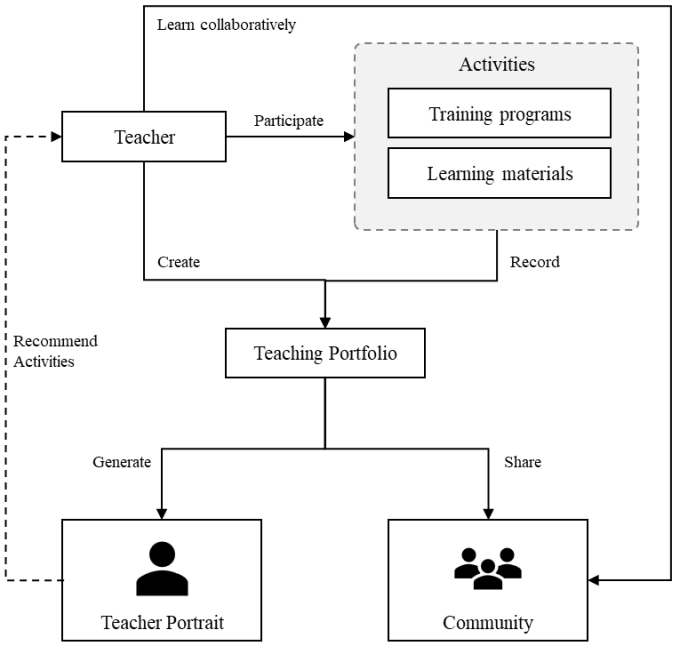

Figure 2. A personalized flow supporting teacher's professional development

3.1 Integrate Professional Development Programs to Support Individualized Development Paths

A University's teacher professional development platform integrates the university's programs and related resources for teacher professional development, where teachers can choose what they need and plan their own path to self-development.

First, it organizes teacher training with various themes. In response to the different development stages of BYU faculty and different development needs, different types and themes of training programs are provided on the platform, such as capacity enhancement training for new faculty members; internationalization training; academic writing training, etc. Training topics cover: innovation and evidence-based teaching, assessment of student learning outcomes and teaching, active learning and innovative teaching, Inclusive teaching and learning online, the future higher education and AI, what do we need from assessment in the post covid-19 era, etc. These trainings are offered on the platform each year for teachers across the school to attend freely. Front-line teachers can go to the platform and select the topics they need according to their teaching needs and learning goals. This is similar to an open learning platform where students can choose the courses they need to improve their learning ability and proficiency.

In addition to a wide variety of topics, the platform also provides teachers with multiple learning formats, for example, teachers can choose to attend training offline for learning, or participate online or watch playback videos, while the platform will also have documents provided by the lead teacher for downloading and learning. Teachers can choose the appropriate way to learn according to their time and preferences.

Through teachers' behavioral performance on the platform, this study found that: first, the number of young teachers who participated in the professional development program was absolutely dominant, which may be due to: 1) Young teachers are less experienced in teaching and are more likely to encounter problems in teaching, while the vast majority of young teachers do not have systematic training in teaching before they embark on their teaching positions, therefore, they have real needs for professional development. (2) Many universities have certain requirements for young teachers to participate in teaching training, for example, the "New Teacher Study Camp" of Southeast University and the "Honghu Academy" of Beijing Institute of Technology have requirements for the length or number of young teachers' participation. Second, teachers prefer the offline face-to-face learning format to self-learning through playback videos, and the platform can play a greater role in providing supplementary text and video materials.

Table 1. A summary of training topics on the platform

Training Topics	Object Oriented	Rounds	Number of people	Form
Improvement of teaching ability for new teachers	New teachers in our school	6	12,000	Offline + video replay
Midwest young faculty teaching skills enhancement	Midwest young teachers	1	2,000	Online live streaming + video replay
Cultivation of ideological and political model course	All teachers in our school	2	500	Online live streaming + video replay
PKU-MU professional development seminar	College teachers nationwide	2	1,000	Offline + video replay
Academic paper writing guide	College teachers nationwide	1	1,825	Online live streaming
Artificial intelligence to help build the teaching force	All teachers in our school	2	200	Offline
Digital and humanities	All teachers in our school	1	45	Offline

Second, the platform provides rich resources for teachers' training. Providing rich learning resources for teachers' professional development is an important foundation for promoting teachers' independent development. The teaching resources provided for teachers on A University's teacher professional development platform include a collection of common problems in teaching, excellent short videos shared by teachers, teaching ideas of outstanding teachers, teaching methods, teaching research papers, and teachers' teaching portfolios. These resources share the practices, experiences and achievements of outstanding teachers from different perspectives. For other teachers, they can play a good role in leading and modeling. Teachers can browse and download the learning resources they need on the platform independently for their own teaching scenarios, or they can share their achievements and insights and share resources with their peers.

3.2 Building Teaching Portfolios to Promote Reflection on Teaching

Teaching portfolios are an important tool to facilitate teachers' reflection on teaching. Nowdays in many countries such as US, UK and Canadia, teaching porflios is effective to help teachers' professional development (Wang, 2005). Institutions adopting teaching porfolios could profit from monitoring their development, implementation and impact (Burns, 1999). However we found in a survey that teachers were unfamiliar with the concept of teaching portfolios, as shown in the figure. This has brought about a lack of motivation and a lack of mastery of the construction methods by teachers to build teaching portfolios. For this reason, we also provide guidance and support to teachers in building teaching portfolios by organizing seminars. In the construction of the teacher professional development platform, we reduce the workload and technical threshold for teachers to build teaching portfolios by automatically integrating data on teacher development in through technical support. While automatically integrating data, we also support teachers to build and form teaching portfolios on their own to support their self-directed development. For example, teachers' activities on the professional development support platform automatically generate some of the process data of professional development, and the platform accumulates these data in an organized and purposeful way to help teachers form the prototype of a teaching portfolio. The platform not only allows teachers to choose their own resources and activities for professional development, but also provides them with an objective and comprehensive understanding of their teaching professional development process and helps them to conduct evidence-based reflection on their teaching.

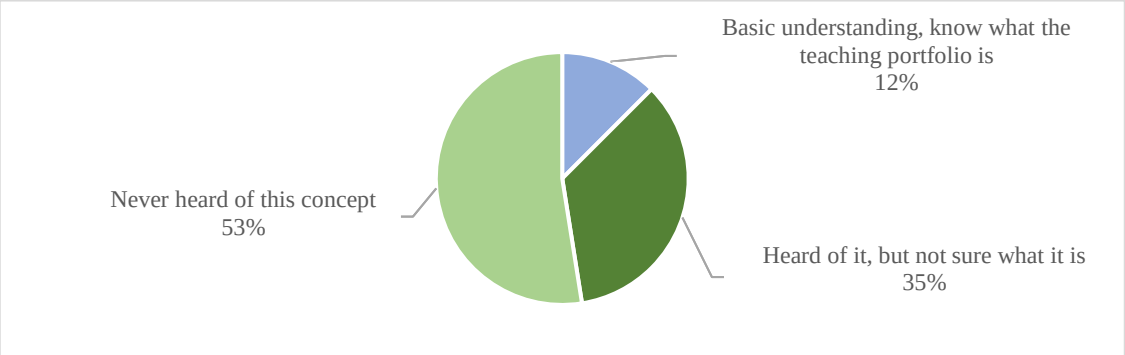

Figure 3. A survey of the familiarity of teaching portfolios

At present, A University teachers organize their teaching resources and reflect on their teaching based on the framework of teachers' teaching portfolios on the platform and have formed teaching portfolios with different content focus. For example, through the construction of the curriculum thinking and politics teaching portfolios, teachers have been able to deeply explore and refine the ideological values and spiritual connotations contained in the knowledge system of the curriculum, refine the elements of curriculum thinking and politics, and build a portfolio with curriculum thinking and politics as the core. The project has been in progress for one year since the start of the Curriculum Civics Cultivation Project at A University in 2021, and more than 120 Curriculum Civics portfolios have been built on the platform. Some teachers have also reflected deeply on how to use digital and artificial intelligence technologies to improve teaching in the course of teaching through the construction of teaching portfolios, and have built and formed cases of teaching portfolios with technology boosting course improvement.

3.3 Create a Profile of Professional Development and Recommend Resources

User profiling is a tool for profiling and analyzing the behavioral characteristics of users by extracting data tags. Through the establishment of profiling models, users' personalized needs can be effectively explored and matched with accurate service resources. As an effective tool to profile target users and improve decision-making efficiency, user profiling is widely used in many fields (Zhang, 2020). Teachers' professional development support platform can record the whole process of teachers' professional development behaviors, such as teachers' preference for training topics, their choice of learning formats, their activity in sharing and communication, and the teaching practice issues they are concerned about. Through the analysis of teachers' behaviors on the platform, teachers' professional development paths and portraits can be formed.

The platform diagnoses and plans teachers' professional development based on their professional development profiles, and provides more targeted resource recommendations (including training activities, articles, resources, etc.). At the same time, teachers can also get their own professional development radar chart to help them objectively and comprehensively understand the characteristics in their teaching professional development, and then better plan their teaching professional development.

3.4 Build an Online Communication Community to Form a Learning Community

Connectivism, as the guiding ideology of learning in the form of Internet education, believes that knowledge circulates in the interaction between people, and that everyone is both a contributor and a transmitter of knowledge(Goldie, 2016). As a platform to support teachers' professional development, it also provides a community of information sharing and crowdsourcing for teachers' learning that is not dependent on temporal and social relationships. In this online community, learners contribute knowledge together, forming collective perspectives and enhancing individual learner development in a network collision(Qin & Zheng, 2020).

The role of the teaching professional development support platform in community building is firstly to meet different teachers' professional development needs. For teachers needing practice-reflections, the platform supports the teachers to accumulate information about their practice and reflective writing in private personal teaching portfolios; for teachers with ecological orientation, the platform provides social functions such as posting topics, leaving comments and sharing. The teacher professional development platform supports teachers' self-directed development not only by providing resources, but also by building and forming online learning communities and providing opportunities for teachers' peer collaboration to exchange and cooperate. Self-directed learning emphasizes learners' self-management, self-regulation, self-evaluation, and responsibility for learning, but this is not the only way teachers develop professionally; teachers also need to engage in collaborative learning, inquiry learning, and other-directed learning in the process of professional development. Learning communities are therefore an important support to help teachers seek cooperation and solve problems by sharing knowledge, experience, materials, and resources among teachers in order to promote the improvement of teaching ability and professional development of individual teachers and teacher groups. Based on the learning common learning body, peers can discuss teaching confusion together and seek expert guidance for answering questions.

Although from a connectionist perspective, communities are not primarily knowledge-generating; knowledge and content are primarily generated by the participants in the community, however, in the initial stage of community development, in order to strengthen the interaction among teachers and guide them to think about teaching methods and practices from different perspectives such as theory, practice, and culture, the construction of the community is also interconnected with the pedagogical development project module in the platform. For example, if teachers are involved in a particular topic of teaching and training, they can further explore and share resources on that topic in the community. At the same time, in the community, teachers can find partners with common learning characteristics and content preferences.

4. CONCLUSION

The construction of the professional development support platform for teachers at A University has been at the forefront in China, supporting teachers' independent development by providing them with rich professional development resources and focusing on teachers' active reflection and peer collaboration on teaching at the same time. To summarize this round of research, we believe that the construction of a teacher professional development platform under the concept of self-directed learning is a continuous development process, and the accumulation and integration of data is the key to forming a portrait of teachers' professional development and an important foundation for the platform to provide accurate services to teachers. While students' behavioral performance and mastery of knowledge in a course are relatively concentrated within a single scope, teachers' pedagogical development is a long-term process that spans their entire professional development journey, so the construction of a teacher professional development platform requires greater integration and completeness of data. And this is the primary challenge in building a teacher professional development platform, especially one that is to support teachers' self-directed development. Secondly, at the early stage of online teaching community construction, teachers are often not highly motivated to participate, so they need to be motivated to take the initiative to share resources and wisdom in the community, and gradually form a community with scale after a period of popularity gathering, in order to better play the role of contributing knowledge and producing knowledge together in the community.

Taking the support platform for teachers' teaching professional development at A University as an example, this paper systematically elaborates the design ideas and implementation of the platform construction under the concept of self-direction, and analyzes the value and challenges of each construction module, hoping to provide some thoughts and inspiration for the construction of the platform and teachers' professional development.

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SUSTAINING STUDENT WELLNESS THROUGH THE DEVELOPMENT OF A MOBILE APP FOR BALANCED STUDENT LIFE: THE "MY VIRTUE" PROJECT

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ABSTRACT

The global COVID-19 pandemic has boosted mental health issues among students worldwide. Many education systems were interrupted due to lockdown and limited business operations hours. Eventually, the pandemic put a halt to the progression toward the fourth sustainable development goal as high cases of depression and anxiety were reported by many institutions, which led to low academic performance and quality. This is due to limited self-service support, such as mobile or web apps provided by the university to the students. Thus, to achieve quality academic, wellness, and moral excellence among students, this study intends to develop a mobile app that would shape a balanced person through humanistic education. This paper will discuss the findings of usability analysis from the "My Virtue" project, which aims to develop and validate a mobile app for students from an international university. A total of 120 students participated in the pilot study, in which they were given opportunities to view and provide feedback based on the mobile app mock-up. The mock-up was designed based on the findings from a literature review. The mobile app is intended to record and evaluate students' performance in their education, physical, emotional, social, and nutrition. According to the data analysis and findings, the degree of agreement of students towards the usability of the mobile app features is high. This is in line with students' agreements on mobile app ability to promote balanced graduates and humanistic education. These results indicate that the "My Virtue" mobile app has the potential to improve students' wellness and humanistic qualities to achieve a balance student life. However, this study might be confirmed by the project's next stage, which focuses on validating the effectiveness of improving students' wellness and achievements.

KEYWORDS

Mobile App, Humanistic Education, Wellness, Balance Student Life

1. INTRODUCTION

The global sustainable development goals (SDG) were introduced by United Nations (United Nations, 2015). It is a global affair to transform the world through 17 SDGs. The Sustainable Development Report 2021 indicates the decline in education progression towards the fourth SDG (United Nations, 2021) due to the global lockdown in 2020. Covid-19 has impacted education systems, quality, and student learning progress. Furthermore, the pandemic has also contributed to the rise of mental health issues among students. However, there is a light for e-learning as an opportunity to expand widely across the globe. Even though e-learning has been the leading platform to pursue students learning progress, some parts of the world are unable to access e-learning due to their location, ability to own a device, limited network connections, and lack of technology infrastructure. This is contradicted with the goal of the fourth SDG due to inequalities in access to education and failure to sustain education quality.

In 2022, the Sustainable Development Report 2022 pointed out that there is a growing gap between health and education outcomes among different countries due to inequity in access to essential services (Sachs et al., 2-22). In addition, another Sustainable Development Report by the United Nations indicates that Covid-19 has caused a lower quality of learning outcomes (United Nations, 2022). Although education institutions started to re-open in, mental health and psychosocial support for students have still been neglected by some institutions (United Nations, 2022; Childs et al., 2022). Still, some international universities, such as Boston University, Curtin University, Harvard University, and International Islamic University Malaysia, to name a few, have established counselling centres and implemented health education programs to support students' well-being.

The impact of the pandemic may have a more prolonged effect on students' wellness due to limited movement and social distancing.

For this reason, to achieve SDG on providing quality education, health, and well-being, it is crucial to deliver support and awareness on developing healthy lifestyles that improve students' wellness and achievements. Many wellness dimensions were published since wellness refers to the status of a person's emotions, intelligence, spiritual, body, and social attributes (Kirsten, 2009). In this project, wellness is defined as a way to monitor students' education, physical, emotional, social, and nutrition.

Undoubtedly, many students are equipped with mobile devices now that e-learning is the panacea for delivering education. Many health mobile apps are available in the Apple store and Google Play. Nevertheless, none or a few mobile apps were designed to balance student life. Even with numerous mental health apps available in the Apple (Apple) and Android online stores (Google Play), a few innovative mobile app features have been overlooked in mental health apps, including mixed reality and artificial intelligence. The most common features of a health assessment mobile apps are personal records, health history, dietary, disease, weight loss program, meditations, physical exercises, healthy food recipes, menstrual cycle, ad sleep management (RMIT University, Ward, 2022, Forbes, 2022). The is no or limited mobile app that records both education and wellness to promote a balanced life. Self-reflection on learning and healthy achievements and self-monitoring on daily activities intended to assist students in gaining awareness of personal wellness.

Since the gap between the student's health and education continues to grow, there is a need for a service that serves the students to enrich their wellness. This project aims to design and develop a mobile app called "My Virtue", which intends to support students' health and deliver knowledge on morality, ethics, values, and wellness to enhance their human qualities.

2. METHODS

2.1 Research Design

The research design for this "My Virtue" mobile app project is outlined in Figure 1 below. Firstly, literature reviews on wellness, sustainable development goals, progress on quality education and good well-being objectives, existing mobile applications, and higher education reports. At this point, a research gap between students' health and education was identified. Next, a mock-up of the mobile app interface was designed to monitor student wellness in the aspects of education pillars, physical fitness, emotional health, social connectivity, and nutrition. Furthermore, the faculty can monitor their students' health conditions based on activity reports. This feature could allow the university to be aware of their student's health, which may affect their learning performance. The perspective from the university will be presented in a separate publication.

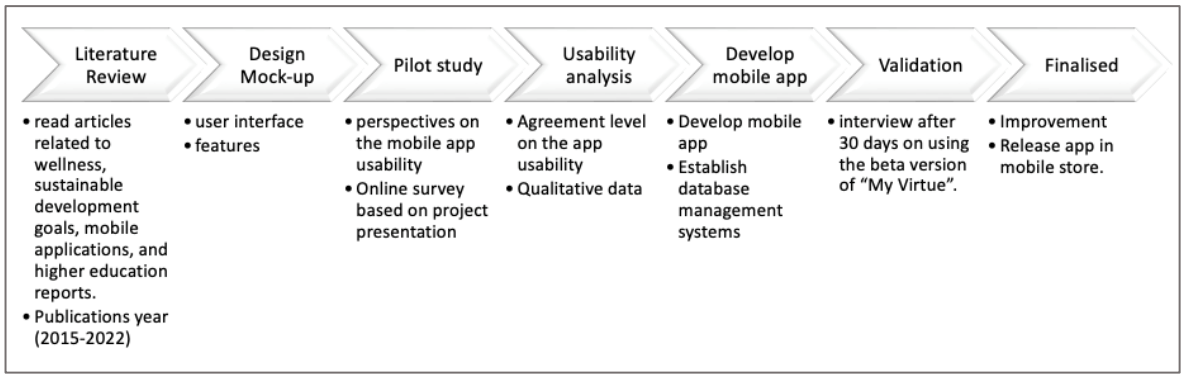

Figure 1. Summary of "My Virtue" mobile app project stages

A pilot study on 120 students was conducted to gain the students' perspectives on the usability of the mobile app. Implementing usability analysis before the mobile app development allows the developer to ensure that the mobile app is helpful to the students and identify any particular features to meet user expectations (CLA; Sniegula & Glinka, 2017). These students were invited to participate voluntarily to attend the project presentation that explained the project objectives and the significant contributions of the "My Virtue" mobile app. After the presentation, a consent form was distributed to the participants who agreed to participate prior to taking the online survey. This paper consists of a report on the usability analysis for the "My Virtue" mobile app. Further development of this project will be published in a future article.

2.2 Design of the Mock-Up

Once the essential elements of student wellness were identified, the development of the mobile app started with the mock-up design of the user interface (see Figure 2). The mock-up design represents some of the features that allow users to log their learning achievements based on the education pillars (Nan-Zhao, 2006, Sobe, 2021).

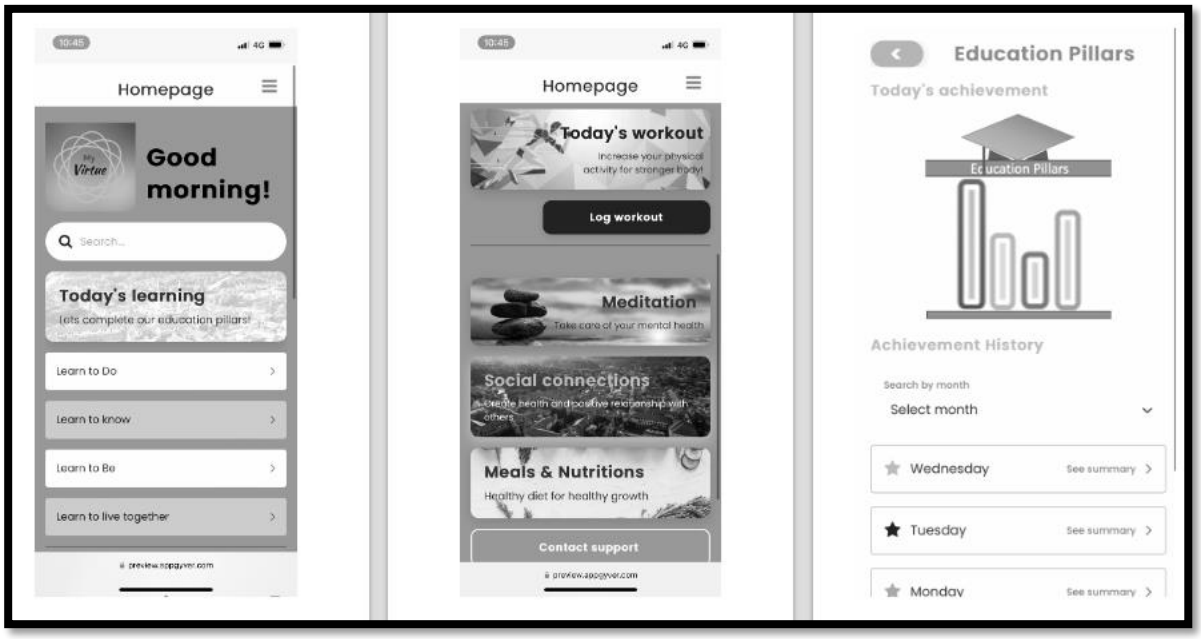

Figure 2. Screenshots of the "My Virtue" mobile app that showed some of the app features

Not only designing the mock-up but also drafts of data and function modelling such as system flowcharts, data flow diagrams, and use cases were produced to prepare the system's data, inputs, process, and outputs (Vasilyev et al., 2020; Lupanda & van Rensburg, 2021; Jarvis Alka et al., 2022). his project will use Firebase as a back-end database due to effective data control. n the other hand, the front-end design used the Appgyver platform, which recently partnered with the System Applications and Products (SAP) company (Lehtimaki, 2021). This platform was used due to hioptimisationion on React Native apps which allows the developer to design based on all device capabilities and fast access to the Application Programming Interface (API) integration.

2.3 Usability Evaluation

The link to the online survey was given to the participants after the project was showcased. Some of the survey questions from previous studies on mobile app development were used to improve the survey questionnaires and avoid irrelevant questions. The online survey consists of 15 statements that covered the concern about the usability of the mobile- app. Five Likert scales were used to indicate participants' level of agreement. The survey data were analyzed using SPSS software for descriptive data findings.

3. RESULTS

The pilot study was conducted on 120 university students in Malaysia. Only students who agreed to participate in the project and filled out the consent form had access to the online survey. All 120 surveys are valid since all questions were answered completely. The sample population for the pilot study survey are shown in Table 1 below.

Table 1. Characteristics of the sample from the pilot study

Characteristic	Sub-characteristic	Frequency (%)
Gender	Female	46.7
	Male	53.3
Age	18-20	2.5
	21-25	25
	26-30	72.5
	Above 30	0
Student type	Local	60.8
	International	39.2
Device owns	None	0
	Mobile	86.7
	Mobile phones & Tablet	13.3
Years of experience in using mobile apps	Never	0
	A year to 5 years	75.8
	More than five years	24.2

Referring to the descriptive analysis in Table 1, all participants own a mobile device and have experience using mobile apps. Thus, the participant's responses to the 15 usability statements were considered justifiable due to their experience in using the mobile app.

3.1 Usability of "My Virtue" Mobile App

Based on the descriptive analysis, the Cronbach value was 0.802 which indicates a good level of internal consistency that indicates the data is reliable based on the George and Mallery rule of thumb (George & Mallery, 2003). Since user participation is essential in a system development process (Issa and Isaias, 2022a), the results highlight the user participants' agreement score on the 15 usability statements presented in Table 2 below. The findings indicate that the usability of the mobile app seemed good based on the overall agreement was strong, as highlighted by an average score of 4.5.

Table 2. Level of agreement with the "My Virtue" mobile app usability statements

	Questions	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Score
1.	I like the design of the user interface.	-	-	12	69	39	4.2 (0.6)
2.	The information was categorized and easy to navigate.	-	-	2	21	97	4.8 (0.4)
3.	The app would be useful for my health.	-	2	16	44	58	4.3 (0.8)
4.	The app would be useful for creating a balanced life.	-	-	4	53	63	4.5 (0.6)
5.	The app would enrich my food nutrition intake.	-	3	11	49	57	4.3 (0.7)
6.	The app would increase my social interactions.	-	6	19	42	53	4.2 (0.9)
7.	The app could educate and train me to become a sustainable person (e.g., good health and well-being, eating clean, keep learning).	-	-	14	44	62	4.4 (0.7)
8.	The features of the app could improve my learning performance.	-	1	15	55	49	4.3 (0.7)
9.	The "Education Pillars" feature could improve my education quality.	-	-	1	34	85	4.7 (0.5)
10.	I would use the app to improve my wellness.	-	-	5	30	85	4.7 (0.6)
11.	I would use the app to improve my mental health.	-	-	37	32	51	4.4 (0.7)
12.	I believe this app will support self-care among students.	-	-	5	30	85	4.7(0.6)
13.	I believe this app could promote humanised education through health & wellness support.	-	-	15	33	72	4.5 (0.7)
14.	I believe this app could make me a balanced graduate.	-	-	7	36	77	4.6 (0.6)
15.	I would recommend this app to others when it is released.	-	-	6	40	74	4.6 (0.6)

The result demonstrated that the highest score on participants' agreement was on the ease of navigation and information management. This significant finding indicates that the design of the "My Virtue" mobile app is aligned with sustainability practices in the context of navigation (Issa and Isaias, 2022b) that meets users' needs. Also, the score for agreements on the "My Virtue" mobile app offers easy navigation and the ability to improve user learning outcomes, health, and wellness have provided evidence for the criteria for health app assessment outlined by the government of the United Kingdom (Public Health of England, 2017). The lowest score referred to the user interface and social limitations. Since the participants only view the mock-up instead of the finished product, limited experiences with the overall design have impacted the result of the user interface. "My Virtue" is a mobile app that collects information on learning outcomes and physical activities, promoting social engagement maybe be limited. Thus, to promote social wellness to support a healthy community lifestyle (Nugent, 2013, Boratto et al., 2017), a community engagement feature will be introduced to allow users to support each other wellness.

Looking at the score for the 15 usability statements, most of the participants strongly agreed that the "My Virtue" mobile app would enrich their wellness towards a sustainable lifestyle. As stated by Burns et al. (2010), the use of mobile health technology to promote mental health among young adults is essential. Thus, the "My Virtue" mobile app could become an essential platform that supports self-care among students and achieves different goals for academic, health, and personal development. Despite the potential of the "My Virtue" mobile app to promote self-care among students, it also intends to support the university in evaluating students' wellness and develop balanced graduates. In line with the Mobile App Rating Scale (MARS) that measures the quality of mobile health apps (Stoyanov et al., 2015), "My Virtue" mobile app ratings satisfied the acceptability and usability. Furthermore, questions on functionality, engagement, and outcomes were asked to evaluate the usability as recommended by Dawson et al. (2020) to evaluate the mobile app for research.

4. CONCLUSION

Since the pandemic and low education performance have indeed flagged the vulnerability of students' health support, the mobile app will give students access to wellness supports toward a balanced life. Based on the pilot study, the participants found that the mobile app would be useful to the students in improving their quality of life. Clearly, the digital world has increased mobile app development since it enhances user productivity and education. The purpose of the "My Virtue" mobile app is to support the Sustainable Development Goals (SDG), specifically towards good health and well-being (Third SDG) and quality education (Fourth SDG). Consequently, the use of the mobile app will promote sustainable communities (Eleventh SDG), where the community practices a healthy lifestyle. Unlike many health app assessments, "My Virtue" mobile app records both education and wellness to develop a balanced graduate. Instead of focusing only on academic achievements for the future economy and industry development, the "My Virtue" mobile app delivers wellness education that intends to promote humanistic education while supporting students' mental health for their academic performance.

Based on the findings, additional feature on community engagement will be added to support healthy university community lifestyle. Thus, the completed "My Virtue" mobile app will offer features such as workout, rest, and self-reflection logs, motivational quotes, wellness progression, community engagement, meals and nutrition facts, and education achievements that would provide a significant contribution to creating a balance and sustainable student life. This will be done in the next phase of the "My Virtue" mobile app project, which will later be validated by experts in health, education, and nutrition. However, financial management or related activities were not considered due to increased cybercrime concerns. Additionally, the promotion of human qualities through community engagement and humanistic education delivered by the mobile app would improve the sustainability and lifelong wellness lifestyle among the university community. In the future, the mobile app could improve the university environment and the quality of education. This mobile app project could also be useful for other groups of users while promoting lifelong learning and wellness.

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PHYTOREMEDIATION AS NATURE-BASED SOLUTION IN TERRITORIES OF SOCIO-SPATIAL AND ENVIRONMENTAL FRAGILITY: GUARAPIRANGA NAUTICAL SPORT CLUB CASE STUDY

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ABSTRACT

This paper intends to expose the results of a research that proposes phytoremediation of sewage by Evapotranspiration Tanks, as Nature-based Solution (NbS), in a significant equipment — the Guarapiranga Nautical Sport Club in Jardim Ângela, São Paulo —, whose territory is located in the area of legal watershed protection, characterized by insufficient sanitation and informal housing. This Club, very frequented by local residents, has sewage sanitation problems, which can affect the Guarapiranga Reservoir, to which the Club is adjacent. This problem is recurrent in the region, occupied by low-income population. The methodology was guided by the critical investigation of bibliographic and documentary references of Nature-based Solutions, phytoremediation systems and urban-regional characteristics of Jardim Ângela. Tests were conducted to implement Evapotranspiration Tanks in the restaurant and social lounge of the clubhouse building of the sports complex. The study case pretends to subsidize inputs for its replicability in similar situations of need or emergency. It is considered that this research can contribute to future feasibility and community reverberation as an example in environmental education processes, due to its replicability power for sewage sanitation in situations of need or emergency, similar to the Club and its territory of influence.

KEYWORDS

Nature-based Solutions, Sewage phytoremediation, Jardim Ângela, Sao Paulo, Brazil, Guarapiranga Nautical Sport Club, Urban Peripheries, Environmental protection areas

1. INTRODUCTION

This paper presents the results of a research that investigated the possibilities of phytoremediation as a Nature-based Solution (NbS) for sewage sanitation, having as a case study a significant equipment, which can subsidize inputs for its replicability in the territory — the Guarapiranga Nautical Sport Club, in Jardim Ângela, in the southern region of the city of Sao Paulo. The technique chosen for the case study was that of Evaporation Tanks, given their safety in terms of proximity to people and use, as well as reduced implementation costs and operational ease. These Evaporations Tanks were applied to the social lounge and the restaurant of the clubhouse building. This investigation is justified by the situation of deficiency or complete absence of sewage sanitation that affects a large part of the peripheral areas of the municipality of Sao Paulo, whose problem is aggravated in the south region as it is an area of watershed protection of the Guarapiranga and Billings dams.

The work is part of the inquiry of a Research Group that seeks, through successive studies, to propose solutions to the urgent problem of sewage sanitation, in processes that can lead to participatory socio-environmental education and future concrete achievements, in a systemic way. This effort is aimed at operating articulations between the academia and communities, including the voluntary and constant activity of one of the authors in popular Forums in the region of the case study. It is understood that the research is conducted in a reference equipment for the community and for this reason it may constitute a replicable pilot.

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2. THE GUARAPIRANGA NAUTICAL SPOT CLUB AS A CASE STUDY

Jardim Ângela is a district in the south of the city of Sao Paulo, characterized by great socio-spatial and environmental vulnerability, which houses the Guarapiranga Nautical Sport Club, in its southernmost territory, better known as "The Deep of Jardim Ângela (Fundão do Jardim Ângela)". The Guarapiranga Nautical Sport Club, very frequented by the locals, also presents problems with sewage sanitation, which can affect the Guarapiranga Dam, to which the Club is contiguous (Figure 1). This problem is recurrent in the region, occupied by a population of low income, without adequate provision of infrastructure, equipment, and qualified public spaces. Although there is a pumping station of the state concessionaire that must direct the effluents to the Barueri Sewage Treatment Station, it is verified that the distance of this Station is approximately 50 km from the region, and that there are recurring problems with the operation and maintenance of this pumping station. In addition to this, the Club is located at a lower level that the aforementioned pumping station, which makes it impossible to direct its effluents to it by gravity, as is the case of the settlements in its surroundings. This fact is aggravated by the great contingency of informality in these houses, which do not include its regularized land and possession, which prevents the provision of basic sanitation by the state for the most part of them (Aceituno et al., 2016; Begiato et al., 2017; Silva and Luz, 2019).

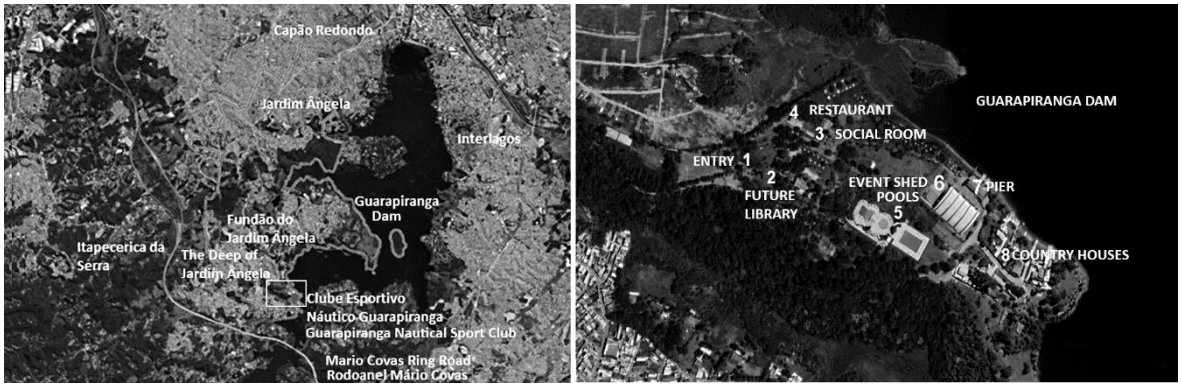

Figure 1. Left: "The Deep of Jardim Ângela" (Fundão do Jardim Ângela). Right: Guarapiranga Nautical Sport Club
Source: Google Earth with author's notes

2.1 The Phytoremediation as a Technique

Sewage phytoremediation comprises a range of possibilities of effluent treatment techniques using plants. These techniques can contribute to the decontamination of the water to be returned to the spring, and in the case of this territory, the possibility of applicability and management can be observed, as there is around 30% of open areas, subject to reforestation according to the Atlantic Forest biome, installation of community gardens, as well as the phytoremediation systems, as proposed in other inquiries of our Research Group (Aceituno et al., 2016; Begiato et al., 2017; Silva and Luz, 2019). In the system of Evapotranspiration Tank (TEVAP), the return of the treated water to the environment is guaranteed by the transpiration of steam by the leaves of the plants used, which are also fed by the nutrients in the biological chain involved (Winblad and Simpson-Hérbert, 2004 cited in Silva and Luz, 2019; Galbiati, 2009). The treatment of effluents is done from microbial degradations that occur in the reception chamber and in the granular substrates, with processes of anaerobic digestions of organic matter. These processes are carried out in three steps: hydrolysis of complex organic compounds; the production of acids (acidogenesis, acetogenesis); and the production of methane. In this way, as the effluents accumulate in the Evapotranspiration Tank, the liquid ascends to the upper layers with less granularity, until it reaches the roots of the plants, which feed on nutrients and minerals resulting from the decomposition of organic matter carried out by the bacteria in the system. Finally, the leaves of the plants finish the process by the evapotranspiration of the water involved, absorbing nutrients as components of their biomass (Galbiati, 2009; Pamplona and Venturi, 2004; Vieira, 2010). The construction of an Evapotranspiration Tank is made in stages. The first step is the excavation of the space to be occupied by the system since it generally works by gravity. Next, the construction of the containment and isolation box of the

system from the outside is preceded. This can be done in several ways, like reinforced mortar, concrete base and concrete masonry blocks with coating mortar waterproofed with additives and, preferably, a layer of waterproofing film or canvas on the sides and on the lower base. In some cases, only a waterproofing blanket of compatible resistance is applied.

After the formation of the containment box, successive layers are applied. First, the anaerobic chamber is installed, which can be composed, in a simplified way, by in-line tires and ceramic or other adherent materials. In industrial processes, this chamber could be executed in different prefabrication systems. As a conjecture, this research allows the premise of associating the problem of disposal of solid waste from civil construction and, for example, plastic waste, which could replace the tire tube, if shaped by recycling in relatively simple manufactures, generating income for the residents, similarly to what was encouraged by the socio-environmental militant group Precious Plastic (no date) initially conceived by Dave Hakkens, which carries out pedagogical processes for the dissemination of knowledge in needy communities around the world, for the use of plastic waste, providing properness and environmental balance. After the installation of the inlet pipes, of the inspection ducts regularly distributed, the Tank receives layers of filtering material, from bottom to top, with larger to smaller granulometries, such as gravel and sand. After the filtering layers, the substrate for planting is applied on top. After the plants are installed, it must be applied a layer of straw or dry foliage to prevent the percolation of rainwater inside the Tank. Minute details are important, such as the slightly convex shape of the ground surface for rainwater runoff as well as providing upper edges above the external ground level, for proper sealing (Monteiro, 2015; Vieira, 2010).

2.2 The Natured-Based Solutions as a Comprehensive Precept

The socio-territorial situation of Jardim Ângela can be considered opportune to what is recommended as Nature-Based Solutions (NbS) by the United Nations (United Nations World Water Assessment Programme, 2018) for water management and also by the International Union for Conservation of Nature and Natural Resources (IUCN) (2016), which was concerned with establishing efficiency standards (International Union for Conservation of Nature and Natural Resources, 2020). The NbS are indicated for various infrastructure systems, in the sense of protection, restoration and management of urban, peri-urban and rural territories, including water bodies and sewage sanitation, among others. The NbS were included in the IUCN Global Program 2013-2016, as a key piece, considering their importance for mitigation and adaptation to the impacts of climate change and disaster risk prevention, reinforcing their inclusion in the 2017-2020 Program, as a starting point. During the World Conservation Congress held in Hawaii, USA, between 1 and 10 September 2016, the IUCN began to adopt a definition for the NbS and corresponding principles, seeking to inform governmental and civil society strategies and financing, considering the NbS as an important tool for sustainable development. The definition proposed by the IUCN (2016) is formulated as follows: Nature-based Solutions are defined as “actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (International Union for Conservation of Nature and Natural Resources, 2016, p. 1). According to the IUCN (2020), the NbS, having as a precept the human well-being and benefits to biodiversity simultaneously, are intended, specifically in ecosystem-based approaches, to: protection; issue-specific; infrastructure; management and restoration, and, with respect to social challenges: mitigation and adaptation to climate change; disaster risk reduction; ecosystem degradation and biodiversity loss; food security; human heath; social and economic development and water security, and multiple benefits to economic and social development (International Union for Conservation of Nature and Natural Resources, 2020, pp. 1-3)
(Figure 2).

A Nature-based Solution can imply the conservation or rehabilitation of ecosystems and/or improving the creation of natural processes in artificial ecosystems (United Nations Educational, Scientific and Cultural Organization, 2018). It has the potential to promote environmental, social and economic benefits, such as low-impact and low-cost infrastructure possibilities. According to UNESCO (United Nations Educational, Scientific and Cultural Organization, 2018), NbS encourage greater resource efficiency to reduce waste, through reuse or recycling and avoid contamination. The NbS are also linked to the concepts of green growth, which promote the sustainable use of natural resources and the use of natural processes to sustain economies (United Nations Educational, Scientific and Cultural Organization, 2018). The World Water Development Report 2018: Nature based Solutions for Water (United Nations World Water Assessment Programme, 2018)

attests that biodiversity plays a key role within NbS, as it is the basis of ecosystem processes and functions and taht the supply of water in NbS is directly linked to precipitation, humidity, storage, infiltration and water transmission, therefore they depend on these aspects, so that water is available for human needs. According to this report, NbS support a circular economy that promotes greater resource productivity in order to reduce waste and avoid contamination, through reuse and recycling in restorative and regenerative processes, in contrast to the linear economy (United Nations World Water Assessment Programme, 2018).

The phytoremediation of sewage — scope of this research —, can therefore be considered among the systems and processes of NbS. In the case study of sanitation at Guarapiranga Nautical Sport Club, given its socio-territorial importance, it covers an important scale with respect to the population involved and the condition of insertion in an area of environmental protection, bearing in mind, at the same time, its potential for reverberation as an example of environmental education for the community, what is been discussed by the participation of one of the authors in community forums.

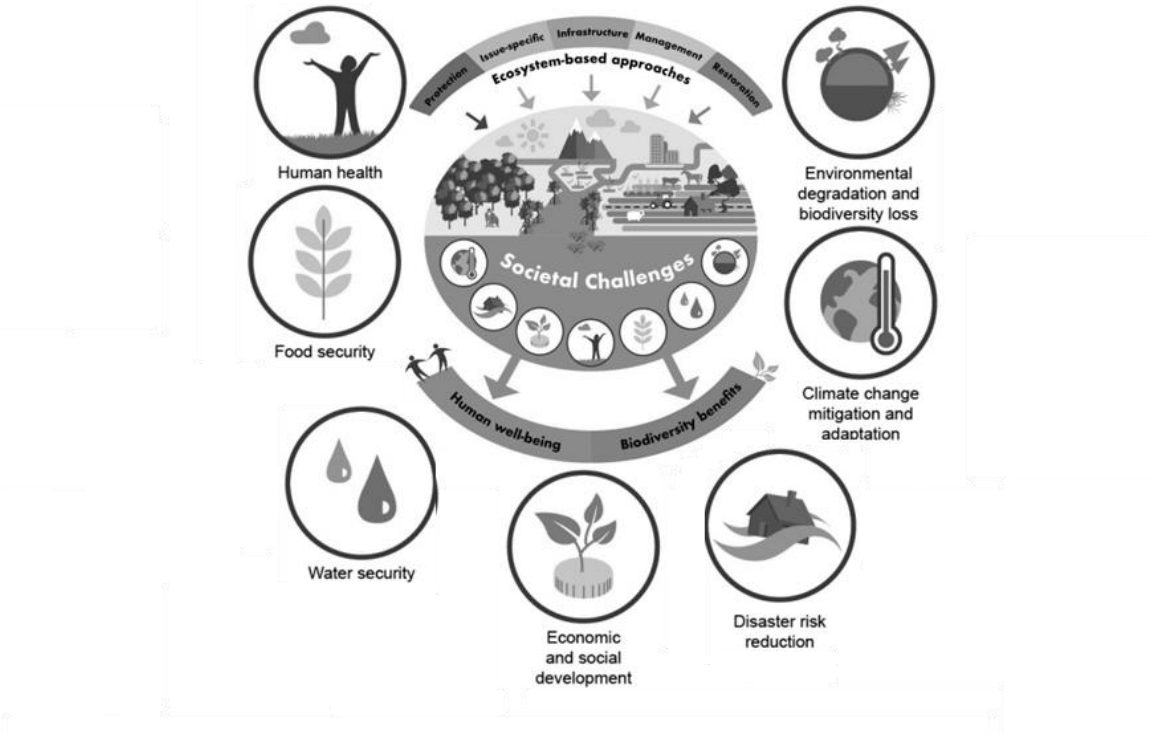

Figure 2. Scheme of the definition of NbS and its main social challenges. Source: Adapted from International Union for Conservation of Nature and Natural Resources, 2020, pp. 1-7

2.3 Case Study of the Phytoremediation Tank: Dimensions and Insertion on the Terrain

2.3.1 Capacity

The parameters for calculating the capacity maximum, for available area in meeting places, recommends 0.4 m²/person in sectors for standing public and 1.00 m²/person in sectors for sitting public, according to Code of Buildings (Prefeitura Municipal de São Paulo, 2017) and to the Brazilian Standard NBR 9077 ((Associação Brasileira de Normas Técnicas, 2001). The NBR 9077 describes the rates as: 2 persons/m² for public meeting places in social clubs and 1 person/m² in places for meals, what constitutes an analogy. With respect to the clubhouse building of the Guarapiranga Nautical Sport Club it is verified that both values coincide for the restaurant, that is, 1m²/person or 1 person/m². In the case of the social lounge, the least favorable rate is 2 persons/m² (which proportionately amounts to 0.5m²/person). This rate of 2 persons/m² was adopted as the most indicated. The restaurant area corresponds to 226m² and the social lounge area is 250.25m².

Since the use of these places would be hypothetically crowded only on weekends, with occasional use on weekdays, we established the following proportion as the average to be used for the purpose of calculating the average number of users per day (N): Saturdays and Sundays (2 days/full capacity); from Monday to Friday (5 days/ 25% of the capacity). Thus, for the restaurant, the following formula will be used:

N = {[(2 days x 1person/m²) + (5days x 1person/m² x 25%)] x restaurant's public use area} ÷ 7

And, for the Social Lounge, we have the following formula:

N = {[(2 days x 2persons/m²) + (5days x 2persons/m² x 25%)] x Social Lounge use area} ÷ 7

Substituting the values in the formula above, we have the number of users:

Restaurant — 105 persons or users per day and Social Lounge — 233 persons or users per day.

2.3.2 Flow Rate

According to Brazilian Standard NBR 13969 (Associação Brasileira de Normas Técnicas, 1997, p. 7), the daily contribution of sewage effluent (Qd) and the organic load by type of building and occupants establishes the values of 25 liters/day (corresponding to 25 g($DBO_{5,20}$/day) for restaurants and 50 liters/day (corresponding to 20 g$DBO_{5,20}$/day) for public and commercial buildings or day schools and long-stay places, which is consistent with the case of the social lounge.

To calculate the total flow (Q_t) (in liters/day), the average number of users per day (N) is multiplied by the daily discharge contribution of sewage effluent (Q_d) (in liters x user/day), that is:

$Q_t = N \times Q_d$

Substituting the values in the formula above, we have the following total flows per day:

Social Lounge — 5825 liters/day and Restaurant — 2625 liters/day.

2.3.3 Evaporation Tanks Area

The upper area of a TEVAP is given by the following formula (Galbiati, 2009, p. 27):

$A = (N \times Q_d) \div [ETo \times K_{tepvap} - (p.k_i)]$ or $Q_t \div [ETo \times K_{tepvap} - (p.k_i)]$

Where:

A = upper area (m²);

N = average number of users per day (persons);

Q_d = daily discharge contribution of sewage effluent per person (liters/day);

Eto = average reference evapotranspiration of the site (mm/day);

K_{tepvap} = tank coefficient;

P = average rainfall of the site (mm/day);

K_i = infiltration coefficient, varying from 0 to 1.

Since the values of athe average number of users per day (N) and the daily discharge contribution of sewage effluent per person (Qd) have already been determined, it is still necessary to establish the values of:

Eto (mm/day), K_{tepvap}, P (mm/day) and K_i (ranging from 0 to 1).

The average reference evapotranspiration (Eto) of the site was obtained by the annual average of the State of Sao Paulo, based on the stablished by Tanguni (2017), summarizes in Table 1, bellow:

Table 1. Variation of maximum, minimum and average evapotranspiration (Eto) coefficients, its standard deviation and coefficient of variation in the seasons of the years for the State of Sao Paulo, Brazil. Source: Tanguni (2017, p. 104)

Period	ETo (mm/dia)				CV (%)
	Maximum	Minimum	Average	SD	
Spring	5.20	3.12	4.16	0.47	11.25
Sumer	5.54	3.42	4.48	0.50	11.19
Autumn	4.04	2.02	3.03	0.43	14,21
Winter	4.68	1.94	3.31	0.73	22.15
Year	5.00	2.64	**3.82**	0.51	13.43

The average reference evapotranspiration coefficient (Eto), as given in Table 1, corresponds to 3.82, using Tanguni (2017) as a reference.

For the tank coefficient (K_{tepvap}), we adopted the value of 2.71, from Galbiati (2009), for the conditions which we will consider quite analogous to our case study. The average rainfall of the site (P) was obtained from Marcuzzo (2016), through the average of the annual minimum and maximum values, for the city of São Paulo. From this value, it is divided by the days of the year for the daily average of the index. The infiltration

coefficient (k_i) varies depending on the construction parameters of the TEVAP. As the use of covering of dry leaves or even the convexity of the superior layer of the substrate, both reducing the value of this index, as well as the level of 20 cm above the external soil. This infiltration refers to the penetration of rainwater. According to Galbiati (2009, pp. 27-28), k_i values closer to 1 are related to the penetration of all the precipitated water into the TEVAP. Lower values mean that there is runoff of surface water from the rains to the outside of the system.

So we adopted, for the case study:

The infiltration coefficient (k_i) was definet as 0.5, considering the protection of the surface with dry leaves as well as a wall 20 cm higher than the external level and its bulging towards the external perimeter.

The average rainfall of the site (P) was defined from Marcuzzo (2016), who presents the values of rainfall in the city of São Paulo, indicating, in the South region, the highest rainfall, which reaches values of 1950 mm per year. Marcuzzo (2016, p. 14) defines the variation of average annual rainfall values in the city of Sao Paulo, in the region corresponding to the territory of Fundão do Jardim Ângela near the Guarapiranga Nautical Sport Club, between 1465 and 1526 mm, having as reference the period between 1977 and 2006. For this research, the least favorable index was adopted, namely, 1526mm per year.

Thus, we have the average daily rainfall as:

P = 1526mm/year ÷ 365 days = 4.18 mm/day

For calculating the upper area of the TEVAP, applying all these values to the formula above, the following results are obtained:

Social Lounge — 706 m^2; Restaurant — 318 m^2.

It is observed that NBR 13969 establishes the height limit of the filter bed at 1.20 m (Associação Brasileira de Normas Técnicas, 1997, p. 4).

By way of comparison, using the empirical average indicated by Watson (Pamplona and Venturi, 2004) for domestic situations, which corresponds to 2m²/person, for both Evapotranspiration Tanks for the social lounge as well as for the restaurant, the result obtained corresponds to the ratio of 3 m²/person, which is consistent with the more intensive use.

2.3.4 On-Site TEVAP Implantation

Next, in Figures 3 and 4, we present the insertion of the two Evaporation Tanks at the site:

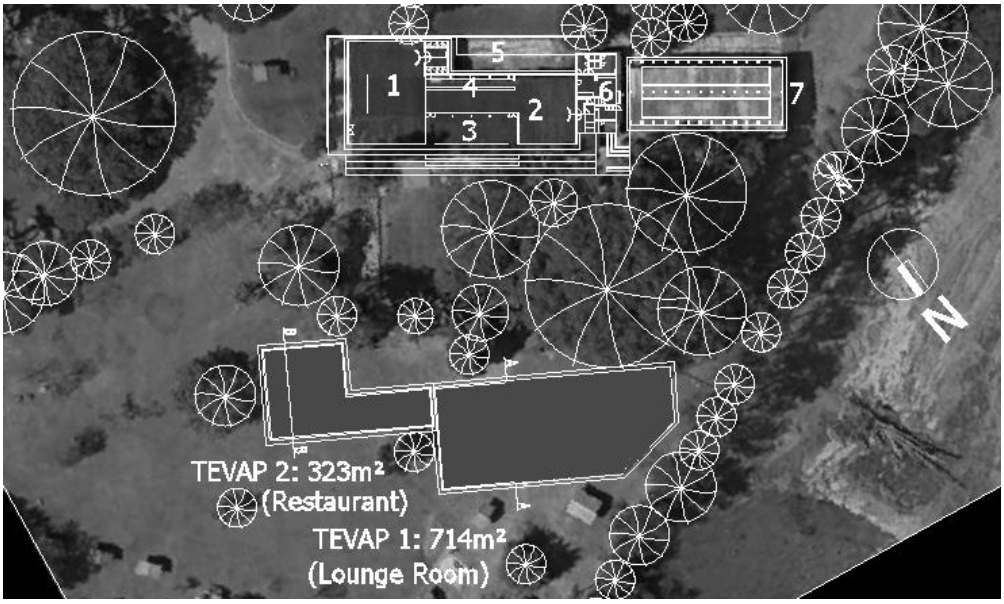

Figure 3. Implatation of the Evaporation Tanks on the site. Legend: 1 – Social Lounge; 2 – Restaurant; 3 – Porch; 4 – Grills; 6 – Backyard; 7 – Bocce shed. Source: The authors

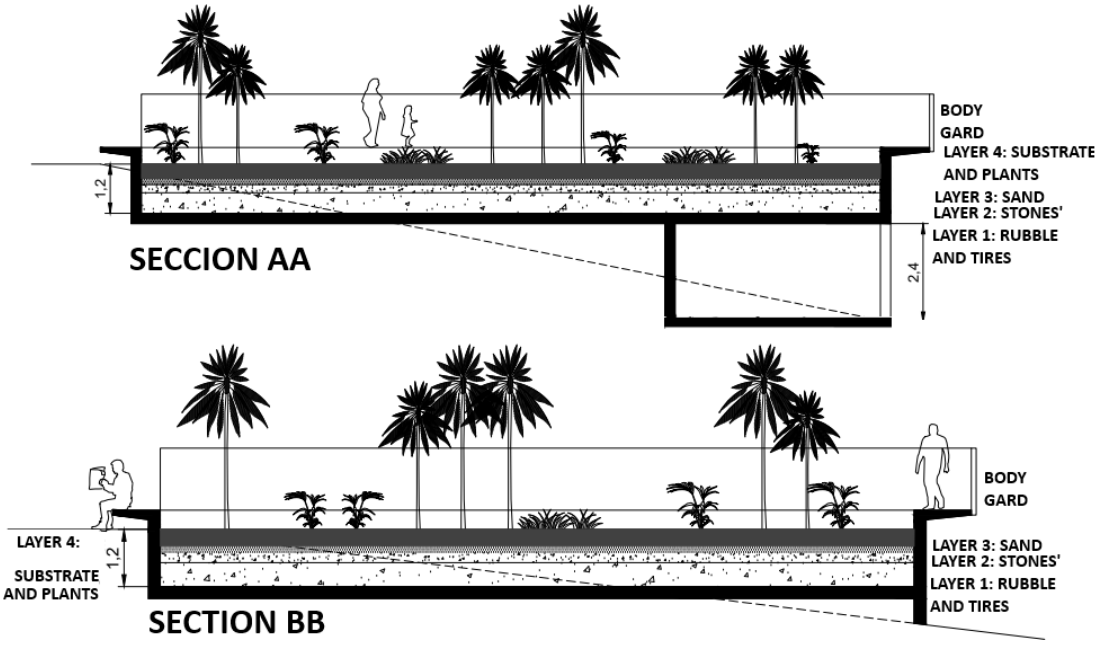

Figure 4. Sections of the Evaporation Tanks on the site. Source: The authors

According to Vieira (2010), the layers of the TEVAP are successively filled with construction ceramic rubble and tire lines forming hollow anaerobic fermentation chambers (45 cm), gravel (25 cm), sand (15 cm) and the substrate for planting (40cm). The inlet pipings are introduced at the bottom of the Tank and there are inspections ducts in the top area that rise above the surface. The plants defined for planting are broad-leaved or must have great evapotranspiration capacity and fast growth, like banana trees, papaya trees, taiobas and caetés. The spacing between the seedlings should be around 30 cm, ensuring convenient sunlight and regular pruning needs to be carried out.

Seeking to compare preliminary the proposal for the case study to the Sustainable Development Gols (SDGs), even considering its local scale, we can point out its correspondence to: SDG 3 – Good Health and Well Being; SDG 6 – Clean Water and Sanitation (in all its Targets); and SDG 11 – Sustainable Cities and Communities and, indirectly, to the SDG 14 – Life bellow Water (United Nations, no date).

3. CONCLUSION

The research demonstrated the feasibility of using phytoremediation as a Nature-Based Solution for the case study of Guarapiranga Nautical Sport Club, having the social lounge and restaurant of the clubhouse building as a pilot. In this building the occupation is concentrated with a lot of users, and the spaces needed to install the Evapotranspiration Tanks technique resulted in expressive areas that, in this case, are available.

The importance of the real possibility of implementing the systems is considered, given its socio-environmental educational potential in situations of vulnerability in which sewage sanitation is poor or very sufferable.

Virtuous results can unfold from this case study in the region of “Deep of Jardim Ângela” that is characterized by being a watershed protection area of the Guarapiranga dam, under specific legislation and, for the same reason, it includes important remnants of free areas, in permanent conflict with the need for housing.

The lack of sewage sanitation in Brazil is systemic, even affecting large cities. although contemplating legal frameworks that advocate its universalization. We believe that this work can contribute to a more balanced articulation between the apparently conflicting rights of housing and the environment.

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LEARNING OF SOLVING SUSTAINABILITY CHALLENGES IN DIGITAL ENVIRONMENTAL ENGINEERING STUDIES

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ABSTRACT

The study summarizes the green project management digital teaching and learning methodology and achievements so far, which are integrated and generated in the B.Sc. and M.Sc. levels in environmental engineering study programs of the LAB University of Applied Sciences (LAB), Finland. It is important to share the experiences internationally.
The paper introduces the theoretical green management methods, which serves as a framework for the practical implementation in the sustainability challenges' courses. The practical implementation takes places in project form, where the companies and public bodies have the role of the sustainability challenges' commissioners. The commissioning organizations define the sustainability challenges for the students.
The data collection for the study started in the spring 2019 and now, in the third year, it is time to report about the mid-term results of the study. The study has been carried out as an in-depth, multi-method case study collecting data from the students and commissioners and in oral and written form. The study introduces four project courses as practical implementation cases. The results give material and guidance for the further development of green project management studies.
So far very few scientific papers report about the practical implementation of project form teaching and learning in green project management sphere in technology studies. The originality of the introduced concept is based on the originality of the regional strategy, LAB's role in the regional development system and own innovative ways to carry out problem and project-based learning. The relevance of the topic area is increasing as the ability to act as a sustainability maker is becoming as a norm, soon not to be "a special agent's work" solely. The main limitation of the study is the uniqueness of each project case and the amount of the gathered project cases so far.

KEYWORDS

Sustainability Challenge, Sustainability Education, Virtual Studies

1. INTRODUCTION

Sustainable development and the interplay between its ecological, social, and economic dimensions can be regarded as a highly complex task. As a logical consequence, educating for sustainable development also has a complex character (STEINER & POSCH, 2018) The dimensions are interlinked is to have balance between them. The sustainability measures are activities that do not compromise the ability of future generations to meet their needs.

Three main challenges have been identified to address global learning needs: a) self-directed learning options for the development of competencies, b) transdisciplinary settings to make knowledge applicable and effective in real-life situations, and c) overlapping the boundaries of academic versus nonacademic learning to achieve a holistic approach to lifelong learning (OECD, 2020).

Furthermore, there are two sides of education that can be seen as complementary:

• Learning *for* sustainable development: By both facilitating changes in what we do and promoting (informed, skilled) behaviors and ways of thinking, where the need for this is clearly identified and agreed (ADOMSSET, 2011)

• Learning *as* sustainable development: By building the capacity to think critically about (and beyond) what experts say and testing sustainable development ideas, as well as by exploring the contradictions inherent in sustainable living (VARE & SCOTT, 2007)

At the same time, the weakness in the relationship between development activities and knowledge production is one of the sources of the persistence and consequences of unsustainability and underdevelopment (DZISAH & ETZKOWITZ, 2008). Based on all above-mentioned key principles, the LAB UAS has taken an ambitious goal to show and develop practical implementation capability in these areas for the regional development and sustainability change management. This is a challenge with high expectations and requirements from the regional stakeholders as the community-based implementation of the sustainable principles is only possible as the stakeholders own these principles and, thus, create the basis for participatory, transparent, democratic, and above all, peaceful conditions for action. Peaceful contexts are necessary for communities to achieve the socio-ecological transformation that is necessary to mitigate climate change and to build models of a sustainable coexistence that preserves our common good, which is, first, the environment (OBRECHT, 2022.).

At LAB it seen that environmental engineering students, and in Bachelor and in Master level, should have the curriculum links with the sustainability engineering courses and social change with specialized labs (lab works in certain course project types) that enhance technological and social-institutional sustainability literacy and build team-based project collaboration skills (BACON et al., 2011). Furthermore, project-based learning (PBL) is a good method for letting the students explore an engineering project that considers the sustainability, environmental and social aspects (GAUGHRAN et al., 2007). The overall aim at LAB is that the student will be able to work as sustainability agent in the working places.

The research has indicated that future professionals require knowledge from a variety of disciplines, but also competencies to accomplish real-word change. And, in this study, also to gather eal-world learning experiences in the education of sustainability professionals (HEISKANEN et al. 2016). The best way is to use problem and project based learning (PPBL) methodology. Teachers' new role and tasks are well summarized in the commonalities section in the following figure.

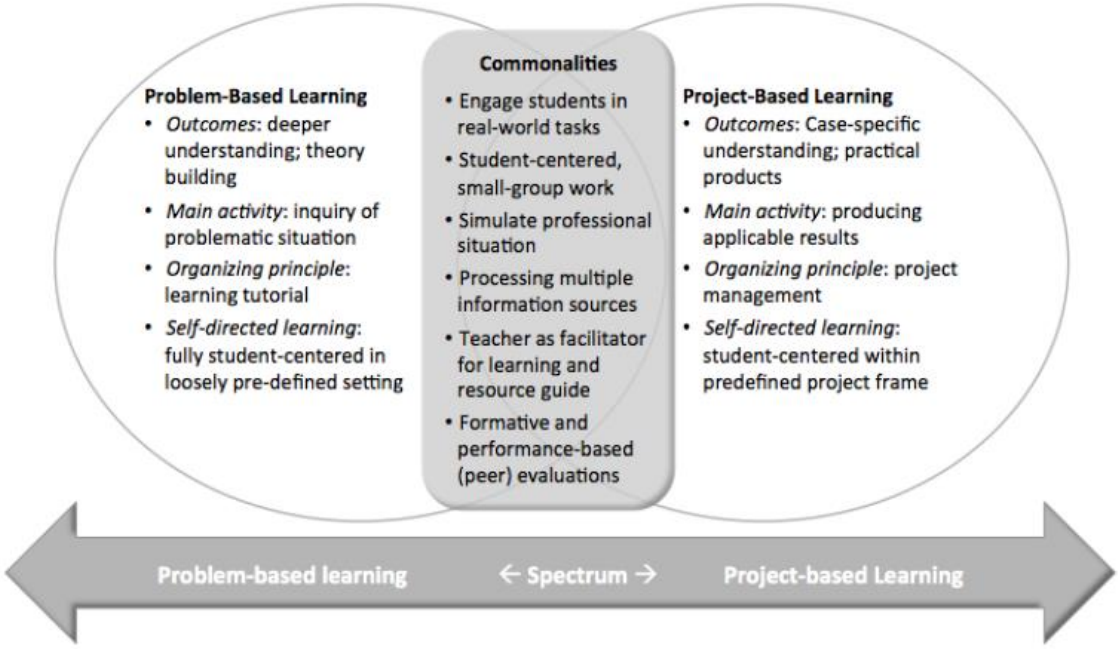

Figure 1. PPBL as a continuum of a constructivist, experiential learning approaches (Source: Brundiers & Wiek, 2013)

2. GREEN PROJECT MANAGEMENT METHODS

The basics of three applied green project management methods are introduced. These theoretical methods are applicable in any project, but according to experience of student groups from the last three years, these methods have not been known for the students beforehand, from earlier studies or from their working experience. As concerning any theoretical approach, the mixed implementation of these methods is possible and even recommended, depending how reasonable they are for the project case.

2.1 Method 1- Green + Quality = Greenality

Maltzman & Shirley (2010) introduced a new word, 'greenality', which shows the relationship between green and quality. The equation is indicated in the title above. It is a new method for a project's green quality. According to the authors, the famous quality gurus like Crosby, Deming and Juran laid the foundation for this new quality concept as there are many parallels between greenality and quality. The process of the project and its outcome should serve sustainability and greenality is an integrated activity for both the product of the project and the process of managing a project.

Even if projects differ in the amount of environmental sustainability aspects they contain and how the aspects manifest themselves, in greenality thinking all project have some element of green. Maltzman & Shirley (2010) categorized projects as follows: 1) Green by definition (GBD), which means that this type of projects are all about sustainability or environment, 2) Green by project impact (or the lack thereof) is a project, which may not have immediate positive impact on the environment, like manufacturing electric cars or building underground. As known, whatever we do, it has an impact on the nature environment. Still, in this project type, the long-term impact may be positive, 3) Green by product impact is a project, which focus is not to be green project itself, but the steady state operation of the end product has, and 4) Green general project, actually multitude of project, which not seems to have green elements at the first glance. In this case it is especially project manager's duty to improve projects greenality.

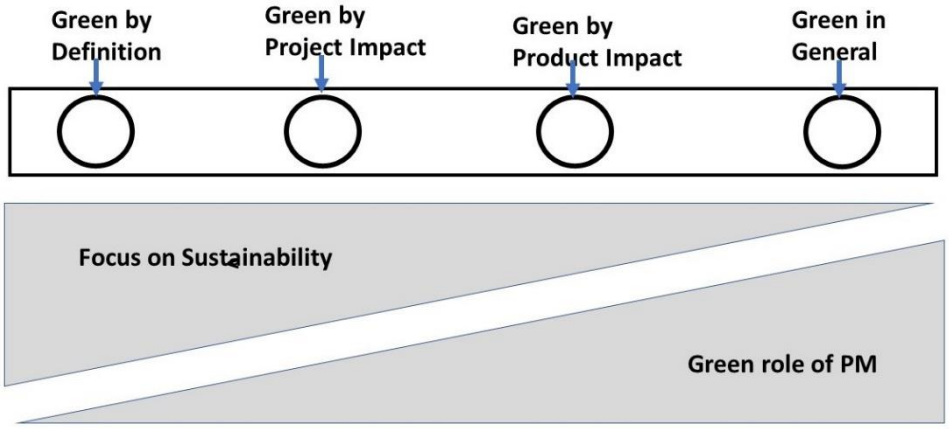

Figure 2. Role of the project manager as greenality focus changes (Source: Maltzman & Shirley, 2010)

If the project's focus is less and less green, the project manager must assert a stronger and stronger role to have a positive effect on the sustainability of the project. It is important to know that the role of the project manager changes as the focus on green changes.

2.2 Method 2 - 4L

The second method (MALTZMAN & SHIRLEY, 2010) for the green project management is 4L, inspired by the lean methods. Four Ls are Lean-Learn-Linked-Lasting (*Figure 3 below*). It indicates how these aspects can be linked to the projects and to project managers. The practical guidelines are 1) how to lean – it is to be aware of the operational counterparts and their efforts to reduce waste and make operations more efficient. It is to

apply to the project and its products; 2) to learn – it is to collect project artifacts, lessons learned, and share benefits from the community of project managers with respect to environmental/sustainability and to grow organisationally; 3) linked – to connect with your organisation's environmental management plan and break downs organisational walls; and 4) lasting – encourages to thing long-term and of the lasting effects of your actions as project manager, not only for this and future projects, but also in terms of the product of your project.

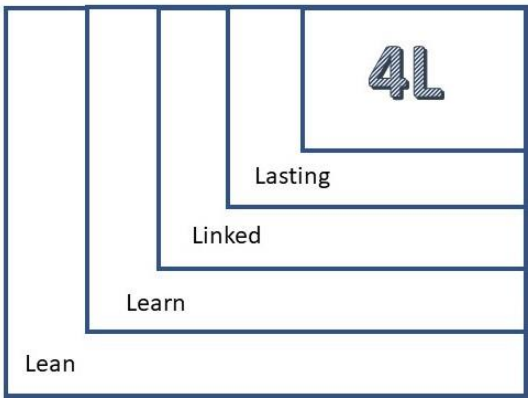

Figure 3. The 4L approach (Source: Maltzman & Shirley, 2010)

Lean means to work for the efficiency. That is any kind of efficiency and avoidance of all kinds of unnecessary structures and bureaucracy. Learn means that the project always generates something to learn for individuals, teams and organizations. Linked underlines the importance of the internal and external stakeholders as well as system thinking, which is essential in the sustainability. The special attention is for the principle of Lasting. That is essential for all sustainability activities and the sustainability is to work in the long run, for the future.

2.3 Method 3 - Industry 4.0 and Biosphere Rules

Fourth Industrial Revolution (Industry 4.0) propagates an increasing digitalization and intelligentization of production processes and projects. Intelligent production systems requires subsystems to be well equipped with sensors, embedded software and actuators that continu-ously and ubiquitously generate and exploit data to be able to plan and execute concrete actions. Industry 4.0 does not explicitly refer to ecological sustainability of production systems as a major objective. However, the production technology and operations research community has addressed ecological impact and sustainability in various ways throughout the past decades (EROL, 2016.).

Still, there are many doubts towards digital technologies, what is their impact on the nature, is it more harmless than the enthuasiastic technology people claim. Value creation might positively contribute to a sustainable development in many cases. Anyhow, in some countries, especially critical areas with expected negative contributions are related to the quantity of materials used, primary energy consumption, and working conditions in thesphere of the Industry 4.0 (STOCK et al., 2018). The Biosphere Rules (UNRUH, 2018), which is a biomimicry-inspired management method for circular economy initiatives. The rules are also potentially keys in the emergence of a true circular economy that will bring about environmentally sustainable manufacturing. Rule #1 is called Material Parsimony, which means eco-design concept of mononmateriality. This enables efficient reuse and recycling of material. Rule #2 Value Cycling refers to actual cycling of materials from one high-value to another one. Rule #3 Power Autonomy is to maximise energy efficiency and use renewable energy forms. Sustainable Product Platform is the principle of the Rule #4 meaning to mimic the scope and scale of the nature in the commercial production. Rule #5 Funciton over Form is inspired by the function of the nature: as conditions change, the function is not lost. In practice, internet and open access databases take on the role of the DNA.

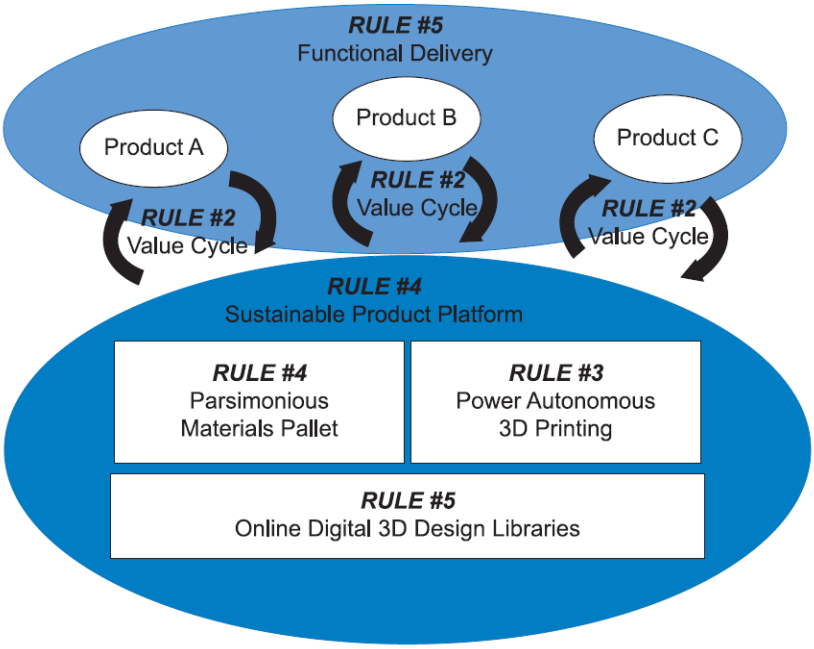

Figure 4. Schematic of a 3D-printing-based circular economy founded on the biosphere rules (Source: Unruh, 2018)

According to the experience from LAB student projects, Biosphere Rules are especially applicable in manufacturing pilot projects, laboratory works and ICT projects aiming at decrease of harmful environmental impact – which should be a starting point of any project. In any student project, the students should not be "thrown into the deep end" (LAMBORN, 2009), they are to led through the process by teacher-mentors.

3. RESEARCH METHODOLOGY AND IMPLEMENTED CASES

The LAB University of Applied Sciences locates in three campuses, in cities of Lahti and Lappeenranta in the South-Finland and it also has a virtual campus. The study is carried out as an in-depth, multi-method case study, which allows to utilize a range of research methods (YIN, 1984) following the grounded theory, which is designed to inductively build a substantive theory regarding some aspect of practice depending on the research questions (MAHDIUON et al., 2017). To summarize, this method aims at rich information, which is interrelated.

The first study period was spring 2019 – spring 2022 sustainability project courses. The study is continuing with the new study period. This paper introduces mid-term results.

Multiple methods of data collection were applied to allow for triangulation and to ensure the validity (CRESWELL & CLARK, 2017). The empirical data was gathered from four course rounds from bachelor and master students' courses with sustainability challenges in 2019-2022 by observations and interviews, from course project reports (students' group reports to commissioning companies and public employers), feedback assessment forms and interactive feedback sessions with students as follows:

- Observations n = 55 (mentoring sessions with students, meetings, and events), unstructured, real-time fieldnotes
- Interviews to the graduated students, n = 8 participating students, recorded by Zoom/Teams
- Course project reports to the commissioner, n = 19, feedback from commissioners n = 19 (11 oral and 8 written), real time hand notes and written files
- students' feedback assessment form, n = 69, written files
- separate three feedback sessions, n = 69 students, Zoom recording

The cases, which are introduced as follows, are from the Lahti campus and the virtual campus of their environmental engineering (B.Sc.) or sustainable urban environment (M.Sc.) study programs. The teaching method, study level and the main sustainability method is indicated:

Case 1: Environmental engineering energy innovation competition
Study level: B.Sc.
Teaching method: classroom teaching, virtual mentoring
Sustainability method: Biosphere Rules

In the spring 2019 two student teams from participated in the Inssiforum 2019, an annual engineering students' competition among Universities of Applies Sciences. The competition targeted to the student teams' project, which are from the energy innovation field. The purpose of the competition was to raise innovation spirit, to pay attention to the climate change locally and globally, to position students as key stakeholder group of the forum and as a remarkable part of the engineering education development and to emphasize joy of learning, multi-sectoral approach and problem-solving skills by doing real innovation projects. LAB students' proposal "Bike, walk, run with clean energy" got the second place and the winner was "So Boss", a new solar energy IoT application that uses sensor technology to analyse, control and maintain solar panels.

Case 2: Future Use of New Industrial Zones of Hollola Municipality
Study level: M.Sc.
Teaching method: virtual teaching and mentoring + site visit
Sustainability method: Greenality

In the autumn 2020 six student teams conducted a study project within the Urban Sustainability master program's course Managing Urban Change. The commissioner was the municipality of Hollola. The students investigated two industrial zones, Hopeakallio and Paassilta, how the development plans fit with the sustainability goals of the municipality and the region. and suggested various future scenarios and activities. As a result of the project, the municipality got six different reports, where sustainability was emphasized as a key asset for the development and future steps. The students were motivated to test their skills in the real-life challenges and learn new sustainability approaches and applications.

Case 3: Climate Partnership of Päijät-Häme Regional Council
Study level: M.Sc.
Teaching method: virtual teaching and mentoring
Sustainability method: Greenality

In the autumn 2021 three student teams conducted another study project within the Urban Sustainability master program's course Managing Urban Change. The commissioner was the regional council of Päijät-Häme. The students have three different tasks, first, for the non-Finnish speakers and exchange students, to benchmark climate partnership/ networks in other countries. Second, to guide companies to set up climate action goals suitable for different type of companies including indicators /effectiveness for monitoring. Third, to implement a survey for students and residents in the Päijät-Häme region on selected roadmap themes.

Case 4: Solutions.now sustainability challenge course
Study level: B.Sc. and M.Sc.
Teaching method: virtual teaching and mentoring
Sustainability method: Greenality

Climate University is a Finnish university network, which gives free online courses everyone who wants to make the sustainability transition in the society real (CLIMATE UNIVERSITY, 2022). The courses are made in multidisciplinary collaboration of several universities in Finland. The network was originally funded by the Ministry of Education and Culture, Finnish Innovation Fund Sitra and the participating universities, but now working only by funding of the universities in the network. LAB University of Applied Sciences is one of the original members, a co-developer and producer of Solution.now project course. In this annually organized and totally virtually conducted project course students produce sustainable solutions for real-life challenges presented by companies or other employer organizations. During the course students from several universities work together with their project in multidisciplinary groups in connection with the company. Teachers are involved as mentors in this process and to be able to follow and support the projects. Approximately 150 students have participated in the course and solved around 20 sustainability challenges of the companies and public sector employees (years 2020-2022).

4. CONCLUSIONS AND DISCUSSION

In this paper, the background, development goals, and practical implementation cases of the green student project management have been presented. Although the concept is very multidimensional and complex, three main points can be identified after three years (spring 2019 - spring 2022):

- Students work in a small team to which their commissioners undertake the sustainability development. The basic idea is to work on this collaborative team-based project. The communication and dynamics of this small team, in all cases and so far only between students, has caused more challenges for mentoring teachers and students themselves than the challenges as such. The possible problems arise because of this, not because of the content-based difficulty.
- Sometimes students feel the project goals unclear and timetables stressful, but after the project end, they are much more satisfied and feel more self-assured. The impression of unclarity is driven from the commissioner, which does not have the clear picture or answers before the project start. Both sides work as peers, but the majority of students expect clear and easy tasks rather than work with the uncertainty and find novelty and innovative solutions.
- Students are not used to take big responsibility as the teaching norm is more top-down and they expect that teacher solves and it is not their duty. Sometimes a commissioner is active in tutoring the project, sometimes they are not available at all. This, of course, makes every case for a teacher unpredictable.

Finally, let us consider a generally accepted opinion about the abstract characteristics of the sustainability, which makes it practical implementation and learning difficult. According to the experience of the LAB environmental and sustainability technologies' study programs, the important is just to start the implementation as it is mostly about learning by doing. And, keeping in mind the core idea of quality – continuous improvement – shows the track to go on. Every new implemented project case brings added value, new learning, and experience and for the participating students, commissioning companies and the regions, where student works.

On the other hand, outside environmental engineering teachers, many teachers of other technology fields do not have the background to undertake the role of teaching engineering within a sustainability context. That is why the results looks very positive. There is a practical solution also for this challenge. Either environmental engineering teachers could join other study program's course and share the teaching and during the course learning happens also in teachers' side or other technology study program's teacher can visit environmental engineering project course, when there is such content in the commissioner's challenge that the deeper knowledge would serve better the goal of the challenge, e.g. in material knowledge, ICT solutions, which are typical examples of today's development areas in the environmental field.

Three years after the start of the implementation it looks like convincing, that students made progress on the learning about the sustainability and getting more motivation for solving sustainability challenges. The way towards wider deployment of the method(s) it is to pilot and integrate in other study programs, units and faculties.

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A METHODOLOGY FOR GENERATING SYNTHETIC PERSONAL INFORMATION REPOSITORIES

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ABSTRACT

Researchers who need to work with personal information face complex privacy-related challenges. In almost all situations, personal information must be adequately protected. In some cases, the research works may require the utilization of data from actual patients. However, privacy and confidentiality concerns can make using such data impossible or challenging. In addition, access to actual data can be affected by several factors, including cost, ethical issues, acquiring consent, and other approval requirements. Anonymization, pseudonymization, and de-identification are approaches that provide some privacy protection. Even so, applying these approaches may not always be possible or appropriate. These approaches are intended to omit sensitive information, such as the patient's first or last name, ethnicity, spoken language, eye colour, skin colour, and the like. Nevertheless, some studies may require the use of such data. For these situations, synthetic data resembling factual patient information can provide the required resources. However, the synthetic data must be free from bias as much as practicable. Data bias can lead to an erroneous depiction of the phenomenon under study or the population. This paper presents a framework for creating synthetic personal data repositories without referring to actual data. The created synthetic data should be free from both selection and cognitive biases.

KEYWORDS

Synthesis Repositories, Personal Information, Data Bias

1. INTRODUCTION

Researchers face several challenges when researching social science, medicine, or their interests. First, individual privacy should be protected while releasing personal information (Barrows Jr & Clayton 1996). Second, there are challenges in obtaining actual data, and maintaining their confidentiality is even more challenging (Lamberg 2001). Third, data use by researchers is restricted by many factors, including costs, ethical issues, and approval from the relevant institutes (Caine & Hanania 2013). It may be possible to provide some privacy protection by anonymizing the data.

In some cases, it may be necessary to obtain more information from a patient, such as his or her first name, last name, ethnicity, language, eye colour, or skin colour (Benaloh et al. 2009). This information will be omitted or obfuscated during the anonymization process. Thus, we require synthetic data similar to actual data but with minimal bias. As the name implies, synthetic datasets are generated programmatically. This can be achieved by generating random data controlled by specific statistical percentages (Abay et al. 2018).

Different techniques have been proposed to generate lists of datasets for multiple purposes. One of its primary purposes is to provide flexibility in machine learning, data analytics, and other similar research areas. In order to be able to experiment with various classification, regression, and clustering algorithms, the generated data must be flexible and rich enough. Furthermore, datasets should be generated with minimal bias Data bias leads to an inaccurate depiction of a population or phenomenon. Due to the structural characteristics of the systems that produce the data, bias can be present in natural or synthetic data.

Synthetic data can be generated using several methods, including a number drawn from a distribution, an agent-based model, and a deep learning model (Chen et al. 2021; Fearon et al. 2017; Goncalves et al. 2020; Mugunthan et al. 2021). In order to draw numbers from a distribution, it is necessary to observe an actual statistical distribution and reproduce its results. Agent-based models and deep learning models require observations of behavior in order to construct a relevant model. After the model is derived, the data is

reproduced based on the derived model. As discussed above, all methods for generating synthetic data are based on actual data. It is the real data that provide the input to the synthetic data. As a result, if the actual data were biased in the selection process, then the selection bias level would be inherited in the synthetic data. For example, in the case of a community where unemployment has reached up to 20%, the synthetic data would reflect the same percentage. However, this percentage may not be representative of reality.

Data bias can take several forms, from the collection of data to the fitting of models (White & Poldrack 2014). Some data biases exist, including selection bias, algorithm bias, measurement bias, prejudice bias, and exclusion bias (Smith & Noble 2014). There can also be other types of bias introduced into synthetic data; this is known as cognitive bias. As a result of the randomness of the algorithm that generated the data records, the data presented cognitive bias. The data records are generated randomly by computer programs. For example, the list may contain a variety of ethnicities, so each patient receives a random ethnicity. In general, random values should be influenced by specific conditions. In the case of prostatic carcinoma, for instance, this diagnosis can only be assigned to males. Therefore, the programmer should be aware of such cases.

This study aims to identify a framework for generating a synthetic patient repository with minimal selection bias and cognitive bias. By implementing the proposed framework, these biases will be minimized. The remainder of the paper is broken down as follows. A literature review is provided in the second section of this report, while a discussion of cognitive bias is presented in the third section. The fourth section of this paper examines a framework for overcoming cognitive bias, while the fifth section describes a framework for creating a virtual repository of patient information. Results and discussions are presented in the sixth section. The last section of the paper provides the concluding remarks.

2. MEASURING SELECTION BIAS

Based on statistical values found in government reports, censuses, research studies, and other documents, this article aims to create synthetic data from these sources. Statistics such as these are generally found without the original data. In data science, residual results are challenging to find that agree with the predicted data. Consequently, there is a possibility that the data will not completely fit the derived model; rather, the data will overfit or underfit the model. Bias values and error rates are both terms used to describe this non-fitting. When collecting data, there is always the possibility of error.

A measure of selection bias, or sample bias as it is sometimes referred to, can be calculated by comparing the error rate between the residual data and the predicted data if the data are based on predictions. However, sometimes, the statistical data is not based on predictions but rather on descriptions of the data. The measurement of bias for such a case is challenging. Data needs to be collected again or the population of interest needs to be changed to measure bias.

Comparing descriptive statistics with predictive data analytics, descriptive statistics have a very low error rate. Consider a scenario where the error rate is low, for example, less than 20%. It is possible to calculate the bias rate in the actual data by using the error rate. The error rate will be calculated using the sample size equation (Charan & Biswas 2013). In a statistical study, sample size refers to the number of observations or replicates used. According to Eq 1, the sample size (n) can be expressed in a simple form.

$$n = \frac{Z^2 \times p(1-p)}{\varepsilon^2} \quad (1)$$

p: is the population portion
Z: is the Z score as shown in Table 1
ϵ: Acceptance Error

Three main factors determine the sample size: the certainty factor, the acceptance error, and the population proportion. The certainty factor indicates the level of confidence in the output. If the certainty factor is 95%, then the output is also 95% confident. The acceptance error is the margin level of accuracy. In order to maintain good confidentiality, the acceptance error should be as low as possible. For example, if a survey indicates that 10% of participants are vegans, this percentage is not precisely 10%, but it is closer to that level, denoted by 10±1%. In relative terms, an acceptance error of 1% would be equivalent to 1/10=10%.

Table 1. Confidence level and Z-score

Confidence Level	Z-score (±)
0.92	1.75
0.95	1.96
0.96	2.05
0.98	2.33
0.99	2.58

The sample size for the finite population size should be estimated according to the study goal and the population size. In this study, we calculated the sample size with a confidence level of 95%, a margin of error of 1%, and a population proportion of 50%. According to the data, the sample size for the finite population is 9604. Table 2 indicates the sample size for a variety of values of the finite population size. The sample size (n) was calculated using Eq.1 Based on the table, the largest two sizes of the population imply a similar sample size of 9604

Table 2. Sample size with the population size in the finite population

Population Size	Sample Size
30,000	7276
50,000	8057
250,000	9249
1,000,000	9513
10,000,000	9595
100,000,000	9604
1,000,000,000	9604

In this context, population proportion refers to the percentage of the value associated with the survey. Consider the case in which you must study 200 households, for example. It was found that 150 households owned at least one computer. As a result, the population portion is calculated as follows: $p = \frac{150}{200} = 0.75$.

In our study, we have multidimensional data that includes a variety of attributes and proportions. For each attribute, it is impractical to calculate the population portions. The generated data may include information about the colour of the eye, the colour of the hair, an individual's ethnicity, blood type, and other areas of personal identification. Therefore, it is easier to approximate one value for all attributes. Choosing the appropriate population proportion percentage is not a difficult task. In order to determine the benefits of population proportions, we must first determine whether they are beneficial. Doing so makes it possible to determine how many samples should be collected. The results indicate that the value of p=50% would result in the maximum value of (n). Using a finite sample size, the largest sample size was determined to be n=9,604 records. Therefore, p can be considered a constant value of 50%.

The study's sample size will be determined per the previous discussions. In this case, the confidence interval is 95%, resulting in a z-score of 1.96. The margin of error is 1%, the population portion is 50%, and the population size will not be considered. Following is a calculation that illustrates the unlimited population equation in terms of sample size.

$n = \frac{Z^2 \times p(1-p)}{\varepsilon^2} = \frac{1.96^2 \times 0.5(1-0.5)}{0.01^2}$ =9,604

Eq. 2 presents the acceptance error or the margin of error, which will be considered to calculate the original bias value.

$$\varepsilon = Z * \sqrt{\frac{(p*(1-p))}{n}} \qquad (2)$$

Using the calculation above, it is possible to reduce the bias value in the generated data by providing an interval of proportion parameters. As an example, our eye colours (EC) are defined as [Blue, Brown, Green, Black], and their percentages are defined as [0.1", "0.6", "0.1", "0.2"], with a total of 0.1 + 0.6 + 0.1+ 0.2 = 1. If the error margin is 1%, a minimum sample size of 9,604 is required, along with the following percentage interval:

Error of Blue Eye colour = ε / p = 0.01 / 0.10 = 0.1 [in relative term]

Percentage interval of Blue Eye colour = 10±1%, or [0.09 – 0.11].

In this interval, three different lists should be generated, with the following eye colour percentages: 0.09%, 0.10%, and 0.11%. Additionally, the remaining percentages of eye colour need to be considered. To demonstrate this, we will create three rounds with 9,604 in each round. Following is a breakdown of the percentages:

Round 1: EC= ["0.09", "0.61", "0.09", "0.21"]

Round 2: EC= ["0.1", "0.6", "0.1", "0.2"]

Round 3: EC= ["0.11", "0.59", "0.11", "0.19"]

Three rounds are repeated for each characteristic, such as hair colour, skin colour, ethnicity, gender, and the like. When dealing with large datasets, each of the 9604, or for simplicity, 10,000 records, will be considered in one round, and the three rounds will be iterated as a block of 30,000 records. Taking the example of 150,000 records, the records would be divided into 150,000 / 30,000 = 5 blocks. There are three values assigned to each block.

3. RESOLVING COGNITIVE BIAS

Scholars across a wide range of scientific disciplines have provided various definitions of cognitive bias in their research. It is possible to use it in this case as a way to display the non-logical information that was generated randomly. The information in this list needs to be removed or modified manually to provide the best results. Discovering these records is very time-consuming, especially with such a large data set. It is possible to add additional filtration statements to the algorithm so this may mitigate the cognitive bias in the data records. In general, when it comes to generating a list of Personal Identifiable Information, there may be several cognitive biases that cannot be remedied by algorithms, such as the person's first and last name, as an example. Personal names are usually associated with factors such as ethnicity, gender, religion, political orientation, age, and geographic location, as well as a person's ethnic origin. Table 3 illustrates an example of this type of bias. You may find a discrepancy between these records' first and last names. It is so unusual to find these full names in real life. For instance, "Aaron" is a Jewish name, while "Husaini" is a Muslim name. Both Muslims and Jews may live in the same geopolitical area. However, they use different names.

Table 3. Names with cognitive bias

First Name	Last Name	Bias reason
Devaki	Singh	This is an Indian name, Bias Reason: Devaki is a Hindu name, while Singh is a Sikh name
Ahmad	El-Khoury	This is an Arabic name, Bias Reason: Ahmad is a Muslim name, while El-Khoury is a Christian name
Aaron	Husaini	This is an Israeli name, Bias Reason: Aaron is Israeli Husaini is Palestinian
Francisco	Abai	This is a Brazilian name, Bias Reason: Francisco is white Brazilian, and Abai is Afro-Brazilian

The data generation algorithm has been corrected to mitigate cognitive bias during the data generation process. As a result, how this kind of bias can be resolved depends on the ethnicity generated. In every country of origin, some biases have been inherited from the country's ethnic background, religion, origin, and colour. As a result, an individual's ethnicity is manifested in that person's name.

Input:
1. read hindu_names.csv
2. create a list hindu=[] and insert the hindu_names.csv values int
the hindu list
3. create a list Indian_names=[] and insert values into Indian nam

Process:
4. if relgion!="Hinduism" and country=="Indian"
5. while random_first_name in hindu
6. random_first_name=random.choice(male)

Output:
7. random_first_name NOT in hindu

Algorithm 1. A Hindu Algorithm

It will be possible to collect biased ethnicity names so that they can be avoided when randomizing the names according to ethnicity in the future. In the case of Muslim and Hindu names likely to lead to bias in terms of name selection, a list of Muslim and Hindu males and females with suggested names can be prepared as an example. The algorithm works based on a reverse concept. In order to generate a name, the first step should be to generate the name and then compare it with a Muslim list, for example. If the name is found in the Muslim list, but the religion field value is set to Christian, the name will be generated again and checked until it cannot be found in the Muslim list, at which point it will be removed from the list. To facilitate comparisons among ethnicities, all ethnicities are prepared as a list. As a result, Algorithm 1 will be repeated on each biased ethnicity to avoid cognitive biases.

4. MATERIALS AND METHODS

To generate synthetic patient repositories, it is necessary to preconfigure population and patient characteristics to create synthetic repositories for patient data. Therefore, creating patient objects at the population level in the initial configuration was necessary using a Python program. As a result, a clinical profile and information regarding each patient's admissions were created for each patient. As a result, these patient data objects were stored in a database. With the help of this methodology, three databases containing a total of 1,000,000 virtual patients were created as a result of the study.

4.1 Population-Level Configuration

As part of the criteria for configuring a population, it is necessary to specify how many individual records must be generated and to provide preconfigured values for key demographic characteristics of the entire population. In order to represent the Australian community, 1,000,000 records are to be generated. Several factors make up demographic characteristics, including gender, ethnicity, the ethnicity of the mother, age group, date of birth, place of birth, the colour of the eyes and skin, the tongue of the mother, the country of origin, the name of the mother, the name of the father, religion, and blood type. As a consequence of configuring categorical variables, various possible values are available for the variable, and a percentage of the population is assigned a particular value. For example, for a population of n = 1,000,000 individuals in Australia, a possible configuration for ethnicity would be English 25.90%, Australian 25.40%, Irish 7.50%, Scottish 6.40%, Italian 3.30%, German 3.30%, Chinese 3.10%, Indian 1.40%, Greek 1.40%, Dutch 1.20%, other 15.80% (IndexMundi 2021).

4.2 Generating a Synthetic Patient Record

Upon acquiring the population-level configuration, the Program generates a set of n objects representing a virtual patient. A specific demographic characteristic was associated in each of these objects. As a result of the Program, a synthesis of personal information records is created containing first and last names, as well as demographic information (gender, ethnicity, mother's ethnicity, date of birth, place of birth, eye and skin colour, mother's tongue, country of origin, mother's name, father's name, religion, blood type). Algorithm 2 describes the steps involved in generating the records. In total, there are fourteen processes, one input and one output. The first step is to choose the ethnicity from the list before using the Program (Australians, Indigenous, English, Irish, Scottish, Greeks, Germans, Dutch, Italians, Indians, Chinese, Lebanese, Vietnamese, and Filipinos). In the second step, the software will request an estimated number of records required. Lastly, the percentage of males in the records is requested.

Input:

1. Enter the Ethnicity
2. Enter records Numbers
3. Enter Male %
4. read names_list.csv
5. create a list male=[] ;female=[];family=[];skinColour=[];sColour=[];hairColour=[]; hColour=[];the_max=[];eyeColour=[];eColour=[];muslim=[];hindu=[]; bloodType=[];bType=[];motherTongue=[];mTongue=[];countryofOrigin=[]; cofOrigin=[];religion=[];relig=[]; datefbirth=[]; PlaceOfBirth=[];POfBirth=[]; Motherethnicity=[]; Methnicity=[]; FName=[] hindu=[] and insert the names_list.csv values into the lists

Process:

6.

1. for o in range(1,num_of_records):
2. sColour.append(skinColour1)
3. hColour.append(hairColour1)
4. eColour.append(eyeColour1)
5. bType.append(bloodType1)
6. mTongue.append(motherTongue1)
7. cofOrigin.append(countryofOrigin1)
8. relig.append(religion1)
9. datefbirth.append(random_date)
10. POfBirth.append(PlaceOfBirth1)
11. Methnicity.append(Motherethnicity1)
12. random.shuffle(sColour)
13. random.shuffle(hColour)
14. random.shuffle(eColour)
15. random.shuffle(bType)
16. random.shuffle(mTongue)
17. random.shuffle(cofOrigin)
18. random.shuffle(relig)
19. random.shuffle(datefbirth)
20. random.shuffle(POfBirth)
21. random.shuffle(Methnicity)
22. MName=M_Name(Methnicity[i-1]
23. FName=np.random.choice(male,1,replace=True)

Output:

7. INSERT INTO Personal (First_Name, Family_Name, Gender,Ethnicity,SkinColour,HairColour, EyeColour BloodType, MotherTongue, CountryofOrigin, Religion, DateofBirth, PlaceOfBirth, Motherethnicity, MotherName, FatherName)

Algorithm 2. Record Generation Algorithm

The above algorithm creates records using descriptive statistical results. Most of this statistical data was derived from governmental census data. First, the Program reads the preconfigured demographic characteristics for the selected ethnicity from the names' lists. The names' lists were derived from the following references (*List of common Chinese surnames* 2021; Adoption 2021a, 2021b, 2021c; Australia 2017; BCG 2021; Behindthename 2021a, 2021b, 2021c, 2021d, 2021e, 2021f; Company 2021; Digital 2021a, 2021b; FamilyEducation 2021a, 2021b, 2021c, 2021d, 2021e, 2021f, 2021g, 2021h, 2021i; Forebears 2021a, 2021b, 2021c, 2021d; Government, Australian 2017; ImproveMandarin ; Peanut 2021; Scottishgirlsnames 2021; Surnamemap 2021; Team 2021; VietnamOnline 2021). As a result of the available information, we have compiled a comprehensive list of names representing every ethnic group available in Australia and the most popular names for boys, girls, and families (Australia 2017; Behindthename 2021c; FamilyEducation 2021g; Forebears 2021b; Government, Australian 2017). The second step involves the generation of a random skin colour shade based on the Fitzpatrick skin type (Parra, Kittles & Shriver 2004; TV 2005).

Through a third process, the hair's colour is created. Following the Fischer-Saller hair colour scaling, a randomized hair colour shade will be generated based on the Fischer-Saller scale (Steffensen 1952; Web 2020). During the fourth process, the eye colour is determined. There are several common eye colours: brown, blue, hazel, amber, grey, green, red/violet, and heterochromia. These will be generated and randomly assigned based

on the prevalence of eye colour (Campbell 2016; worldatlas 2021). In the fifth process, a person's blood type is determined using O+, A+, B+, AB+, O-, A-, B-, AB-, which are generated at random (Bureau 2021; Lifeblood 2021; Ltd 2022). Mother tongue determination is the sixth step in the process. The most common languages spoken in Australia will be used to determine a random mother tongue (Government, Australia 2017). The seventh step plays a significant role in determining the country of origin. On the basis of the 2016 Australian Census of Population and Housing (Goverment, Australia 2017), a random selection of countries will be made. Our eighth process allows us to determine a person's religion. A random religion will be selected as the most common religion in Australia during this process.

It is important to note that the ninth, tenth, and eleventh processes were developed using the 2016 Australian Census of Population and Housing (Government, Australia 2017). In the ninth process, a random date of birth is generated based on the Distribution of age group years (0-120) recorded in the Census. Based on census data, the tenth process generates the Distribution of birthplaces between Australia and a country of origin. This procedure will culminate in the generation of a random mother ethnicity based on the Distribution of ethnicities within Australia. As a result of the twelfth, thirteenth, and fourteenth sets of processes, a random mother's name, a random father's name, and a random family name were created. Based on the ethnicities selected in the first step of the input procedure, the names were generated based on the name list.

The record is finally exported to the database at the end of the algorithm. Using an SQL command, the output of each process will be combined and sent to the MySQL server in one transaction.

5. RESULTS

A virtual database of one million patient records from Australia has been created using Algorithm 2. Based on the ethnic composition of Australians (Australian: 300000, Indigenous: 30000, English: 300000, Irish: 80000, Greek: 20000, German: 40000, Dutch: 20000, Italian: 40000, Indian: 20000, Chinese: 40000, Lebanese: 10000, Vietnamese: 10000, Philippines: 10000, Scottish: 80000). As depicted in Figure 1, this is an example of a virtual record that may be found on GitHub. (Kashef 2022). To minimize the selection bias, the sample size equation was used to determine the appropriate sample size. Based on the equation's output, a selection bias of approximately 10,000 records will be reduced as a result. In order to produce more realistic results, the data was generated three times and with three different rounds, adding 1% to each personal attribute percentage throughout the three rounds. Thus, to establish a low level of selection bias, it was necessary to examine 30,000 records.

idpersonal	First_Name	Family_Name	Gender	Ethnicity	SkinColor	HairColor	EyeColor	BloodType	MotherTongue	CountryofOrigin	Religion	DateofBirth	PlaceOfBirth	Motherethnicity	MotherName	FatherName
525600	Gene	MCKENNA	Male	English	ivory skin	blond	Brown	O+	English	United Kingdom	No Religion	1940-08-10	Australia	English	Polly	Sterling
198190	Amherst	IRELAND	Male	English	fair to beige	gray	Green	O-	English	United Kingdom	No Religion	1986-01-20	Australia	English	Taite	Huxley
830500	Melody	Roosa	Female	Dutch	fair to beige	gray	Blue	B-	Dutch	Switzerland	Christianity	2003-01-23	Australia	Dutch	Nadia	Tygo
209947	Yardley	FARMER	Female	English	ivory skin	blond	Blue	O-	English	United Kingdom	Christianity	1981-10-16	Australia	Greek	Dionne	Kolton
993475	KYSON	WADE	Male	Australian	fair to beige	blond	Green	O+	English	Australia	Christianity	1975-12-18	Australia	Australian	ZAHRA	SEPANTA
1163355	Aadhish	Bhil	Male	Indian	dark brown	black	Brown	AB+	Hindi	India	Hinduism	1966-05-30	India	Indian	Anila	Urvaksh
617229	ARMIN	Hill	Male	Australian	fair and pale	blond	Brown	O+	English	Australia	Christianity	2021-02-03	Australia	Chinese	Qiao	RAIYAN
67078	JAFAR	STACEY	Male	Australian	fair to beige	blond	Brown	O+	English	Australia	Christianity	1944-07-03	Australia	Chinese	China	ZECHARIAH
246786	Teri	BETTS	Female	English	fair and pale	auburn	Blue	A+	English	United Kingdom	No Religion	2020-08-22	United King...	Irish	Kayley	Keane
138223	DWITIKA	Bell	Female	Australian	fair to beige	blond	Green	O+	English	Australia	Christianity	1998-04-06	Australia	Irish	Donelle	FINLEY
834691	Urukirti	Gorai	Female	Indian	dark brown	gray	Hazel	B+	Punjabi	India	Sikhism	2017-12-11	India	Indian	Yamal	Wiplove
579134	Ysolde	FRENCH	Female	English	fair and pale	gray	Blue	A+	English	United Kingdom	No Religion	1981-09-15	Australia	English	Wilona	Gresham
239341	Selby	STANLEY	Female	English	fair to beige	blond	Green	O+	English	United Kingdom	Christianity	1979-03-10	Australia	English	Twyla	Kennard
1056382	Conall	Mulroy	Male	Irish	fair to beige	blond	Green	O+	English	Ireland	No Religion	1956-03-31	Ireland	Irish	Murphy	Aeary
843325	Tan	Hoang	Female	Vietnamese	fair to beige	black	Blue	B+	Vietnamese	Vietnam	No Religion	1945-12-30	Australia	Vietnamese	Khanh	Phong
323306	Ing	Spangler	Male	German	fair to beige	blond	Brown	A+	Dutch	Germany	Christianity	2015-05-16	Australia	German	Aemilia	Drake
348028	Ave	Lucchini	Female	Italian	fair to beige	black	Blue	B+	Italian	Italy	Christianity	1982-07-16	Australia	Italian	Mafalda	Bertrando
692842	ANNABEL	Guthrie	Female	Australian	fair and pale	blond	Green	O+	English	Australia	Christianity	2021-01-26	Australia	Australian	ANNIE	PRABHNOOR
175304	Farnell	LINDSAY	Male	English	fair to beige	blond	Blue	O+	English	United Kingdom	No Religion	1957-05-11	Australia	English	Falynn	Pelleas
982064	SASCHA	Sherman	Male	Australian	fair and pale	blond	Blue	A+	English	Australia	No Religion	1967-02-03	Australia	English	Vala	JORDY

Figure 1. Sample of virtual records

Algorithm 1 was repeated on the Indian and Lebanese ethnicity generation lists to counteract cognitive bias. In the case of Indian ethnicities, the algorithm reduced the bias from 7.5% to 0.1%. For Lebanese ethnicity, the bias was reduced from 13% to 0.1%. This can be seen in Table 4, which shows the percentage of biased records before and after the algorithm was applied. Some records contained a minority ethnic bias, for example, Sikhs whose family names are usually Singh, Kaur, Arora, Anand Bajaj, and others (Gatrad 2005). Many Lebanese family names originate from Christian backgrounds. These include names, such as Khoury, Mutran, Butrus, Malouf, Francis, and many others. These family names can be included in the Christians list in Algorithm 1.

Table 4. The percentage of biased records before and after applying the algorithm

Ethnicity	No. of Records	Before	After
Indian	1000	9%	0.25%
Indian	10,000	8.2%	0.15%
Indian	100,000	7.1%	0.1%
Indian	1000,000	5.7%	0.07%
Lebanese	1000	15.5%	0.15%
Lebanese	10,000	13%	0.1%
Lebanese	100,000	12.2%	0.07%
Lebanese	1000,000	11.5%	0.025%

The virtual personal patient dataset is available for immediate download to enable researchers to run algorithms on similar EHR (Electronic Health Record) data for use in the proposed research. In addition, this personal dataset can be connected to read medical data. The use of repositories does not require the installation of any software. As these datasets contain only raw data in the form of flat text files, they are independent of particular operating systems. They can be accessed using a variety of database systems. In addition, the dataset can be accessed on low-performance computers because they can run on open-source software such as R and MySQL, which do not require extensive installation.

Furthermore, the dataset can be deployed on the existing open-source EHR platforms. It is based on the Australian community used to generate the dataset. It is possible to generate different datasets for different communities and ethnic groups using the Program and the algorithms included in the Application. The dataset can also be expanded by adding new ethnicities and other groups to generate a new set of data in the future.

Since electronic health records are populated with linear and nonlinear associations among all medical elements and random associations among all medical elements, it is challenging to create virtual patient repositories that accurately reflect actual electronic health records. Therefore, a suitable algorithm must consider individual and population-level assumptions and have an intelligent algorithm to assign acceptable temporal differences between each medical event.

6. CONCLUSIONS

This article proposes a novel method of generating a synthesis of patient records that maintains the privacy and confidentiality of the underlying personal information. This study describes a method for creating a longitudinal synthesis of patient records closely resembling actual patient records while minimizing biases. Synthetic data is necessary to reduce the possibility of identifying individuals. The actual data is usually anonymized. The anonymization reduces the benefit of data, which may adversely affect some research methods. It is, therefore, possible to reduce the adverse effects of anonymization by creating synthetic data in such a case. Our research has discussed two types of data bias, selection, and cognitive bias. Resolving selection bias was possible by increasing the number of generated records. Resolving cognitive bias was possible by altering the data generation algorithm. The algorithm alteration was completed by categorizing names. Such names depend on the synthetic data's target country or ethnicity. Researchers may need to invest considerable time and effort into their data generation. Therefore, it is necessary to include such a list to expand the category field. A patient's name should be categorized based on their ethnicity and religion, clan, doctrine, ideology, or spoken language. In contrast to synthetic data, the actual data differs significantly. Our future research will focus on generating synthetic data for certain medical diseases. More studies are needed to categorize ICD10 codes based on ethnicity, gender, and age group. This will be essential to increase the range of synthetic data for research purposes.

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IMPORTANT FACTORS THAT MUST BE DEVELOPED BY ONLINE LOAN PLATFORMS FOR STUDENTS: CASE STUDIES OF CAMPUSES IN INDONESIA

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ABSTRACT

The use of financial technology, especially in the loan and fund provision sector, is currently rife in Indonesia. It can be seen from the increase in the number of lending transactions through peer-to-peer lending (P2P lending) services that occur every year. Even so, P2P lending is a financial service that has many benefits as well as risks. Based on that, there is a need to identify factors that can influence the intention to use P2P lending services especially in development countries. The aim of this research is to identify the structural relationship between the researched variables that influence the intention of loan service users in P2P lending using Partial Least Square-Structural Equation Modeling (PLS-SEM) method by adopting several variables from TAM and UTAUT. The analysis result of this study indicates that the intention to use the P2P lending platform is highly influenced by "Perceived Usefulness" (PU), "Individual Mobility" (IM), "Subjective Norms" (SN), "Hedonic Motivation" (HM), and "Personal Innovativeness" (PI). It also known that "Perceived Ease of Use" (PEOU), "Perceived Trust" (TR) and "Perceived Risk" (PR) has no significance influence towards intention of use. Based on the results, several recommendations were made for the P2P lending platform providers that can be used as input for the development of their services. This research collected 282 data from P2P lending's borrowers through online questionnaires.

KEYWORDS

P2P Lending, Financial Technology, Intention to Use, Structural Equation Modeling (SEM)

1. INTRODUCTION

The development and adoption of technology in the financial industry in Indonesia have been rapidly increasing (Wewege & Thomsett, 2016). P2P lending platform is one of financial technology in lending, financing, and fund provision sectors. Even though the use of P2P lending platforms has been increasing and booming in Indonesia, it is found that the level of financial literacy of the Indonesian people is still low compared to the financial inclusion that is carried out. It is shown that there is a significant gap between financial knowledge possessed by Indonesian people and the usage intensity of financial service products, so it can be concluded that there are still many people who use financial products without prior knowledge of the functions, requirements, and risks of the financial products used (Noor, Fourqoniah, & Aransyah, 2020). Based on that fact, it can be questioned regarding the factors that influence the intention to use P2P lending services, considering that this type of service has various advantages and risks that need to be considered thoroughly. Currently, there is still few research that focuses on identifying the factors that influence the intention to use P2P lending platform, especially from the borrower's side. It is necessary to conduct further research related to factors that can influence the intention to use P2P lending platform as a borrower.

There are several previous research that have been conducted. Related study from (Kalinic, Marinkovica, Molinillob, & Cabanillasc, 2019) which adopt its conceptual model from TAM stated if there are 6 factors that influence the use of P2P mobile payment. Those factors are subjective norms, perceived trust, perceived usefulness, perceived enjoyment, and perceived risk. This study also indicated that that personal innovativeness has no significant influence on the intention of use. This statement is in accordance with previous research conducted by (Nguyen, Cao, Dang, & Nguyen, 2016) which states that perceived trust is the strongest variable that affects the intention to use mobile payment services, followed by perceived ease of use, perceived enjoyment, perceived behavioral control, perceived usefulness, and subjective norms. However, the (Kalinic, Marinkovica, Molinillob, & Cabanillasc, 2019) research results contradict the result of subsequent study conducted by (Cabanillas, Milinillo, & Japutra, 2021) which stated that personal innovativeness has a positive impact on behavioral use of P2P mobile payment. The conceptual model of the study combines some additional variables adopted from Technology Acceptance Model (TAM) and Unified Theory of Acceptance and Use of Technology (UTAUT). There are also additional variables such as Individual Mobility (IM) dan Hedonic Motivation (HM) that was included based on previous research conducted by (Schierz, Schilke, & Wirtz, 2010) that investigated the intention of use mobile payment services.

Up to this point, studies related to the use of P2P lending platforms from the perspective of borrowers are rarely conducted. Many researchers focused on calculating and managing the risks of using P2P lending as an investment platform and there is no specific study that investigates the influence of Technology Acceptance Model (TAM) factors on the intention to use of P2P lending platform as a borrower. Hence, this study aims to further investigate the factors that influence the intention to use P2P lending, especially from the borrower's perspective, based on the adoption of TAM and UTAUT variables. It measures the influence of perceived usefulness (PU), perceived ease of use (PEOU), individual mobility (IM), perceived trust (TR), personal innovativeness (PI), subjective norms (SN), hedonic motivation (HM), and perceived risk (PR) towards the behavioral intention of use (IU). We implement this research by choosing the well-known P2P lending platforms in Indonesia, as a case study and measure the factors that influence customers to use their loan services.

2. METHODOLOGY

This research begins with the literature study phase to gather reference sources from journals, books, etc related about P2P lending and financial services development. This research was conducted based on the main reference of a paper in the journal of Information Systems Management by Cabanillas et al. (Cabanillas, Milinillo, & Japutra, 2021). Following the literature studies about related topics, the questionnaire was created based on the adaptation from previous study. Before the questionnaire being distributed, it has been validated by 20 respondents to make sure that it is easily understood and have no bias meaning. Then the questionnaire is distributed directly to the respondents who use education loan services. It was distributed through social media and Student Ambassador community. This research use Partial Least Square (PLS) methodology using SmartPLS to process the data and evaluate the research model and proposed hypotheses. Although the analysis must be carried out in two steps, analysis of the measurement or inner model and analysis of structural or outer model, PLS can estimates measurements and structural parameters simultaneously.

3. MODEL DESCRIPTION

The conceptual model in this study uses the Structural Equation Modeling (SEM) model from the (Cabanillas, Milinillo, & Japutra, 2021) research. Based on the theories discussed (TAM and UTAUT) this research proposes that seven “drivers” including perceived usefulness (PU), perceived ease of use (PEOU), individual mobility (IM), perceived trust (TR), personal innovativeness (PI), subjective norms (SN), hedonic motivation (HM), positively influence intention of use (IU). On the other hand, perceived risk (PR) was proposed to be a “barrier” that negatively influences intention of use (IU). This research also proposes that perceived ease of use (PEOU) has positive impact on perceived usefulness (PU).

The "perceived usefulness" is a factor that indicate the extent to which users believe that the system used is useful and more effective than the existing system. "Perceived ease of use" factor relates to the user's perception on how easy to operate the system. "Individual mobility" is a factor that shows the extent to which users believe that the technology allows them to perform tasks from any location and situation. "Perceived trust" indicates the perception of how reliable the provider is. "Personal innovativeness" defined as the user's willingness to operate a new technology. "Subjective norms" defined as the extent to which people think that their closest people believe that they should operate a particular technology. "Hedonic motivation" in this study refers to the believe that there will be pleasure and enjoyment derived by using the technology. As the barrier, "Perceived risk" is defined as a factor that indicate the extent to which users believe that there are risks that may occur due to the use of technology. In this model, the relationship between those 9 variables causes 9 hypotheses that shown in Table 1.

Table 1. Research hypothesis

Hypothesis	Question		Hypothesis	Question
H1	"Information Quality" has a significant positive impact on "Perceived Usefulness".		H6	"Personal Innovativeness" has a significant positive impact on "Behavioral Intention of Use".
H2	"Perceived Ease of Use" has a significant positive impact on "Perceived Usefulness".		H7	"Subjective Norms" has a significant positive impact on "Behavioral Intention of Use".
H3	"Perceived Ease of Use" has a significant positive impact on "Behavioral Intention of Use".		H8	"Hedonic Motivation" has a significant positive impact on "Behavioral Intention of Use".
H4	"Individual Mobility" has a significant positive impact on "Behavioral Intention of Use".		H9	"Perceived Risk" has a significant negative impact on "Behavioral Intention of Use".
H5	"Trust" has a significant positive impact on "Behavioral Intention of Use".			

The research model of this study can be seen in Figure 1 The following stage describes the mathematical equations of the structural model and measurement model developed based on the SEM. The structural model. Based on thorough study, the structural model is a model that depicts how latent variables relate to one another. The quality of a structural model in PLS-SEM can be calculated based on the model ability to predict the endogenous variable that can be measured based on the evaluation of Coefficient of determination (R-square), cross-validated redundancy (Q-square), path coefficients, and effect size (f-square) (Hair Jr, Sarstedt, Hopkins, & Kuppelwieser, 2014). Meanwhile, the measurement model specifies the relationship degree between latent variable and their respective indicators (Fan, et al., 2016). The evaluation of the measurement model can be evaluated based on the convergent validity, discriminant validity, and construct reliability of each indicator (Hair, et al., 2021).

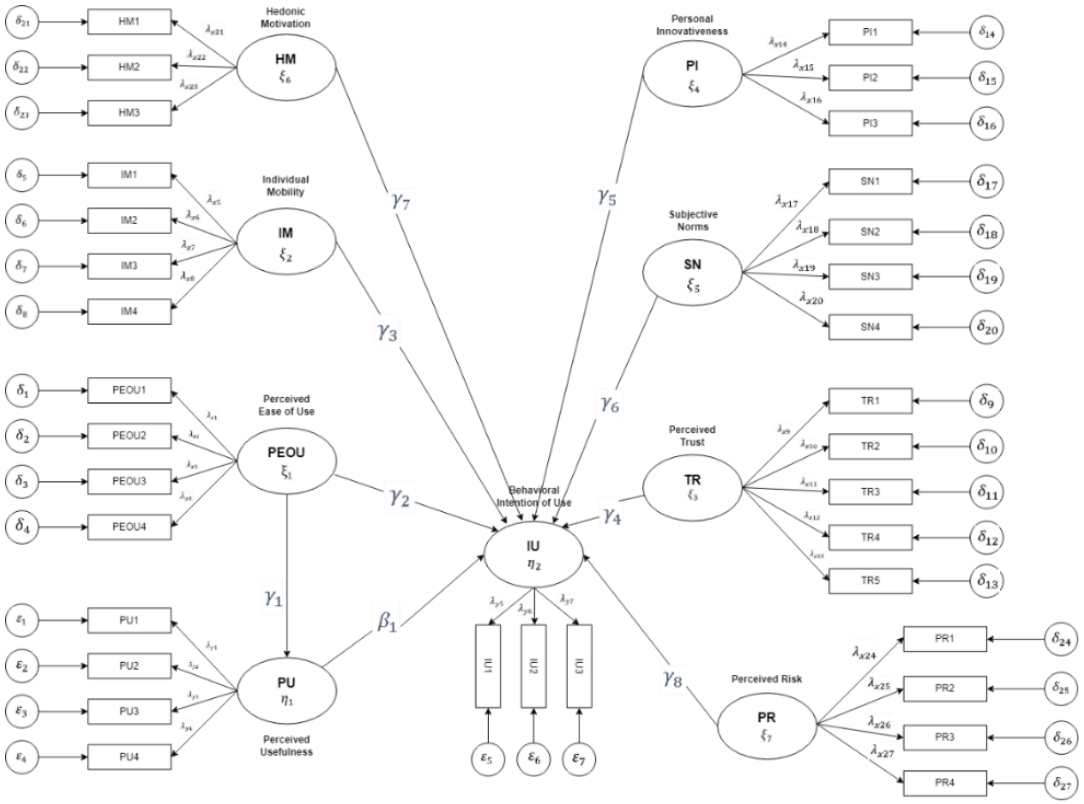

Figure 1. The structural model factor that affects the intention of use P2P lending platform

4. QUESTIONNAIRE DEVELOPMENT AND TESTING

The next step is to prepare a questionnaire related to the variables of the research model (Figure 1) and mathematical equations (Table 2). The questionnaire consists of 34 questions that were adapted from the previous research by (Cabanillas, Milinillo, & Japutra, 2021). The questionnaire was created using Google form which capture a Likert scale assessment range from 1 (implies to negative response) to 7 (implies to positive response). There are 295 data that was collected, but after removing some inconsistent data and outliers, there are 282 data that are ready to process.

Table 2. Loading factor for each exogenous and endogenous latent variable

Variable	Equation	Variable	Equation
Structural Model Equation "Perceived Usefulness" (η_1)	$\eta_1 = \gamma_1 \xi_1 + \zeta_1$	"Personal Innovativeness" consist of 3 loading factors	$PI1 = \lambda_{x14} \xi_4 + \delta_{14}$
Structural Model Equation "Behavioral Intention of Use" (η_2)	$\eta_2 = \gamma_2 \eta_1 + \gamma_3 \xi_1 + \gamma_4 \xi_2 + \gamma_5 \xi_3 + \gamma_6 \xi_4 + \gamma_7 \xi_5 + \gamma_8 \xi_6 + \gamma_9 \xi_7 + \beta_1 + \zeta_2$		$PI2 = \lambda_{x15} \xi_4 + \delta_{15}$
"Perceived Usefulness" consist of 4 loading factors	$PU1 = \lambda_{y1} \eta_1 + \varepsilon_1$		$PI3 = \lambda_{x16} \xi_4 + \delta_{16}$
	$PU2 = \lambda_{y2} \eta_1 + \varepsilon_2$	"Subjective Norms" consist of 4 loading factors	$SN1 = \lambda_{x17} \xi_5 + \delta_{17}$
	$PU3 = \lambda_{y3} \eta_1 + \varepsilon_3$		$SN2 = \lambda_{x18} \xi_5 + \delta_{18}$
	$PU4 = \lambda_{y4} \eta_1 + \varepsilon_4$		$SN3 = \lambda_{x19} \xi_5 + \delta_{19}$
"Perceived Ease of Use" consist of 4 loading factors	$PEOU1 = \lambda_{x1} \xi_1 + \delta_1$		$SN4 = \lambda_{x20} \xi_5 + \delta_{20}$
	$PEOU2 = \lambda_{x2} \xi_1 + \delta_2$		$HM1 = \lambda_{x21} \xi_6 + \delta_{21}$

Variable	Equation	Variable	Equation
	$PEOU3 = \lambda_{x3}\,\xi_1 + \delta_3$	"Hedonic Motivation" consist of 3 loading factors	$HM2 = \lambda_{x22}\,\xi_6 + \delta_{22}$
	$PEOU4 = \lambda_{x4}\,\xi_1 + \delta_4$		$HM3 = \lambda_{x23}\,\xi_6 + \delta_{23}$
"Individual Mobility" consist of 4 loading factors	$IM1 = \lambda_{x5}\,\xi_2 + \delta_5$	"Perceived Trust" consist of 5 loading factors	$TR1 = \lambda_{x9}\,\xi_3 + \delta_9$
	$IM2 = \lambda_{x6}\,\xi_2 + \delta_6$		$TR2 = \lambda_{x10}\,\xi_3 + \delta_{10}$
	$IM3 = \lambda_{x7}\,\xi_2 + \delta_7$		$TR3 = \lambda_{x11}\,\xi_3 + \delta_{11}$
	$IM4 = \lambda_{x8}\,\xi_2 + \delta_8$		$TR4 = \lambda_{x12}\,\xi_3 + \delta_{12}$
"Perceived Risk" consist of 4 loading factors	$PR1 = \lambda_{x24}\,\xi_7 + \delta_{24}$		$TR5 = \lambda_{x13}\,\xi_3 + \delta_{13}$
	$PR2 = \lambda_{x25}\,\xi_7 + \delta_{25}$	"Behavioral Intention to Use" consist of 3 loading factors	$IU1 = \lambda_{y5}\,\eta_2 + \varepsilon_5$
	$PR3 = \lambda_{x26}\,\xi_7 + \delta_{26}$		$IU2 = \lambda_{y6}\,\eta_2 + \varepsilon_6$
	$PR4 = \lambda_{x27}\,\xi_7 + \delta_{27}$		$IU3 = \lambda_{y7}\,\eta_2 + \varepsilon_7$

The following step is data pre-processing. Using SPSS, the pre-processed data were examined to verify the validity and reliability of the questionnaire. Based on the validity test result, it is known that the calculated R-value of all indicators is greater than the R table value, except for the indicator PI3 which makes sense because indicator PI3 was intentionally measured in negation conditions. Based on that, it can be concluded that all indicators on the questionnaire is valid. The reliability test also calculated that the Cronbach Alpha value was 0.830, which met the standard of Cronbach Alpha > 0.6, which indicates that the questionnaire is reliable. After that, the evaluation of the model suitability was conducted by testing the measurement (outer) model and the structural (inner) model.

The evaluation of the outer model is to measure the correlation between constructs and latent variables in the research model with a minimum standard of Loading Factor value 0.7, and the interpretation value of Composite Reliability must be ≥ 0.7 (Hair Jr, Sarstedt, Hopkins, & Kuppelwieser, 2014). The result of the test indicates that there are two indicators that has loading factor value below 0.7 and need to be deleted. Those indicators are IM3 and PI3. After deleting those two indicators, the composite reliability of all variables has met the requirements so that it can be concluded that the research variables have demonstrated precision and consistency as a valid measurement instrument. The test results of measurement model evaluation are presented in Table 3.

Table 3. Estimated value of the loading factor for each exogenous and endogenous latent variable (≥ 0.7)

Variable	Equation	Variable	Equation
Structural Model Equation "Perceived Usefulness" (η_1)	$\eta_1 = 0{,}703\,\xi_1 + \zeta_1$	"Personal Innovativeness" consist of 2 loading factors	$PI1 = 0.892\,\xi_4 + \delta_{14}$
Structural Model Equation "Behavioural Intention of Use" (η_2)	$\eta_2 = 0{,}223\,\eta_1 + 0{,}018\,\xi_1 + 0{,}143\,\xi_2 - 0{,}167\,\xi_3 + 0{,}217\,\xi_4 + 0{,}294\,\xi_5 + 0{,}174\xi_6 - 0{,}016\xi_7 + \beta_1 + \zeta_2$		$PI2 = 0.898\,\xi_4 + \delta_{15}$
"Perceived Usefulness" consist of 4 loading factors	$PU1 = 0{,}833\,\eta_1 + \varepsilon_1$	"Subjective Norms" consist of 4 loading factors	$SN1 = 0.835\,\xi_5 + \delta_{17}$
	$PU2 = 0{,}776\,\eta_1 + \varepsilon_2$		$SN2 = 0.884\,\xi_5 + \delta_{18}$
	$PU3 = 0{,}806\,\eta_1 + \varepsilon_3$		$SN3 = 0.857\,\xi_5 + \delta_{19}$
	$PU4 = 0{,}770\,\eta_1 + \varepsilon_4$		$SN4 = 0.864\,\xi_5 + \delta_{20}$
"Perceived Ease of Use" consist of 4 loading factors	$PEOU1 = 0{,}755\,\xi_1 + \delta_1$	"Hedonic Motivation" consist of 3 loading factors	$HM1 = 0.818\,\xi_6 + \delta_{21}$
	$PEOU2 = 0{,}743\,\xi_1 + \delta_2$		$HM2 = 0.896\,\xi_6 + \delta_{22}$
	$PEOU3 = 0{,}722\,\xi_1 + \delta_3$		$HM3 = 0.863\,\xi_6 + \delta_{23}$
	$PEOU4 = 0{,}801\,\xi_1 + \delta_4$	"Perceived Trust" consist of 5 loading factors	$TR1 = 0.834\,\xi_3 + \delta_9$
"Individual Mobility" consist of 3 loading factors	$IM1 = 0{,}801\,\xi_2 + \delta_5$		$TR2 = 0.756\,\xi_3 + \delta_{10}$
	$IM2 = 0{,}735\,\xi_2 + \delta_6$		$TR3 = 0.874\,\xi_3 + \delta_{11}$
	$IM4 = 0{,}740\,\xi_2 + \delta_8$		$TR4 = 0.777\,\xi_3 + \delta_{12}$

Variable	Equation	Variable	Equation
"Perceived Risk" consist of 4 loading factors	$PR1 = 0{,}854\,\xi_7 + \delta_{24}$		$TR5 = 0.825\,\xi_3 + \delta_{13}$
	$PR2 = 0{,}833\,\xi_7 + \delta_{25}$	"Behavioral Intention to Use" consist of 3 loading factors	$IU1 = 0.862\,\eta_2 + \varepsilon_5$
	$PR3 = 0{,}861\,\xi_7 + \delta_{26}$		$IU2 = 0.805\,\eta_2 + \varepsilon_6$
	$PR4 = 0{,}864\,\xi_7 + \delta_{27}$		$IU3 = 0.835\,\eta_2 + \varepsilon_7$

Then, the structural model was evaluated by checking the significance values between variables. The significant level can also be known from the calculation of R-Square value (regression interpretation), effect size value (f-square), T-count, and path coefficient value. Testing on the structural model is carried out using the Effect Size test (f^2). It is important to calculate the effect size to find out how important the influence of the latent variable on the exogenous variable being measured is. Value of 0.02 represent weak effect, 0.15 represent moderate effect, and 0.35 represent strong effect (Cohen, 1988). The following are the results of effect size test in this study which can be seen in Table 4.

Table 4. The result of effect size value of the exogenous latent variable

Exogenous Variable	Endogenous Variable	f-square Value	Effect
PU	IU	0.035	Strong
PEOU		0.000	None
TR		0.021	Weak
PR		0.000	None
IM		0.030	Moderate
HM		0.030	Moderate
SN		0.102	Strong
PI		0.060	Strong
PEOU	PU	0.980	Strong

Based on Table 4 it can be concluded that there are two exogenous variable that have no effect on its endogenous variable. Those variables are PR on IU and PEOU in IU. In the opposite, there are four variables that has strong effect, those are PU on IU, PI on IU, PEOU on PU, and SN on IU which has the strongest influence with f-square value 0.102. Meanwhile, IM and HM variable has moderate effect on PU and TR variable has weak effect on IU.

5. RESULT AND DISCUSSION

In this study, there are 9 hypotheses that were tested using the evaluation of its path coefficient value and the model significance level to determine the relationship between variables that was stated in each hypothesis. Path coefficient value range from -1 to +1. If the value is closer to -1, the variable has a negative influence and if the value is closer to +1 the variable has a positive influence (Hair Jr, Sarstedt, Hopkins, & Kuppelwieser, 2014). The model significance level indicates how strong the influence of the variables stated in the structural model based on the proposed hypothesis. The influence of the variable will be considered valid if the *t-statistic* $\geq 1{,}96$ and *p-value* $\leq 0{,}05$ (Sarstedt, Ringle, & Hair, 2017). The results of hypothesis testing and analysis in this study can be seen in Table 5.

Table 5. Path coefficient value, T-value and P-value of hypothesis testing

Hypothesis	Model	Path Coefficient	T Statistics (|O/STDEV|)	P Values	Decision
H1	PU → IU	0.223	2.552	0.011	Accepted
H2	PEOU → PU	0.703	22.855	0.000	Accepted
H3	PEOU → IU	0.018	0.223	0.823	Rejected
H4	IM → IU	0.143	2.143	0.032	Accepted
H5	TR → IU	-0.167	2.092	0.036	Rejected
H6	PI → IU	0.217	2.977	0.003	Accepted
H7	SN → IU	0.294	4.144	0.000	Accepted
H8	HM → IU	0.174	2.372	0.018	Accepted
H9	PR → IU	-0.016	0.270	0.787	Rejected

Based on the results of the hypothesis testing on Table 5, there are 6 variables that are proven to be statistically significant to have positive influence towards “Intention of Use” (IU). “Perceived Usefulness” (PU) positively affects “Intention of Use” (H1) with the value of 0.223, “Individual Mobility” (IM) positively affects “Intention of Use” (H4) with the value of 0.143, “Personal Innovativeness” (PI) positively affects “Intention of Use” (H6) with the value of 0.217, “Subjective norms” (SN) positively affects “Intention of Use” (H7) with the value of 0.294, and “Hedonic Motivation” (HM) positively affects “Intention of Use” (H8) with the value of 0.174.

It is also known that the relationship between “Perceived Ease of Use” (PEOU) on PU is not significant, but PEOU has a positive and significant effect on “Perceived Usefulness” (H2) with the value of 0.703. In addition, it was also found that “Perceived Risk” (PR) did not have a significant negative relationship with “Intention of Use” (H9). As well as new findings that “Perceived Trust” (TR) has a negative impact on “Intention of Use” which contradict with the proposed hypothesis.

This study indicates that “Subjective Norms” variable has the biggest influence towards the intention to use loan services through P2P lending platform. That statement shows that the influence and recommendation from user’s closest people will drive the individual to use P2P lending platform suggested by them. This result aligns with the marketing strategy that has implemented by recruiting Student Ambassadors who are fellow students and are close to their targeted customers.

The finding that “Perceived Risk” has no significance negative influence towards intention of use has also been found in the study conducted by (Cabanillas, Milinillo, & Japutra, 2021). The study stated that with so many innovations nowadays, users tend to think that transactions made via mobile phones and the internet do not have harmful risks because it is something that is normally done every day. This study also found that "Perceived Trust" had a significant negative effect on "Intention of Use" contrary to several previous studies conducted by (Kalinic, Marinkovica, Molinillob, & Cabanillasc, 2019) and (Ooi & Tan, 2016) which stated that “Perceived Trust” is one of the key parameters that positively influences the intention to use fintech services. Based on these results, it is necessary to carry out further improvements to these two variables.

6. CONCLUSIONS

This study was successfully describing the conceptual model into the structural mode so it can use to analyses factors that influence the intention to use P2P lending platform from the borrower’s perspectives. Based on the outcome of this study, it is found that:

- "Perceived Usefulness" has significant positive influence on "Intention to Use" (H1)
- "Perceived Ease of Use" has significant positive influence on "Perceived Usefulness" (H2)
- "Individual Mobility" has significant positive influence on "Intention of Use" (H4)
- "Personal Innovativeness" has significant positive influence on "Intention of Use" (H6)
- "Subjective norms" has significant positive influence on "Intention of Use" (H7)
- "Hedonic Motivation" has significant positive influence on "Intention of Use" (H8)

This study has identified and analysed the factors that influence the intention to use P2P lending platform that can be used as a reference for developing and improving the strategy of P2P lending platform towards its customers. P2P lending platform providers can focus on developing strategy related to the factors that has been proven to influence the intention to use P2P lending platform. As the study case, the P2P lending platform could also improve their strategy focusing on the rejected factors in this study. One way to improve "Perceived Risk" and "Perceived Trust" factor, P2P lending providers can clearly put detailed information related to the service procedures offered, testimonials from previous users, details concerning security procedures and data protection users, as well as security certifications from third parties on their website or application.

Suggestions that can be delivered for further research based on the research that have been carried out include expanding the diversity of respondent in order to obtain result that have vast range of variety that represent population and the user of P2P landing platform. In addition, the suggestion for further research is to develop and implement future study by considering the newest research model that correlate with the topic of using P2P lending platform as loan services. By doing so, there will be more things that can be compared.

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MOBILE APPLICATION FOR TRAFFIC LIGHT-BASED PERSONAL RISK ASSESSMENT FOR EARTHQUAKE ALARMS

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ABSTRACT

Natural disasters are an increasing domain of application of a full range of technologies and a matter of scientific and social studies due to its implications for human security, including infrastructure safety and economic savings for both persons and governments.
We endeavor in producing a system to situate people in case of a natural disaster accordingly to the risk, vulnerability and personal features of individuals, mean of a traffic light signaling. The risk traffic light-based alert proposed in this paper allows calculating the Risk Index of a person in a natural disaster through an app developed to Android OS, considering seismic events as its case of study.
This personalized calculation considers physiological, sensory and location variables of the user together with the data provided by the official seismic monitoring systems. In this way, the risk traffic light allows informing in a visual and personalized way the risk presented by the user, by means of three colors: green, red, and yellow.
The mobile application it is called Semáforo Móvil de Riesgo Personal (SMRP), and its purpose is to provide an auxiliary digital tool for people when an earthquake occurs, based on their own physical and sensory characteristics, and improve the Risk Index calculation with the use of the smartphone integrated sensors such as GPS, accelerometer, etc.

KEYWORDS

Application for mobile devices (App), Danger, Personal Risk Index, Risk Traffic Light, Vulnerability

1. INTRODUCTION

The main objective is to develop an application for mobile devices with Android system to improve the calculation of the Risk Index with the use of the built-in sensors of the device so that users can see graphically (with a traffic light of three colors) the level of vulnerability to which they are exposed given their own conditions at the time of an earthquake.

This requires the development of a module for reading the user's personal data related to the Risk Index: disability (visual and hearing) and mobility, as well as implementing a graphical representation (traffic light) with the data obtained from the analysis of the Risk Index and displaying recommendations from official sources of earthquakes in our country (Mexico) such as CENAPRED (Centro Nacional de Prevención de Desastres | Gobierno | gob.mx, s. f.) and SSN (Servicio Sismológico Nacional, s. f.).

2. DEVELOPMENT OF THE SMRP APP

Currently, there are applications designed for mobile devices, which offer different services in the event of a natural disaster, for example, notifications before the event occurs and even messaging between the same devices without the need to be connected to a network or have coverage. However, none of these applications offers a level of customization that includes the user's physical capabilities, which may represent an obstacle to their actions and which, together with other criteria such as their real-time location and their location within a building, allows them to know an estimate of the level of vulnerability to which they are exposed in an emergency caused by an earthquake.

2.1 Related Work

At this point it can be deduced that, based on the search of applications for current mobile devices operating both in Mexico and in some Latin American countries (SkyAlert, s. f.) (SASSLA: Monitoreo y Registro Sísmico, s. f.) (quakeRisk - Apps on Google Play, s. f.) (Earthquake Network, 2022), there is no application or web system whose objective is to indicate to a user the vulnerability to which he/she is exposed to an earthquake, considering his/her physical and sensory capabilities, as the application SMRP proposed here intends to do, which is based on the work introduced in (Vazquéz-Espino et al., 2021) and extends it by including more information through the mobile set of sensors and user data. In the following paragraphs, a brief review of the related applications is presented.

- **SkyAlert:** This application for mobile devices with Android and iOS operating systems and with coverage in Mexico City, State of Mexico, Puebla, Morelos, Michoacán, Guerrero, Tlaxcala, Jalisco, Colima, Oaxaca, and Chiapas, sends alerts up to 120 seconds before an earthquake, according to the epicenter detected (SkyAlert, s. f.). SkyAlert launches an alert based on its intensity scale, that is, it is based on the Mercalli scale to assign a color label according to the intensity of the telluric movement.
- **SASSLA**: Is an alternative to SkyAlert that detects earthquakes and sends alerts to the cell phone up to 120 seconds before a strong earthquake and without delays, using information from SASMEX and is available for both iOS and Android (SASSLA: Monitoreo y Registro Sísmico, s. f.). Unlike SkyAlert, SASSLA has notifications with a higher priority with respect to those of other applications on the mobile, so they can: Interrupt any current activity or notification on the mobile (notifications, calls, music, apps). Play the alert audio at maximum volume even when the phone is in silent mode and/or do not disturb. Increase the screen brightness to the maximum to facilitate the reading of the alert information. Repeatedly activate the vibration and the led light of the device so that the user notices the alert in situations where there is so much noise.
- **Sismo Detector:** Is an application for mobile devices with Android and iOS and is part of the Earthquake Network research project that seeks to develop an early warning system based on smartphones (Earthquake Network, 2022). The way the application works is as follows: when the device detects earthquake waves, a server is notified along with the geographic position of the earthquake. The server decides whether an earthquake is occurring and, if so, all users with the application are alerted in real time.
- **QuakeRisk:** It is an application for mobile devices with Android and iOS systems and tablets with Windows operating system that allows the user to enter the address of the building, its characteristics such as date of construction, number of floors and type of construction and other parameters to evaluate it against earthquakes of different magnitudes (quakeRisk - Apps on Google Play, s. f.). The app's algorithm, created by engineer Mario Ordaz Schroeder, from the UNAM Engineering Institute, gives a risk percentage for each building, and can be used to determine economic losses in up to one million buildings in the city. QuakeRisk is the result of more than 25 years of work on algorithms for estimating damage from natural disasters.

2.1.1 Comparison of Functionalities of Every App

In Table 1 a comparison between the mentioned application is showed and, in the last column it shows the characteristics of the SMRP in contrast with these apps.

Table 1. Comparison of applications for mobile devices in the current market with respect to the application for the personal risk traffic light

Comparison of current seismic warning apps in contrast with the Mobile Personal Risk Traffic Light (SMRP)

Application´s name / Feature	SkyAlert	Earthquake Detector	QuakeRisk	SASSLA	SMRP
System	Android and iOS	Android	Android	Android and iOS	Android
OS version required	Android 5.0+ iOS 11+	Android 5.0+	Android 9.0+	Android 4.4+ iOS 15+	Android 5.0+
It´s free?	✓	✓	✓	✓	✓
App target?	Smartphone user	Smartphone user	Real estate and insurance companies	Smartphone user	Smartphone user
Where does it get the information of the earthquakes?	SkyAlert Network	Earthquake Network	It does not obtain data because is a build risk simulator	SASMEX	Project server
Does the application have a web version with the same function?	✗	✗	✗	✗	✓
Does the application consider the user´s characteristics?	✗	✗	✗	✗	✓
Does the application consider the user´s ubication in a build?	✗	✗	✗	✗	✓

In the case of SkyAlert and SASSLA, although it detects when there is an earthquake in a certain location of the Mexican Republic and distributes it in alerts to other locations near the epicenter, is a large-scale alert dissemination.

On the other hand, users of the Earthquake Detector application can send a report as soon as they perceive an earthquake and a map with the affected area will be available in less than a minute. Depending on the intensity shown on the map, civil protection, and all other agencies responsible for people's safety can send emergency assistance and emergency teams where it is a priority. As for QuakeRisk, it is mainly based on a simulation of how catastrophic an earthquake would be in each house or building.

The SMRP app will be in one of those apps which will receive the alert propagated by the media in case of an earthquake like SkyAlert and SASSLA, with the difference that it will be based on personalized parameters for each user of the application and will give a personalized result to represent the Risk Index of each one of them and also gives sound recommendations on how the user should act during and after the seismic event. This is the main feature of this application that differentiates it from the rest.

2.2 Personal Risk Calculation

2.2.1 Calculation of the Risk Index and its Interpretation on a Risk Traffic Light

The following input data are used to calculate the earthquake Risk Index: the danger represented with P and the vulnerability represented by *V*. For the calculation of *P*, a relationship between magnitude and danger of the earthquake inspired by the Mercalli scale is proposed and can be seen in Table 2.

Table 2. Relationship between earthquake magnitude (*n*) in Mercalli scale based and Danger (*P*)

Magnitude (*n*)	**Danger (*P*)**
n < 4	1
4 ≤ n < 5	2
5 ≤ n < 6	4
6 ≤ n < 6.5	5
6.5 ≤ n < 7	6
7 ≤ n < 7.5	7
7.5 ≤ n < 8	8
8 ≥ n	10

For the calculation of *V*, two feature vectors are created that represent both the data obtained from the seismic monitoring system as well as the user's personal data. These are denoted as *V1* and *V2* respectively where:

- *V1*: is the user´s ubication in a build represented as *U* and the distance between the epicenter of the earthquake and the current user´s location represented as *D*.
- *V2*: is the user´s physics capabilities represented with *dfis* and the sensory capabilities as well as the hearing and visual impairments represented as *dAuditiva* and *dVisual*, respectively.

In the case of the *V1* vector, the weighting of these elements can be seen in Table 3

Table 3. Weightings for user's ubication and locations of the earthquake used in *V1*

Radius of distance between earthquake and user (km)	**Value (D)**	**User location on a build**	**Value (U)**
n < 80	2.5	**From the sixth floor and up**	2.5
80 ≤ n < 140	2	**Fifth floor**	2
140 ≤ n < 200	1.5	**Between the fourth and second floor**	1.5
200 ≤ n < 300	1	**First floor**	1
300 ≤ n < 400	0.5	**Clear area**	0.5

The purpose of the weightings shown in Table 3 is to obtain a quantifiable value based on the user's environment to have an estimate of how affected the user may be given an earthquake with a specific magnitude. As for the physical and sensory capabilities of the users, they are required to calculate *V* so a weighting of these is also needed. Table 4 below shows this conversion.

Table 4. Weightings for user data such as physical and sensory capabilities used in *V2*

Physical user capabilities	**Value (*dfis*)**
Cannot move	2.5
Depends on the help of others to move around	2
Use wheelchair or crutches to move around	1.5
It can move with slight complications, without the need for assistance	1
Can evacuate in case of emergency without assistance	0.5

Hearing user impairment	**Value (*dAuditiva*)**	**Visual user impairment**	**Value (*dVisual*)**
Cannot hear	2.5	**Cannot see**	2.5
It is difficult to listen	1.5	**It is difficult to see**	1.5
It can listen without complications	0.5	**It can see without complications**	0.5

On the other hand, the purpose of the weightings in Table 4 is to obtain a quantifiable value of the user's capacities which may affect his actions in the event of a possible evacuation of a building at the time of an earthquake. The sum of the values calculated in Tables 3 and 4 will result in V as shown in Formula 1.

$$\begin{aligned} V &= V1 + V2 \\ V1 &= D + U \\ V2 &= dfis + dsen \end{aligned} \quad (1)$$

Where:
V: the vulnerability of the user represented with a numeric value.
V1: the vector of the characteristics of the earthquake according to the user's location.
V2: the vector of the personal characteristics of the user.
D: weighting of the distance between the user and the earthquake.
U: the weighting of the user's intramural location.
dfis: the weighting of the user's physical capabilities.
den: the weighting of the user´s sensory capabilities.

The *dsen* value is calculated with a simple division by two considering that this value is the sum of the user's visual and hearing capabilities represented with a numerical value. The Formula 2 shows this:

$$dSen = \frac{dAuditiva + dVisual}{2} \quad (2)$$

Where:
dsen: weighted value of sensory impairment.
dAuditiva: weighted value for hearing impairment
dVisual: weighted value of visual impairment

After weighting, the values of *V* and *P* are introduced into the Formula 3 to get the Risk Index.

$$IR = a_0 + a_1P + a_2V + a_3P^2 + a_4V^2 + a_5PV \quad (3)$$

Where:
IR is the Risk Index calculated.
P is the danger of the seismic event.
V is the vulnerability of the user under his/her own conditions.
To tune the a_i coefficients we perform regression against a set hypothetical or theoretical cases for representing the (P, V, IR) values. As the parameter configure a set of boundaries of acceptability to be used to determine the color of the signal provided to the user, these parameters need to be adjusted, we take experimentally the following values according to the Formula 4:

$$\begin{aligned} P_1 &= (P_{min} + 0.5, V_{max}, 5) \\ P_2 &= (P_{max}, V_{min} + 0.5, 5) \\ P_3 &= (P_{min} + 0.35P_{ptp}, V_{min} + 0.35V_{ptp}, 5) \\ P_4 &= (P_{min} + 0.6P_{ptp}, V_{min} + 0.6V_{ptp}, 7) \end{aligned} \quad (4)$$

Where:
$P_{min} = 1; P_{max} = 10;\ V_{min} = 1.5; V_{max} = 10; P_{ptp} = P_{max} - P_{min};\ V_{ptp} = V_{max} - V_{min}$

The values obtained for the coefficients using these points are:
$(a0,\ a1,\ a2,\ a2,\ a3,\ a4,\ a5) = (0.23698655,\ 0.59396298,\ 0.63429914,\ -0.02897832,\ -0.02830087,\ 0.02829105)$
Finally, the IR value is considered in Table 5 according to the result of the application of Formula 3 considering the pondered P and V values with Tables 2-4. As shown, if the IR is less than or equal to five, it corresponds to a green traffic light, if it is greater than five and less than seven it corresponds to a yellow traffic light, and if the IR value is greater than seven the traffic light will be red.

Table 5. Relationship of the Risk Index to a phase of the traffic light

Phase	Risk Index (IR)
Green	IR ≤ 5
Yellow	5.1 < IR ≤ 6.9
Red	7 ≥ IR

2.2.2 Implementation of the Risk Traffic Light in a Mobile Application

For the development of the application, the OpenUP model will be used, which is a minimally sufficient agile software development process, meaning that only the fundamental content for the construction of a system is included (Balduino, 2007) and the type of application to be developed will be native because it allows the use of all the hardware components of a cell phone such as GPS, accelerometer, among others (Gill, 2022) (Descripción general de sensores | Desarrolladores de Android |, s. f.). The implementation of the application will be based on the following deployment diagram shown in Figure 1.

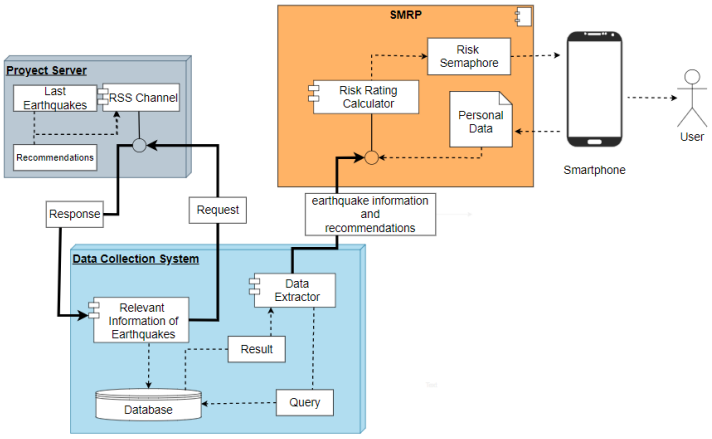

Figure 1. Deployment of the SMRP application

2.2.3 Testing and Results

The Figure 2 show the result of the implementation of the risk traffic light in the mobile application for android devices. It shows a screen with the data entered by a user, the representation of the Risk Index in a traffic light given the simulation of an earthquake. In the case of an alarm, the app will trigger sound alerts according to the color determined by the IRP calculation and display a traffic light accordingly. Additionally, the user is noticed by sound directions about how to act during and after the earthquake. Finally, the details of such a natural disaster event are displayed in a screen in the app.

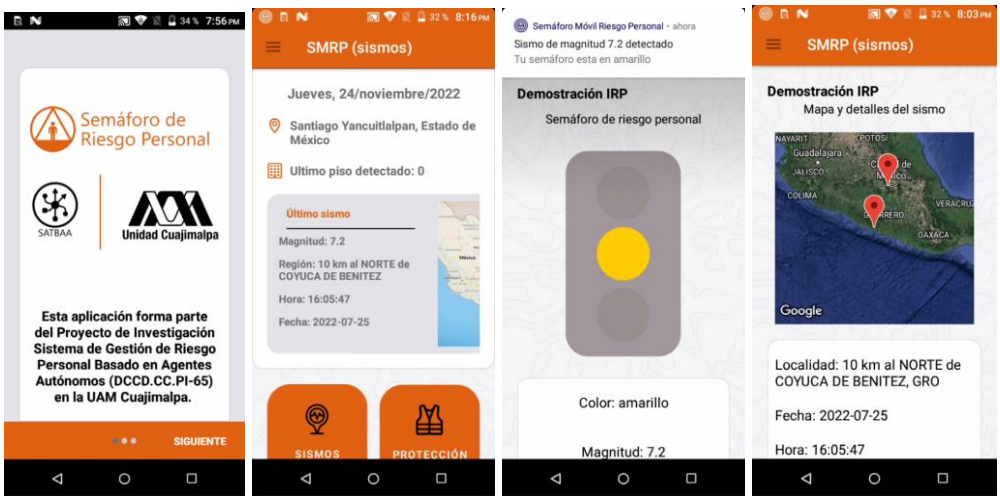

Figure 2. Demonstration of the app when calculates the Personal Risk Index calculation and the associated traffic light witch details of the earthquake (In Spanish). It goes from the profiling of the user to the identification of the seismic event in a map

In addition, the app was evaluated with five users who subsequently answered a test about the functionality, usability, design, and usefulness of the app. The results obtained from the test will be analyzed to determine which aspects of the application need to be improved and will be included in a future work. Results are shown below in Chart 1. According to the results obtained by applying the user test to each of the five users, in the usability aspect there are aspects that still need to be worked on, although the users reported a satisfactory performance of the application now of its use, which is also reflected in the reliability that it produced in the users.

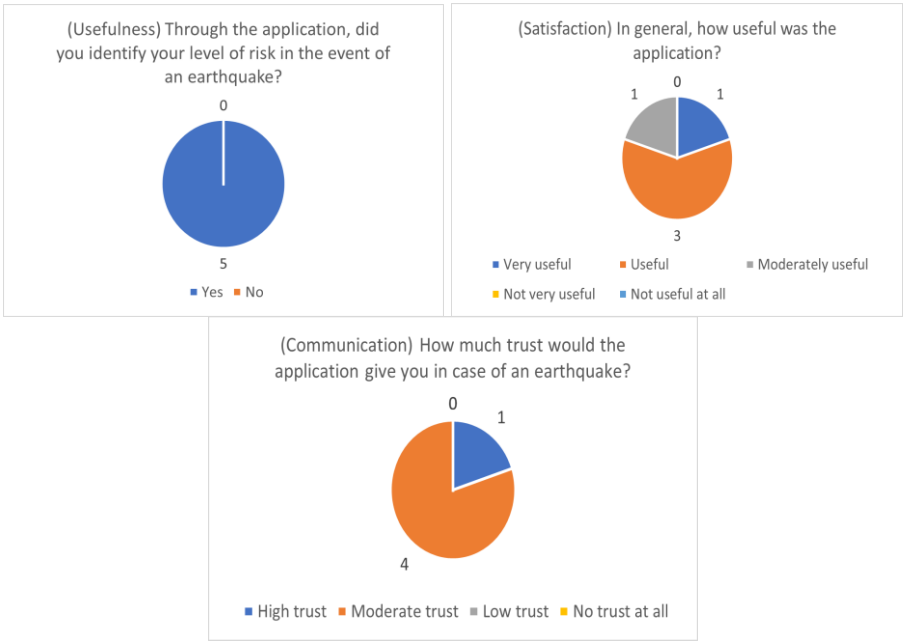

Chart 1. User´s opinion about the usefulness, satisfaction, and communication of SMRP app

3. CONCLUSION AND FUTURE WORK

In this work, a traffic light-based application is successfully developed to alert the user and display his Personal Risk Index. As a specific contribution of this calculation is the inclusion of user's personal data related to the Risk Index such as disability (visual and hearing) and mobility, which are considered in the graphic representation (traffic light) with the data obtained from the analysis of the Risk Index. Additionally, the user is provided with audio safety guidelines based on the official sources of earthquakes in Mexico. All this according to the usability and accessibility standards for mobile applications.

Additionally, the following aspects should be addressed to improve the application in the future:

- Implement intramural localization using Bluetooth beacons.
- Include new sections to determine user vulnerability more accurately in addition to physical and sensory impairments. These can be with emotional issues, i.e., how a person acts in an emergency, and the user's environment, i.e., what are the characteristics of the place where he/she is. Other measures can be taken to increase the Personal Risk Index e.g., pulse, temperature, or blood pressure.
- Implement accessibility issues for blind and deaf users.
- Improve the tests sets based on the results obtained from the first test round to modify aspects like the user interface.
- It may be possible the app automatically perform message and calls for help to the rescue staff and/or other authorities.

Finally, the general model of SMRP app can be extended to other natural disasters by integrating its particularities and introducing an adjusted Personal Risk Index calculation ad hoc to the particularities of the danger and threat in question.

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LINKING CUSTOMER JOURNEY TO CUSTOMER LIFETIME VALUE – TOWARDS A DEEPER UNDERSTANDING OF CUSTOMER VALUATION

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ABSTRACT

Marketing has developed over time towards a comprehensive approach to relationship marketing and customer experience. Consequently, there has also been a common emphasis on the dual creation of firm and customer value since the late 1990s. Following the discussion and targeting an economic value added (*EVA*), the concept of the customer lifetime value (*CLV*) has emerged as one of the critical metrics to manage customer relationships and customer equity in many companies. Customer relationships are seen as the firm's assets; therefore, various models for the valuation of customer relationships have been developed to estimate their economic value added. However, still, the application of these models in companies is rare. In this paper, we contribute to the higher applicability of a customer valuation with a view to the emerging applications of customer journey mapping in recent years. Our approach is based on the principles of calculating an Economic Value Added and on the target-oriented modelling of costs and revenues – which means residual incomes, not cash flows – during the customer relationship and integrating the concept of customer journey mapping.

KEYWORDS

Customer Valuation, Customer Lifetime Value, Economic Value Added, Relationship Marketing, Customer Journey

1. FROM MARKETING TO CUSTOMER EXPERIENCE

Marketing is one of the powerful instruments for gaining a competitive advantage in turbulent contingencies. Marketing itself has developed over time towards relationship marketing. In this context, the customer journey approach has recently received increasing attention in science and practice. The term "customer journey“ basically refers to a specific process or standard sequence that a customer (buyer persons, customer avatar) goes through to access or use an offering of a company, but still, the terms used are incoherent (Følstad & Kvale, 2018). The view is consistent from the customer's perspective, whereas service blueprinting is more from the company's perspective. (Bolton, Gustafsson, McColl-Kennedy, Sirianni, & Tse, 2014). Also, the increasing integration of products and services into customer-specific solutions places particular demands on managerial accounting and control beyond traditional concepts ((Wall and Mödritscher 2013)

The analysis of customer journeys helps highlight critical service events and touchpoints that contribute to a customer experience (Rawson, Duncan, & Jones, 2013). The recognition of the customer journey to enhance and manage a satisfying customer experience has driven the growth of the customer journey literature in recent years. In a comprehensive literature review, Tueanrat et al. (Tueanrat, Papagiannidis et al. 2021) have attempted to establish a basic understanding of the customer journey and the phases of such a journey that can be observed in the process. Although the primary stages, "prepurchase", "purchase", and "post-purchase", are unsurprising, the concrete design of the customer journeys then has to be modelled very differently and specifically in the companies. Kotler's five A's of the customer path is a framework that uses five stages (awareness, appeal, ask, act and advocacy) to map customer journeys through the customer relationship (Kotler, Kartajaya et al. 2017). In the “awareness” phase, potential customers are confronted with many brands – e.g., knowing them from former purchases, purchases or word-of-mouth. However, customers are only attracted to a few of these brands he considers attractive in the “appeal” phase. The potential customer will learn more about these attractive brands in the asking stage. Here, various sources of information come into question (e.g., the corporate website, rating and testing portals, and recommendations from friends or influencers. Kotler et al. (Kotler, Kartajaya

et al. 2017) point out that the customer journey in the “ask” phase changes from a personal to a social one (“confirmed” by others in the social relationships). Convinced customers purchase the product or service in the “act” phase. Subsequently, a sense of loyalty to the brand or company is to be established, and further recommendations are to be achieved in the “advocacy” phase.

For each customer segment – designed as an archetypal buyer persona or customer avatar (Schwarz-Musch, Tauchhammer et al. 2022). –, e.g. the course of the journey, the touchpoints, the channels, the possibilities for interaction, the pains and gains must be described in the customer journey maps (Schwarz-Musch, Tauchhammer et al. 2022). In various industries, firms emerge from product suppliers to providers of customer-specific solutions with complex interactions in the customer journey (Wall and Mödritscher 2013). For example, the idea of the so-called *bundling* is that the supplier develops products (e.g., technical equipment), is also intensely involved in using the product on the customer's site, and provides technical maintenance.

2. CUSTOMER VALUATION AS A TASK FOR MANAGING CUSTOMER RELATIONSHIPS

Thus, *customer lifetime value* (CLV) has emerged as one of the critical metrics for managing customer base and customer equity in many companies. Consequently, there has been a common emphasis on the dual creation of firm and customer value since the late 1990s (Boulding, Staelin et al. 2005, Payne and Frow 2005, Moedritscher 2008). Customer relationships are seen as firm assets (Hogan, Lehmann et al. 2002, Kumar, Ramani et al. 2004), and therefore a wide variety of models for the valuation of customer relationships have been developed. With these models, companies try to support the control of the customer portfolio and its influence on shareholder value (Schulze, Skiera et al. 2012). They also try to figure out the relationship between customer value and customer perceived value (e.g. customer satisfaction) (Mödritscher 2008). Finally, they try to indicate allocating resources for (relationship) marketing initiatives.

Marketing costs and value contributions of all regular customers must be considered a basic idea of customer valuation as customer equity (Cornelsen 1996, Rust, Zeihaml et al. 2000) and thus assets that have to be depreciated in time. Customer equity is then compared with *customer-specific payments* (Plinke 1997). This way, the net present value of customer relationships is calculated, representing the total value of customer relationships (Blattberg and Thomas 2001). Models for this value estimation are, e.g. the *Customer Lifetime Value (CLV)* (Cornelsen 1996, Wyner 1996, Dwyer 1997, Gierl and Kurbel 1997, Wilde and Hickethier 1997, Andon, Baxter et al. 1998, Berger and Nasr 1998, Hoekstra and Huizingh 1999, Köhler 2000), the analysis of *customer contribution margins* (Haag 1992, Dwyer 1997, Köhler 2000), *scoring-models* (Schemuth 1996, Plinke 1997, Cornelsen 2000), the *RFM-method* (Dwyer 1997, Krafft and Albers 2000) and the *ABC-analysis* (Scheiter and Binder 1992, Homburg and Daum 1997). In recent years more literature emerged on the topic of *data science*, extensive *data analysis, and predictive and prescriptive methods* for the estimation of CLV (e.g. (Fitria and Aruan 2019, Binh, Thy et al. 2021, Mosaddegh, Albadvi et al. 2021, Tripathi, Bagga et al. 2021, Abbasimehr and Bahrini 2022). It should also be noted that the customer value from a customer perspective (Parasuraman 1997, Matzler 2000) is not discussed here.

In general, these models for customer valuation can be classified into two significant typologies:

- *Typology 1* – static estimation of customer profits (like customer-specific contribution margins) for a specific period.
- *Typology 2* – dynamic estimation of discounted cash flows focusing on the total customer relationship (customer lifetime value, customer equity)

The models following *typology 1* provide a static perspective on the current customer value and mostly neglect the development over time in the customer relationship. Suppose a company focuses on 'traditional' marketing without focusing on customer relationships. In that case, the costs for marketing and sales are usually computed as a percentage of production costs or as fixed costs per order. The disadvantages of this approach are commonly known (Kirchgeorg 2000). If a company provides customer-specific production, sales costs are sometimes computed as customer-specific costs (e.g. activity-based costs) based on an estimation of cost drivers. Although the costs of sales are a significant part of marketing costs in many companies, the rest of the marketing costs have still been calculated inappropriately. This means that besides the marketing costs, marketing-induced production costs (e.g. for customer-specific modifications of products in the production)

are hardly considered (Homburg and Daum 1997). The reasons for this are weaknesses in the cost accounting systems caused by the production focus of the systems. Consequently, one approach for dealing with this problem is the computation of activity-based customer costs for specific customer orders, individual customer relationships or customer segments. However, the issue of static estimation remains as these approaches usually focus on a single period. In this paper, attention is turned to *typology 2*. For this, the Customer Lifetime Value can be seen as "the net present value of all future contributions to overhead and profit" ((Roberts and Berger 1999) (similar: ""The net present value of the stream of contributions to profit resulting from the revenues from customer transactions and allowing for the costs of delivering products, services and promised rewards to the customer." (Pearson 1994)) Therefore, the calculation of CLV for the entire course of the customer relationship can be carried out on a fundamental *level* (cash flows for an average period or specific cash flows for each period (Gupta, Lehmann et al. 2004)), e.g.:

$$CLV = \sum_{t=1}^{n} \frac{CF_t}{(1+i)^t} \qquad (1)$$

With: *CLV*… customer lifetime value; *CF*…cash flows in period *t*; *i* … interest rate, *t* .. period of the customer relationship; *n* …duration of the customer relationship

It can also be calculated higher by including additional monetary and non-monetary parameters (see figure 1). However, it is arguable that the networking potential leads to a double calculation of cash flow (as the network potential of customer A (referring to customer B) and as the base potential of customer B) and that the knowledge capital is not definable in practice. Furthermore, scientific research considers models on this higher level by using Markov chains (Pfeifer and Carraway 2000, Rust, Lemon et al. 2004) or option prices (Hogan and Hibbard 2002, Haenlein, Kaplan et al. 2006) but with low acceptance in practice.

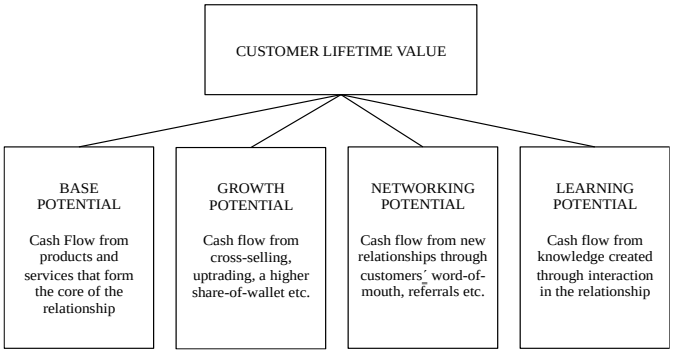

Figure 1. Examples of quantitative and qualitative components of the customer lifetime value (Stahl, Matzler et al. 2003)

Although these methods for customer valuation are well known in science and practice, most are rarely used in companies (Moedritscher 2008). One primary reason for this is that accounting systems are usually based on costs, whereas the estimation of, e.g. customer lifetime values is based on cash flows. This problem is eminently relevant in companies in European countries because of the differentiation between cost accounting and financial accounting. In this paper, we contribute to dealing with this problem on a conceptual basis and, therefore, support the adoption of dynamic customer valuation in practice.

3. LIMITATIONS AND PITFALLS OF STANDARD CONCEPTS OF DYNAMIC CUSTOMER VALUATION

Concerning the weaknesses of the customer lifetime value mentioned above, the following limitations and pitfalls can be identified:

- *Limitation 1 – single investment at the beginning of the relationship*: The assumption that there is just one single investment in the relationship, known future cash flows and reduced scope of action is not reasonable for customer relationships. During the relationship, investments to support cross- and up-selling processes are ongoing.
- *Limitation 2 – lack of predictability*: In customer relationships, it is difficult to predict future cash flows. If relationships have to be predicted for four or five years, companies mostly do not know in detail about their, e.g. products, services, technologies and competitors. Consequently, the use of perpetuities makes no sense in practice, either.
- *Limitation 3 – complexity and distortion*: In some models for customer lifetime value, the result may differ significantly because of factors like retention rate, information value and cross-selling rate.
- *Limitation 4 – accountability of investments*: There are investments in customer relationships that are not directly accountable to single relationships. There is a lack of algorithms for dealing with this problem.
- *Limitation 5 – a massive calculation effort*: Some models require considerable measures and an enormous need for detailed data (e.g. (big data) from CRM systems). Sometimes these costs for the calculation are not practicable.
- *Limitation 6 – use of cash flows*: There are distinctions between financial and cost accounting, especially in European countries. Although there are ongoing developments towards converging the two systems, the calculations of profits of products and customers are based on costs rather than on cash flows. Therefore a customer valuation would have to switch between cost accounting and financial accounting systems.
- *Pitfall 1 – lack of risk evidence*: Customer lifetime values are generally calculated as single-point values. In consideration of uncertainties, a spread of likelihood seems to be more appropriate.
- *Pitfall 2 – wrong managerial conclusions*: Concerning the limitations mentioned above and pitfall 1, there is a high chance of bad managerial decisions concerning customer relationships. In this context, it should be pointed out that most customer relationships have a negative cash flow in the first periods caused by the initial investments, leading to wrong management behaviour because of a behavioural bias like loss aversion (Kahneman and Tversky 1979). Using a cost-based approach, investments are computed as depreciation over time; therefore, initial negative cash flows are not shown.

Because of these limitations and pitfalls, we have tried to develop a different approach for calculating CLV with a higher managerial impact. This allows us to include the concept of estimating an economic value added to the idea of customer journey mapping and to close a significant research gap.

4. DYNAMIC CUSTOMER VALUATION BASED ON COSTS AND REVENUES

Managers usually base their planning processes on experiences from the past, focusing on the commonly used parameters (Bleicher 1997). For this reason, data from cost accounting systems and the expertise in planning based on costs and revenues – not cash flows or payments – should be considered when it comes to customer valuation (Mussnig 2001). But in this respect, one problem arises: costs and expenses differ widely. Common concepts for the customer lifetime value are based on payment calculations based on costs, leading to problematic results. One example is investments: they lead to payments in period 0, but their cost equivalent (depreciation) is calculated in periods 1 to n. The theorem of *Luecke* (Luecke 1955) provides a solution for this problem: subtracting the imputed interests based on the capital invested from the period's profits at the beginning of the respective period (*residual income*). The main advantage is that it is no longer necessary to estimate the customer-specific payment dates if the specific capital investment per customer is foreseeable. This capital investment consists of customer-specific equipment investments, customer-specific demand volume and customer-specific warehouse, e.g., for unfinished and finished products.

With this approach, we also follow the estimation of an Economic Value Added (EVA) based on the residual income. The *EVA* per period is calculated as (e.g., Stern Stewart Management Services, 1993):

$$EVA_t = (ROI_t - i) \times NOA_{t-1} = NOPAT_t - i \times NOA_{t-1} \quad (2)$$

with: EVA_t …economic value added in period *t*; *NOPAT* … net operating profit after tax in period *t;* ROI_t … return on investment in period *t; i* … interest rate (weighted average cost of capital); NOA_{t-1} …net operating assets at the beginning of period *t*

In a dynamic perspective, the net present value of the EVA is calculated as, e.g.:

$$EVA = \sum_{t=1}^{n} \frac{EVA_t}{(1+i)^t} = \sum_{t=1}^{n} \frac{NOPAT_t - i \times NOA_{t-1}}{(1+i)^t} \quad (3)$$

with: *EVA* … discounted economic value added in total; EVA_t … economic value added in period *t*; *i* …interest rate, *t* … period; *n* … number of periods

To deal with the previously mentioned limitations and pitfalls discussed, the Customer Lifetime Value estimation is calculated based on the turnover and cost of the customer-specific solutions as residual income. The prices are either directly eligible for the customer solution or indirectly as targets budgets (indirect costs, costs of indirectly attributable processes and costs for management processes). By including imputed interests in specific customer solutions, the lifetime value of the customer solution can be calculated by discounting the residual profits of the customer solution following the theorem of *Lücke* (1955). This approach allows a controlling of the customer solution over time, not by cash flows (usually used for discounting a net present value of an investment) but by turnover and costs, which seems to be widely applicable in practice. In our approach, we consider the following components:

- *Sales revenues*: The growth and decline rates of the customer revenues are estimated and targeted in collaboration with the sales staff for the life cycle of the customer relationship. Instead, this estimation should be a process for setting targets rather than a prognosis process. Knowing that predictive and prescriptive data analysis is a significant agenda for many companies (Schaeffer & Weber, 2016), this could be a way to deal with the problem that many companies do not have the know-how and resources for massive data science and data analytics (Bley, Giesel et al. 2020). The planning period depends on the planning period of the firm (Kleinaltenkamp 2011) or the product lifecycles of products that are already on the market or have a short time to market. As discussed above, network and learning potentials are not estimated.
- *Fixed Return on Sales*: A fixed return rate is calculated following the basic concept of target costing. This return rate can be considered as following the targets of the customer equity and shareholder value or strategic considerations for managing the customer portfolio.
- *Direct costs of goods sold:* These costs are provided by the cost accounting system and could also consider customer-specific adaptations of products.
- *Activity-based costs for the customer*: These calculations can be based on information about transactions gathered from systems for customer relationship management (CRM) across the customer journey (e.g., costs of specific touchpoints)
- *Target budgets for non-quantity induced costs and target contribution budgets for capacity costs:* If costs cannot be allocated strictly, an appropriate way is to calculate them based on strategic considerations following the considerations for targeted value contribution, sustainability or risk (Reckenfelderbäumer 2003). If this estimation causes difficulties for individual customer relationships, she could be provided by looking at customer segments (and then divided by the number of customers in the segment)
- *Imputed interests*: The planning of customer-specific assets (*CA*, initial investments in the customer relationship, persistent storage of raw material, unfinished and finished products, and accounts receivable) is a precondition for calculating the imputed interests according to the *Luecke Theorem*. In addition, the fixed capital of the already obtained plants could be considered. For planning the capital assets, it is proposed to accept the corresponding depreciated values from the data of asset accounting. The accounts receivable assets can be prepared validly as percentages of the predicted net profits. Concerning the forecasting of raw material supplies, it might be valid for the management to identify these as a percentage of the value of goods and materials employed. The inventory of

unfinished and finished products is predicted based on experience, most validly using the units sold. The weighted average costs of capital (WACC) or a specific risk-adjusted interest rate for the customer (segment) could be considered an interest rate.

Therefore, the Customer Lifetime Value can be calculated as follows:

$$CLV^c = \sum_{t=1}^{n} \frac{CRI_t^c - i \times CA_{t-1}^c}{(1+i)^t} \quad (4)$$

with: CLV_t …Customer Lifetime Value of a specific customer relationship *c;* CRI_t …Customer-specific residual income in period ; CA…Customer-specific Assets of a customer relationship at the beginning of period *t;* ROI_t … return on investment in period *t; i …* interest rate (weighted average cost of capital); NOA_{t-1} …net operating assets at the beginning of period *t;* ; *i …*interest rate, *t …* period; *n …* number of periods

This calculation of CLV over several periods can now be designed against the background of the customer journey. If this is based on the 5-A model according to Kotler et al. (2017), briefly described above, the following structure could be represented conceptually.

	Awareness	Appeal	Ask	Act	Advocacy
Sales Revenues				x	x
Fixed return on sales				x	x
Direct costs of goods sold				x	x
Activity-based costs for the customer (e.g., call center, chats, visits, payed touchpoints)		x	x		
Target budgets for non-quantity induced costs and target contribution budgets for capacity costs	x	x	x	x	x
Imputed interests				x	x

Figure 2. Customer journey and customer valuation

This illustration of a customer relationship and journey (table 2) may be initially designed. The aim is first to establish a customer relationship and allocate customer-related investments (acquisition costs). In the further course of the customer relationship, the Act and Advocacy phases, in particular, can be followed up as an "ongoing customer relationship", where it is usually less difficult to plan and evaluate the customer relationship. Common approaches to calculating customer lifetime value can be applied here (Mödritscher, 2008).

5. CONCLUSIONS AND RESEARCH AGENDA

Due to the limitations and pitfalls of standard concepts of dynamic customer valuation, we still see vast research potential in valuing customer relationships. With our model, we contribute to the extensive discussion on applicable models for calculating Customer Lifetime Values using customer relationship management concepts and customer journey mapping. Our approach provides some essential aspects of controlling customer relationships compared to standard CLV models. With a focus on available data and a target-oriented approach, the value of future customer relationships can be estimated not just for accounting purposes but also for controlling these relationships. Therefore, we focus more on targets than on predictions. This may be an approach, especially for small and medium-sized companies with limited resources for extensive and profound data analytics. As the primary data and information requirements are comparatively low, ongoing monitoring and control of customer relationships could be possible.

For this reason, the managerial implications could be considered high for the proposed concept. Further research could focus on modelling customer relationships and customer journeys in company case studies. This could also shed light on which activities in the customer journey can significantly influence customer lifetime value. This would require a large-scale, quantitative research method planned in a further research project.

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GAMIFICATION AS AN HR TOOL

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ABSTRACT

Computer games have become an established form of entertainment in the consumer industry and are a common leisure activity in many people's daily lives. Aside of hedonistic pursuits of entertainment, games can serve other functions as well as technologies can be re-appropriated for productive use cases. This development has been summarised under the term *gamification*. Educational institutions, companies and associations are increasingly relying on digital games that impart knowledge and skills in an entertaining way. In general, gamification attempts to achieve or generate three main effects: Job satisfaction, engagement, and performance. From a scientific perspective it is undisputed that games, which are used as an entertainment medium in everyday life, can trigger informal learning processes. Games can be used in companies or institutions to sensitise employees to (internal) problems, strengthen the corporate culture, convey changes in sales processes or practice certain everyday behaviours. The literature review has shown that the phenomenon of gamification has become a major focal point of research and is ever growing in popularity.
However, research on gamification is still facing various empirical and theoretical challenges. The field lacks a coherent framework to theoretically and empirically explain underlying psychological processes that occur when people are interacting with gamified systems. Furthermore, there is a lack of research on the contextual factors that contribute to the efficiency and the impact of gamification on employee engagement and organisational productivity. In consequence, there is a need to examine the impact of internal gamification in an organisational context, particularly by looking at the impact of gamification on employee motivation, satisfaction, productivity, and job turnover.
The purpose of the paper is to study gamification and serious games in an intra-organisational context to collect and formulate recommendations for research directions and practical applications. The research is conducted by a literature review of relevant peer-reviewed empirical papers of the last five years that deal with intra-organisational gamification. The goal is to create a concise, up to date literature review on gamification and serious games with a focus on HR applications, to identify examples of driving factors, variables and best practices that can be applied in game design, gamification, and further research avenues. The theoretical framework lenses for the interpretation as well as the critique of current research is provided by the SDT-model, Flow-Theory, and the OCEAN-Model.

KEYWORDS

Gamification, Internal Gamification, Human Resources, Game Elements, Game Design

1. INTRODUCTION

Computer games have become an established form of entertainment in the consumer industry and are a common leisure activity in many people's daily lives (Wünderlich et al. 2020) and as a major part of human practice and culture (Högberg et al. 2019). For more and more children, young people and adults, gaming has become a regular pastime (Witting 2008), making games one of the world's most popular media formats (Van Roy & Zaman 2019). According to Bitkom Research (2021), half of the German population currently plays video or computer games, and the trend is rising (Spies 2022). In the United States, 65% of the adult population regularly engage in computer games as a pastime. As entertainment-oriented technologies are reappropriated for productive uses, games begin serving other functions besides hedonistic self-serving pursuits of entertainment as well.

In consequence our society and reality are becoming more and more game-like: Activities of systems and services traditionally not playful or associated with games are increasingly gamified (Deterding 2015). This development has been summarised under the term *gamification*. The Bunchball company launched the first gamification platform in 2007. It offered game mechanics like points and high score lists for company related engagement (Kodalle & Metz 2022). The concept quickly established itself as one of the major developments

in the field of information systems and other domains (Koivisto & Hamari 2019, Morschheuser et al. 2018). "Gamification refers to the transformation of technology to become more game-like, with the intention of evoking similar positive experiences and motivations that games do (the gameful experience) and affecting user behavior" say Högberg et al. (2019). Gamification has become a rather significant trend in recent years (Wünderlich et al. 2020, Högberg et al. 2019) and is as of 2022 a well-established technique in Human-Computer interaction (Rapp et al. 2019, Korn et al. 2022). Gamification utilises features of interactive systems to motivate and engage users through the targeted application of classic game elements (Polyanska et al. 2022). In the corporate field, specifically the HR-sector, it is used to make employees more productive, efficient and to enhance their skills (spinify 2020). Gamification is being used as a means of training employees in all industries, to create customer loyalty for brands and companies and even influence people to change their behaviour (Rapp et al. 2019). Moreover, it can create a better workplace environment: According to the results of the 2019 TalentLMS survey, employees feel more productive (89%) and happier (88%) at work after the introduction of gamification strategies or tools (Apostolopoulos 2019). Over 70 percent of Forbes Global 2000 companies applied gamification already almost a decade ago (Forbes 2014).

A traditional area for the application of gamification is education and training, where playful approaches have been applied since the rise of pedagogical research. Gamified learning applications are often referred to as serious games (Korn et al. 2022). Serious games can be viewed as entertaining, interactive educational programs (Lampert et al. 2009). In general, gamification attempts to achieve or contribute to three main goals: Job satisfaction, engagement, and performance (Polyanska et al. 2022). The potential of gamification lies within a restructuring of tasks and activities with game elements and playful offers. This can be achieved by breaking down a larger task into subtasks with clear goals and the provision of direct feedback for achievements. Thus, activities are reframed by establishing a meaningful narrative, or creating a social community for support (Koivisto & Hamari 2019).

From a scientific perspective it is undisputed that computer games can trigger informal learning processes. Games can be used by companies or institutions to sensitise employees to (internal) problems, strengthen the corporate culture, convey changes in sales processes or practice certain behaviours from everyday work (Jeske 2022). The literature review has shown that the phenomenon of gamification has become a major focal point of research and is still growing in popularity (Van Roy & Zaman 2019, Mitchell et al. 2020, Polyanska et al. 2022). However, research on gamification is still facing various empirical and theoretical challenges (Rapp et al. 2019). The field is lacking a coherent framework that encompasses the impact of gamification on the various stakeholders (Wünderlich et al. 2020) and fails to theoretically and empirically explain the underlying psychological processes that occur when people are interacting with gamified systems (Van Roy & Zaman 2019). Although research in commercial gamification applications shows broad support for its positive impact on a range of behavioural antecedents and outcomes, concerns have been raised about the (alas unintended) negative as well as potential ethical consequences of gamification in this environment.

Comparatively little is known about the contextual factors that contribute to the effectiveness and impact on employee engagement and organisational productivity (Mitchell et al. 2020). It is simply not sufficient to implement a technically excellent gamification design without considering the diverse and multidimensional aspects of user psychology and engagement (Morschheuser et al. 2018). Current research on gamification lacks a critical lens enabling it to explore unintended consequences of designs (Rapp et al. 2019). To successfully apply gamification in a professional working environment and drive motivation and engagement, it is necessary to utilise appropriate scoring, feedback, and reward systems (Miri & Macke 2021).

1.1 Terms and Definitions

Gamification is the application of game elements and techniques for designing digital games to non-game related systems and services (Becker & Metz 2022). Gamification utilises interactive systems that are engaging and motivating to the users using game elements (Högberg et al. 2019). It is used as an effective engagement tool across many fields and businesses, for example in education, technology adoption, sustainability, health care, and transport (Rapp et al. 2019, Polyanska et al. 2022). The basic goal of gamification is to strengthen or maintain user motivation. Gamification is divided into three categories: External gamification, internal gamification, and behaviour change. External gamification targets the area

outside of a company or organisation, i.e., customers. Internal gamification focuses on the internals of an organisation, thus the employees. Behavioural change refers to situations in which a desirable behaviour, for example the interaction among humans or between humans and a certain (digital) product is stimulated (Kodalle & Metz 2022).

Serious games, digital games or e-business games are terms used to describe the use of applications for targeted learning arrangements (Becker & Metz 2022). A serious game is a game that combines the principal potential of learning by playing, given fundamental characteristics are met. These can be summarised by four central criteria: the characteristic properties of a game, the principle of learning by playing, the interaction regarding usability and playability, and the motivation with the necessary game incentives (Jeske 2022). Game scenarios in a serious game can be viewed as learning tasks to be completed by the learner and therefore represent a method of teaching (Karagkasidis et al. 2022). The content to be conveyed is integrated into the gameplay in such a way that the player must (re-)apply it to be successful (Jeske 2022). Serious games can be utilised in various subject areas, e.g., company policy, conveying values, safety, health management, processes, or internal communication (Becker & Metz 2022).

2. LITERATURE REVIEW

Early research on gamification typically tried to demonstrate that gamified systems lead to better outcomes than non-gamified systems. More recently, advances have been made in understanding the mechanisms by which gamification can achieve these outcomes. Research has focused on how individual game mechanics work (Rapp et al. 2019). The volume of literature on gamification has increased dramatically and is spreading in many different directions. However, what is known about gamification tends to come from fragmented pieces of knowledge, and from a variety of perspectives (Koivisto & Hamari 2019). The literature review is conducted in accordance with Cooper (1988) which seeks to "describe, summarize, evaluate, clarify, and/or integrate the content of the primary reports" (Cooper 1988), via a selected sample of works reviewed in this paper. The theoretical framework lenses for the interpretation as well as the critique of current research is provided by the SDT model (e.g., Ryan et al. (2006)), Flow-Theory (Csíkszentmihályi 2008) and the OCEAN-Model (Satow 2018).

2.1 SDT, Flow Theory and Big Five / OCEAN-Model

A central foundation for gamification research is SDT, or Self-Determination Theory, which is regularly used in classic game design as well (Ryan et al. 2006). It's a theory about motivation and personality and it was developed by Deci & Ryan (2013) (Friedrich et al. 2020). SDT emerged from research dealing with the differences between intrinsically and extrinsically derived motivation. The source of intrinsic motivation is inherent to a behaviour, for example the enjoyment of performing a certain task. Extrinsic motivation on the other hand is separate from a behaviour and is usually derived from its direct outcomes. According to SDT, the core type of motivation underlying playing is intrinsic motivation (Ryan et al. 2006). Furthermore, it describes three basic psychological needs that must be met for such an intrinsic motivation to manifest itself: The needs for competence, for autonomy and for social inclusion (Sailer et al. 2017).

Another fundamental concept or theory in the context of gamification is Flow Theory (Csíkszentmihályi 2008). It focuses on the joy and immersion people perceive when performing an activity. This is characteristic for what Csíkszentmihályi refers to as the flow state in which people are engrossed in their activities to such an extent that environmental stimuli and even their sense of time are blended out (Korn et al. 2022). According to the theory, people strive for the state of happiness that resides within the flow channel. Within this channel, a person can enter the flow state when a constant balance between over- and under-challenging tasks is met. From an empirical point of view, the model bears some weaknesses. The main point of critique is that the state of flow does not depend entirely on the degree of difficulty and the objective skill level, but on the subjective perception of the individual. In consequence, it is necessary to identify the factors that lead to an underestimation or overestimation of an individual's abilities (Csíkszentmihályi 2008).

A common critique of current gamified applications has been the narrow view taken on game design. Often, only a limited set of design elements is utilised, which is then geared primarily towards achieving

immediate engagement by evoking extrinsic motivations and behavioural responses (Rapp 2017, Rapp et al. 2019). A similar assessment can be made for the research studying the effects of gamification. Van Roy & Zaman (2019) for example, highlight the significance of not just studying the effects of gamification but also how gamification works or doesn't on both a psychological and a functional level. However, personality affects response to gamified applications. To make positive use of this fact, certain personality traits can be evaluated in advance to assess how an individual will react to individual gamification elements (Korn et al. 2022). To determine personality types or character traits, the Big Five model — also known as the OCEAN model — is often applied in the field of research and recruiting. The model determines not specific character types but five dimensions of characteristics (Satow 2018): 1) Openness, 2) conscientiousness, 3) extraversion, 4) agreeableness, and 5) neuroticism. These can be assessed using questionnaires. To appeal to as many users as possible, suitable player types should therefore already be considered during game development (Korn et al. 2022).

2.2 Internal Gamification and Serious Games Research

Mitchell et al. (2020) investigated the ethicality of gamification and its potential for practical implications. Utilising SDT they studied the impact of extrinsic motivation, for example social pressure or internalised guilt, on employee's psychological needs, satisfaction, and behavioural intentions. For this they conducted a survey (n = 291) across multiple industries. The results indicate that extrinsic motivation can decrease an employee's autonomy, competence and needs satisfaction. However, when extrinsic motivation is internalised (e.g., through a perceived personal value) it results in an increase in intrinsic motivation, needs satisfaction, and behavioural intention. This illustrates that gamification should not only be enjoyable, but indeed gamification design in an HR context must provide further benefits that are perceived as meaningful and are therefore valued by employees.

Friedrich et al. (2020) analysed the effects of game mechanics on employee motivation and knowledge sharing behaviour in an organisational context as well as the advantages and risks of implementing gamification into internal knowledge management systems. The researchers examined gamification as a method for applying incentives within those knowledge management systems and with it the creation of an incentive system for knowledge management itself. They conducted an extensive literature study of 54 publications that were deemed relevant, including analytical as well as empirical research papers. According to the authors, gamification offers various possibilities to increase employee motivation to engage in knowledge management activities. Long term success is only achievable if knowledge management is combined with an appropriate corporate culture as well as an organisational climate, however.

Polyanska et al. (2022) investigated gamification as an HR tool in the Ukrainian energy market. They conducted a survey (n = 41) among educational and energy sector related Ukrainian individuals who were familiar with the domestic energy industry or had practiced or worked in such enterprises prior. Their goal was to evaluate their perception and identify factors and challenges using gamification. The survey included familiarity with gamification in general, tool efficiency, influence on staff relationships, and methods of gamification. Sixty percent of the respondents had previous experience with gamification in their companies, while 85.6 percent of the respondents reported an increase in productivity when gamification was used in HR management. This confirms its relevance and effectiveness as a tool according to the authors. Finally, the authors conclude that gamification is a useful instrument in HR management, especially for learning and training personnel.

Miri & Macke (2021) analysed how gamification can be utilised to promote employee motivation and engagement at work. They conducted a multi case study of four Brazilian companies that each implement gamification with their employees or whose business offers gamification solutions focused on personal management, thus highlighting different aspects and differing approaches to gamification and serious games. The authors found that gamification cases illustrated more difficulty producing motivation and engagement compared to serious games applications, which were better suited to promote motivation and engagement at work through the tools used.

Allal-Chérif et al. (2022) analysed value creation through serious games along five dimensions: 1) product design, 2) cost optimisation, 3) impact on cognition, 4) experienced emotions, and 5) the socialization process. Utilising a mixed exploratory method, the authors led 11 semi-structured interviews with employees of the AXA insurance firm and subsequently conducted a case study of the company. They

compared five different staff training methods: face-to-face, videoconference, non-tutored e-learning, tutored e-learning, and serious games. The qualitative study showed that serious games create value in five dimensions: conception, optimisation, cognition, emotion, and socialisation. This suggests that the value created by serious games differs significantly from the value created by other learning methods. In addition, managers also recognise a higher added value than trainers and learners. The authors recommend combining serious games with other training methods and to create a balance between face-to-face and distant-learning phases.

Gupta et al. (2021) focused on the challenges practitioners must overcome when their employees are using gamified applications online. Utilising flow and engagement theories, they investigated the challenges of implementing gamification in HR practices among selected Indian companies. A total of 28 semi-structured interviews were conducted with individuals originating from different parts of the world. Using a thematic analysis, they then interpreted the transcribed interviews. The researchers identified three prevalent factors which they labelled organisation, employee, and job specific. The emergent framework suggests a moderating role of organisation-specific factors such as leadership and organisational culture in the relationship between job-specific and individual factors, as well as engagement at work.

Hammedi et al. (2021) examined the effect of a gamified work environment on front line employee's wellbeing and performance in the competitive industry of retailing and telemarketing. Using a mixed method approach they conducted 21 in-depth interviews with front line employees and five with their managers. This was followed up by two field experiments to test the hypotheses formulated based on the interviews. Ninety-four employees participated in these experimental studies. The first experiment featured a sales competition in which the impact of gamified work on the workers performance was assessed, mediated by their level of job engagement. The second field experiment investigated how the employees' well-being, represented by job satisfaction, mediated the negative effect of gamified work on job performance. The researchers were able to confirm a negative effect of gamified work in retail business: Job satisfaction significantly impacts engagement and performance in a gamified context. Therefore, the adoption of gamification must be considered carefully to utilise its potential to improve job satisfaction, engagement, and performance.

The presented results of the reviewed studies have been compiled in a review matrix in Table 1. As previously mentioned, SDT- and Flow-Theory are the predominant theoretical frameworks utilised in gamification research. Qualitative methods such as expert and in-depth interviews as well as case-studies are the preferred methods in the reviewed papers. The studies indicate the positive impact of gamified workspaces. However, utilisation and frequency, as well as workspace climate, management, and intrinsic motivation and perceived value play key roles in the success of gamification as an HR tool.

3. CONCLUSION

The literature presented demonstrates the importance of interdisciplinary cooperation between technical, managerial, and scientific fields regarding the planning and implementation of gamification. Among the main advantages of gamification that have been assessed lie improvements in staff motivation, learning, corporate culture, and internal communications (Polyanska et al. 2022). To facilitate further development of gamification as well as providing guidance for future literature, a larger scale review would be beneficial to map the progress in application, theoretical framework development as well as the long-term impact of gamification (Koivisto & Hamari 2019).

There are justified concerns among scholars over the lack of theoretical, methodical (Rapp et al. 2019), as well as ethical implications (Mitchell et al. 2020). In addition, there is a lack of research on contextual factors influencing the impact of gamification on employees' engagement, efficiency, and productivity. Especially in internal gamification more research is needed to understand how and when gamification in organisational settings leads to favourable outcomes (Wünderlich et al. 2020). For example, Miri & Macke (2021) concluded that it was more difficult to evoke motivation and engagement through gamification compared to serious games in a work environment. While this study cannot be considered representative for every work environment and every gamified application tool currently used, it merits further research into how and when motivation and engagement can or cannot be achieved by means of gamified systems and services (Miri & Macke 2021).

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Table 1. Review matrix of presented studies

Author(s) (Year), Publication Type	Sample/ Country, Industry	Theory	Method	Independent Variable(s)	Dependent Variable(s)	Key Results
Friedrich et al. (2020), Journal Article	54 peer reviewed articles between 1980 and 2017 with specified keywords	SDT	literature review			Gamification provides possibilities to increase motivation of employees for knowledge management activities. Long term success only in combination with appropriate corporate culture climate.
Mitchell et al. (2020), Journal Article	291 individuals who were using a gamification application at work	SDT / Cognitive Evaluation Theory (CET)	online survey	identified regulation, introjected regulation, external regulation	CET needs satisfaction, relatedness satisfaction, motivation, intention	Extrinsic motivation can decrease employees' autonomy and competence needs satisfaction, but when internalised, it can support needs satisfaction, intrinsic motivation, and behavioural intention.
Polyanska et al., Journal Article	41 Ukrainians from educational and related areas familiar or experience with the energy industry		online survey			Confirms relevance and role of gamification in HR management in, concluded 60% of the respondents had experienced it. 85.6% of the respondents reported increase in productivity when using gamification in HR.
Miri and Macke (2021), Journal Article	4 Brazilian tech companies utilising gamification in their business model		qualitative case-study			Gamification cases showed higher difficulty producing motivation and engagement, serious games showed it was easier to promote motivation and engagement at work.
Gupta et al. (2021), Journal Article	28 semi-structured interviews including game designers and HR practitioners	Flow-Theory	semi-structured interview			Emergent framework of individual-, job-, and organisation-specific factors proposes a moderating role of individual and job-specific factors as well as engagement at work.
Allal-Chérif and Jaotombo (2022), Journal Article	11 semi structured interviews with AXA employees		semi-structured interviews, case-study			Value created by serious games is significantly different from value created by other learning methods. Managers recognise significantly higher value creation.
Hammedi et al. (2021), Journal Article	21 interviews with front line workers, 5 interviews with team leaders of call centres, 94 participants in field experiments	organismic integration theory (sub-theory of SDT)	in-depth interviews and 2 field experiments	willingness to participate, job satisfaction / engagement, cooperation, income, …	job satisfaction/ engagement, performance	Highlights negative impacts of gamified work on employee engagement and well-being; willingness of employees to participate in gamified work moderates these negative impacts.

Furthermore, research should investigate the conditions under which gamified systems can be successfully implemented in various scenarios within different organisations and which game mechanisms work best for a given scenario (Polyanska et al. 2022). Future research should also investigate and determine how science and technology defines effectiveness of gamification and serious games in a work environment (Allal-Chérif et al. 2022). Another factor that has been neglected in research to date is the social component. As Morschheuser et al. (2019) point out, gamified solutions utilising both cooperative and competitive structures are potentially the most effective. However, more research is needed to understand how and under which conditions collective, collaborative, and competitive behaviour in gamification can be harnessed to improve its outcome. Therefore, future gamification research should explore the possibilities of incorporating these social components into gamification approaches (Koivisto & Hamari 2019). Furthermore, research must go beyond only measuring the effectiveness of specific mechanisms (Friedrich et al. 2020).

From a methodological standpoint the current research lacks exploratory and confirmatory approaches such as surveys and experimental studies (Polyanska et al. 2022). Research should therefore provide more quantitative evidence to explore sustainable gamified applications in digital human resource management (Gupta et al. 2021). Hammedi et al. (2021) suggest employing a combination of methods including surveys and diary studies as well as experimental designs. Especially studies that provide measurements of long-term effects of gamification in the corporate context are still rare (Friedrich et al. 2020). Moreover, longitudinal data is crucially needed to identify causality. In consequence, longitudinal studies are required, especially to investigate the impact of extrinsic motivation in gamified environments (Mitchell et al. 2020). Finally, gamification must be critically reflected from an ethical standpoint. As Hammedi et al. (2021) pointed out, poorly implemented gamification can also be harmful to employees' satisfaction and engagement, and in consequence to their organisations. Long-term impacts of game design and gamification on individuals and society are still underdeveloped as a whole and warrant further investigation (Rapp et al. 2019).

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CONSTRUCTION MANAGEMENT IN PRACTICE

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ABSTRACT

The paper provides a comprehensive overview of construction management and individual leadership positions on the construction site. It aims to present the application of construction management in practice. The basis is the definition of the term management itself, according to the most famous authors and a smooth transition to the specification of the term construction management. In general, based on the intersection of the definitions of several authors such as Taylor; Van Fleet and Peterson; Kreitner; Koontz; Megginson, Mosley, and Pietri, management is the act of conducting or supervising something. On the other hand, construction management manages all aspects of a construction project professionally and effectively. This overview paper is supplemented with a graphic display of relevant indicators from the field of construction, the primary source of which is the statistical portal www.statista.com. The result is identifying and characterising positions such as project manager, construction manager, foreman, construction supervisor and chief technical supervisor, while based on practice in the Slovak Republic. The methods of analysis, synthesis, induction, deduction and statistics were used. To conclude, this overview paper provides recommendations for construction management, mainly in the conditions of the Slovak Republic.

KEYWORDS

Management, Construction Management, Project Management, Foreman, Supervisor

1. INTRODUCTION

Even though construction management is a relatively young discipline, constructions were built long ago, the implementation of which showed elements of construction management. Nowadays, with the ever-increasing competition of construction companies in the market and the ever-increasing demands for speed and efficiency of work, it is necessary to apply project planning methods as best as possible in the preparation and implementation of construction projects (Vartiak, 2015; Mlynar, 2018).

In general, management is essential for everyday life and necessary to run all types of companies, institutions and organisations. Efficient management is the backbone of successful organisations. "Managing life means getting things done to achieve life's objectives, and managing an organisation means getting things done with and through other people to achieve its objectives." Management represents a set of principles relating to planning, organising, coordinating and controlling, and applying these principles together in harnessing physical, financial, human, and informational resources efficiently and effectively to achieve organisational aims (Kukreja, ret. 2022).

According to the Merriam-Webster online dictionary (ret. 2022), "management means the act or art of managing, as well as the conducting or supervising of something (such as a business)." The term management also represents "the collective body of those who manage or direct an enterprise" or "judicious use of means to accomplish an end." Synonyms of management include:

- administration,
- care,
- charge,
- conduct,
- control,
- direction,

- governance,
- government,
- guidance,
- handling,
- operation,
- oversight,
- presidency,
- regulation,
- running,
- stewardship,
- superintendence,
- superintendency,
- supervision.

According to Taylor, "Management is an art of knowing what to do, when to do and see that it is done in the best and cheapest way." Van Fleet and Peterson define management as "a set of activities directed at the efficient and effective utilisation of resources in the pursuit of one or more goals." The definition of management by Kreitner states that it "is a problem-solving process of effectively achieving organisational objectives through the efficient use of scarce resources in a changing environment." Koontz defines management as "an art of getting things done through and with the people in formally organised groups." Finally, Megginson, Mosley, and Pietri characterise management as "working with human, financial and physical resources to achieve organisational objectives by performing the planning, organising, leading and controlling functions" (Kukreja, ret. 2022).

The use of management is as old as a human civilisation due to being an integral part of human living and is essential wherever human efforts are undertaken to achieve desired aims. If we want to define the term management more precisely, we will find that it appears in three primary forms (Drucker, 2008; Stofkova, Stofkova, 2011; Majerova, Krizanova, 2015; Fabus, Kremenova, Fabusova, 2017; Garbarova, Vartiak, 2022):

Management as a process expresses the interconnectedness and interconnectedness of such activities as planning, organising, leading people and controlling, which enable the setting and achieving the company's goals. Management, in this sense, expresses the practical activity of managers representing the management of a business or some other organisation. It means that managers within management set goals, define tasks, secure resources, involve people in activities, coordinate activities, and monitor the fulfilment of set goals.

Management as a profession refers to a group of people who ensure the management process and are responsible for the course of this process, i. e. to, managers. Management, in this sense, consists of managers who are responsible for the management of the organisation as a whole, as well as for the management of its departments and other organisational units (for example, operations, workshops, and departments). The management of the organisation includes managers from the position of the highest-ranking manager (e.g. director, general manager), who is at the head of the organisation's management, through managers responsible for managing the central functional departments and relatively independent units (directors, heads of plants, operations and professional departments), up to managers at the lowest level of management (head of the department, workshop foreman).

Management as a scientific discipline is derived from the existence of a theory that focuses on the constant improvement of approaches, tools, methods and techniques that allow managers to improve the management process and thereby ensure successful management of the organisation. Within this scientific discipline, scientific branches also focus on specific management problems in various areas (financial management, human resources management, etc.).

2. RESULTS

Construction management is a term used to describe the part of management aimed at construction projects. In general, construction management includes organising and coordinating all the people who are involved in or can exert influence on the construction project directly or indirectly by using construction management functions presented in Table 1 (Haghsheno, 2015; BuildBook Team, 2022).

Table 1. Construction management functions

Construction management function	Definition
Planning	Planning may be the most critical job a construction project manager is required to do. Planning a project involves anticipating the actual work and risks that can impact the budget, timeline, and safety.
Coordinating	Coordinating includes the organisation of people, materials, and equipment, which may be one of the most challenging things they need to handle.
Budgeting	Budgeting means deciding how much money is needed to complete the construction project.
Supervising	Supervising involves more than just telling people what to do. A construction manager is responsible for the safety of those on-the-job sites. In some cases, training is required to ensure that safety protocols are understood and followed.
Reviewing & Documenting	The best construction managers appreciate the value of a project review and make it a formal part of the project plan. A construction manager takes time to talk with the project team and get their insights into what went well and where improvements are needed.

"Construction management is, in essence, professionally and effectively managing all aspects of a construction project on behalf of the project's key stakeholders. This includes meeting the project's objectives on time and within budget" (Haghsheno, 2015; BuildBook Team, 2022):

- **Internal stakeholders** are project owners, project sponsors, suppliers, contractors, subcontractors, consultants, and the end users of the finished product that are directly involved in the construction project, such as our unions, politicians, licensing and inspection organisations, and the surrounding community.
- **External stakeholders** include government agencies, support staff, lab y that don't have to be directly involved in the construction project.

The construction industry is one of the essential industries of the EU economy (Figure 1, Statista.com, 2022). The sector provides 18 million direct jobs and contributes to almost 9% of the EU's GDP. It also creates new jobs, drives economic growth, and provides solutions for social, climate and energy challenges (European Commission, ret. 2022). The number of European companies in construction is 3,668,528, which represents 8.13% of all 45,110,074 companies in the HitHorizons database. Spain has the highest number of companies operating in construction in the EU. European companies operating in construction generate € 3,197,254,839,168 in sales per annum, which represents 4.07% of sales of all companies available in the HitHorizons database. European companies operating in construction have 28,177,934 employees, which means 6.12% of all employees of companies available in the HitHorizons database (HitHorizons, ret. 2022).

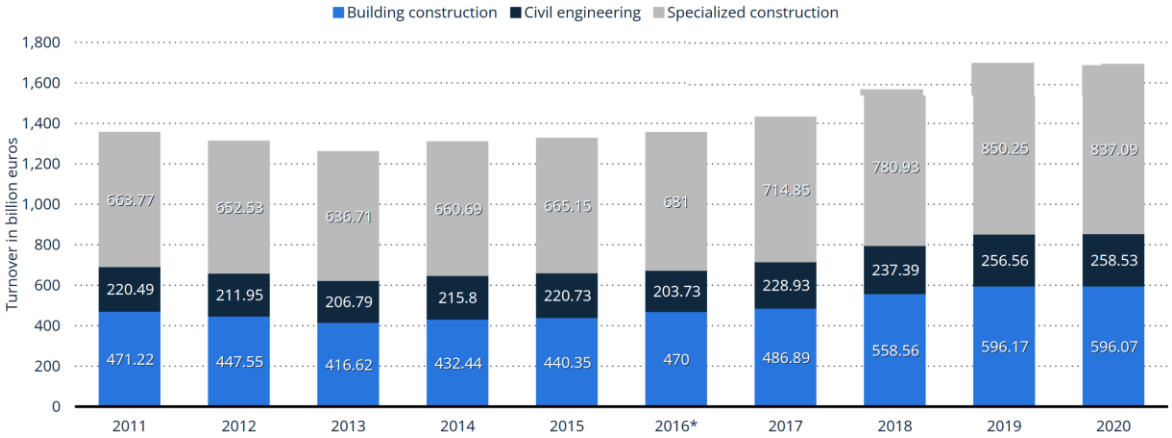

Figure 1. Annual turnover of the construction industry in the EU from 2011 to 2020 by segment (in billion euros)

A construction company is a business entity with predominant construction activity. The construction work is created on the construction site of the building plot. The character of creation is a specific individuality of each separate construction work. A construction company is an organisational grouping of workers (Figure 2, Statista.com, 2022), machines and equipment which aim to conduct construction in the required time, with quality and a sure profit. It is no longer enough to ensure timely and high-quality construction implementation in the current market conditions. Above all, the construction company must implement the construction at a profit. Only such an implementation will allow the construction company to cover the needs of the company and its workers and to invest in new technologies (Fabianova, 2013).

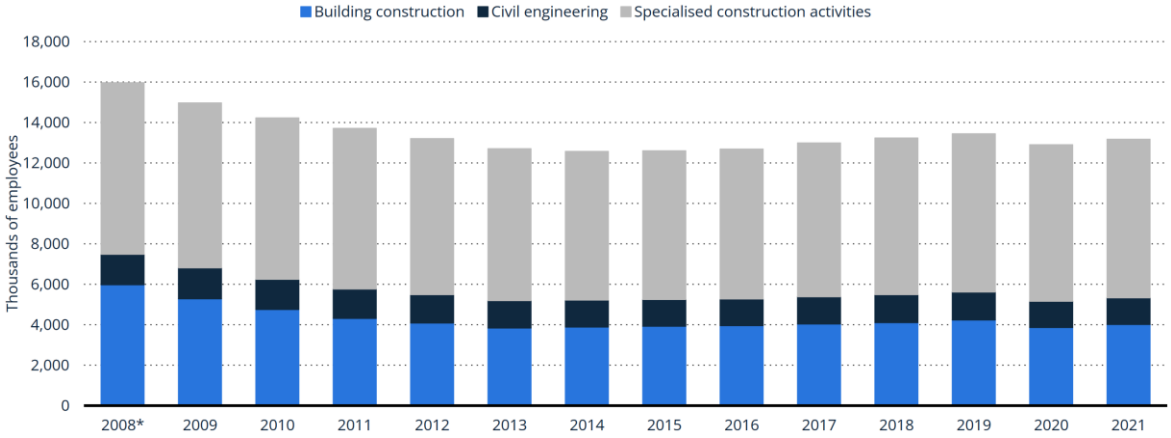

Figure 2. Number of employees in the construction industry in the EU from 2008 to 2021 by segment (in 1,000s)

"Construction management involves directing and organising each part of the project life cycle, from ideation to completion. It's a holistic practice to deliver projects on time and under budget." Construction management is a complex discipline that requires addressing many essential concerns while relying on many team members (Jarsky et al., 2003; Tomankova, Capova, 2013; Mlynar, 2018; EcoSys, ret. 2022, Rittenberg, Bottorff, 2022):

Project manager – A project manager is the main person for the construction company's principal aims by implementing necessary steps and managing teams. "Project managers are involved in the planning, implementation and ongoing support work for company-wide undertakings." They are point mediators between construction teams when something is going wrong.

Construction manager – The construction manager represents the contractor on the construction site. His task is to manage the project's construction concerning legal regulations, safety and health protection and project documentation. Therefore, he must have broad technical knowledge. He should be able to manage construction works and communicate with the parties involved in the project implementation. He directly addresses the foremen on the construction site, is in direct communication with the investor and cooperates with the author and technical supervisor of the construction. His work depends on the data obtained from construction preparation. This data relates to budgets, planned costs and time schedules. Based on these input data, the construction manager manages his implementation of the construction project.

Foreman – Several masters are involved in the implementation of construction projects. Their number depends on the size and complexity of the construction project. They are directly subordinate to the construction manager and are responsible for the completed construction work on the construction section entrusted to them. They ensure that these construction works correspond to the project documentation, comply with the required quality and are completed within the set deadlines. The foreman directs and controls his assigned workers. He gives work to them, checks their attendance, and ensures that they have the necessary materials needed for work.

Construction supervisor – The designer of the construction project carries out the author's supervision on the construction site. The scope of copyright supervision is determined by the contract between the investor and the designer. The main task of the author's leadership is to check the conformity of the completed work with the project documentation. It also approves any changes that occur due to changes in material and technological procedures.

Chief technical supervisor – The investor of the construction project provides construction supervision of the building, and the investor can perform this supervision himself or delegate it to another engineering company. The task of construction supervision is to check whether the construction is carried out according to the agreed documentation and that the budget costs do not exceed the expenses in the approved budget.

3. CONCLUSION

The paper aimed to present the application of construction management in practice. It examines the main terms and definitions from management to construction management, construction industry and construction company. The paper analyses the current state of the construction industry in the EU.

Based on the research results oriented on the empirical application of construction management, we identified and defined the crucial positions in the construction management team, including project manager, construction manager, foreman, construction supervisor and chief technical supervisor.

The results are presented in the form of text and graphs, which makes them clear enough for a wide audience, from experts in the field to students.

In the future, we have the ambition to deal in more detail with key indicators in the construction industry in the Slovak Republic and compare them with the EU.

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FACTORS THAT INFLUENCE THE PERFORMANCE OF A MULTI-SIDED MARKETPLACE: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Many retail companies based their revenue growth strategies on creating and expanding their marketplaces, a disruptive business model that benefits from the interactions between partners and network effects. For sellers, it provides infrastructure, traffic and training; for customers, it ensures security and better shopping experience; the marketplace (intermediary) benefits from greater scalability and exponential increase in sales. However, each party must manage some risks and operational costs of the business model, such as information asymmetry, dependency and governance. To better understand a multi-sided marketplace, a systematic review of the literature was carried out, showing how each party collaborates with its success, but also the restrictions and risks for each of them.

KEYWORDS

Marketplace, Retail, Digital Platform

1. INTRODUCTION

Multi-sided marketplaces (MSM) are digital platforms (DP) applied in the context of e-commerce that facilitate the interaction and exchange of products and services between third-party providers and end-customers (Hänninen et al., 2019). The power of MSM comes from their ability to tap into a large group of end-customers and providers (Gawer & Cusumano, 2014b). A key feature of MSM is its scalability. Furthermore, it makes use of supply and demand data, as well as merchandise, logistics, customer service and payment information to create a harmonic customer experience through the digital platform-based ecosystem (Hänninen et al., 2019). According to Ardolino et al. (2020), although MSM have been discussed in the literature, little research has dealt with the characterization of this type of business. Most studies develop analytical models focusing on a specific feature of multi-sided platforms, such as price structure, network externalities or competition, while a holistic approach to characterize the multi-sided platforms is lacking. The intent of this study is to analyze which factors in the relationship between parties at a MSM influence the business success as a whole.

Marketplace´s expansion strategies are based on the external hiring of suppliers of products and services, with increased variety and diversity of offers for the customer, without the need for greater investment in inventory. The largest portfolio of products offers advantages for the marketplace like commissions on products sold in the platform, greater visitation on the site, increase of the average ticket and sale, customer loyalty and additional data about the customer´s preferences and purchase process. On the other hand, the marketplace, responsible for the final delivery quality and customer loyalty, depends on the quality of the products and services of third-party providers (Ramos, 2016). From the seller's point of view, the strategy of using marketplace as a sales channel generates scalability and increase in sales, using site traffic and audience diversity of the intermediary. The seller's offers are linked to the marketplace´s consolidated brand and credibility. Other advantages for the seller include the use of the structure, tools and monitoring functionality of marketplace, low initial investment, free marketing, less investment in technology and learning with the big retailer. However, the seller's dependence on marketplace is dangerous, considering the high bargaining power of the latter. There is low visibility of the seller's brand, decreased profit margins with

commissioning on sales and increased bureaucratic processes (Zacho, 2017). The relationship between companies (marketplace and sellers) affects the customer experience. Among the positive factors for the customer are the greater variety of stores and items per store, the practicality of the purchase, the safety offered by the recognized brand of the marketplace, savings in shipping costs when concentrating purchases of different items in the same place. But there are negative factors arising from this business model, like the lack of support and privacy issues.

Therefore, MSM offer advantages and disadvantages for all parties involved – marketplace, sellers and customers. This study aims to better understand MSM by conducting a systematic literature review. The following research question guides our scientific inquiry: *How do the different factors of the relationship between parties in the context of platform-based multi-sided marketplace influence the business success?*

The remainder of this article is organized into four sections. The second section explains the research methods of the literature review, including the systematic process conducted in this analysis. The third section realizes a bibliometric and descriptive analysis of the articles in the literature. The fourth section shows a content analysis and consolidates the main factors that affect this business model. Finally, the last section brings the conclusions and some limitations of the study.

2. METHODOLOGICAL PROCEDURES

This paper is based on the Systematic Literature Review Process published by Charters et al. (2009). It starts with the definition of the research question (see above), that is the guide of the entire conduct of the research. The next step was to define the strategy of search and selection of studies that should be included in the list of papers of the systematic literature review. The search thread used in the project was: "Digital platform" and the equivalent terms: marketplace or "two-sided market" or "multi-sided market" or "intermediary market". The citation search was performed using the Aguia Portal from the Faculty of Economics and Administration (USP) on March 2022. Aguia Portal consolidates 313 different data bases, including for instance, Elsevier Science Direct, Scopus, Web of Science, Google Scholar. Our search returned 995 documents. In line with other relevant and recent systematic literature review studies, only peer reviewed articles were selected. We also removed duplication and overlaps, reducing the initial sample of articles to 534 documents. The process of selecting the papers was done in three phases. First, the researcher evaluated each paper for inclusion in the set of candidate papers based on title and abstract. The excluded articles did not focus on the retail segment, but mainly on transportation, hospitality, communication and advertising, health care and education. As a result, a total of 54 documents were selected. After this selection, the researcher selected only papers published on magazines with CiteScore higher than 4,0, to ensure the quality of the study. The final inclusion/exclusion decision took place when full papers were read in parallel with data extraction and quality assessment, following Kitchenham & Brereton (2013) strategy. In this phase, the excluded articles did not focus on MSM and its applicability in the retail segment.

A total of 25 papers satisfied the above mentioned criteria and were the basis for the content analyses. The descriptive and content analysis included synthesizing the articles in a narrative by systematically describing, reporting, tabulating and integrating the features and results of the studies. First, a bibliometric and descriptive analysis was used, which included yearly distribution, thematic analysis and research techniques. Next, the content analysis was fundamental to address the research question. We used a structure method to code all the selected papers. During a preliminary analysis of a sample of articles, a list of codes of categories (factors) that influence the MSM business was developed. The data interpretation consisted of making note in all the papers of these codes and others that emerged during the analysis. The qualitative data analysis software Atlas.ti 9.0 was used to organize the documents and set the codes in the texts.

3. BIBLIOMETRIC AND DESCRIPTIVE ANALYSIS

Petticrew, M. & Roberts (2006) recommend that the initial key task for data analysis in a systematic literature review involves summarizing the results of the articles, according to the study's objective. We first conducted an assessment of the characteristics of our sample by performing a bibliometric and descriptive analysis. The analysis shows the growing interest in MSM and DP topics since 2018, as they are increasingly

being adopted in business. The research collected papers from journals in different subject areas, with a focus on management journals, as DP and MSM affects the business model of the firm with impacts on the economic and social environments. The selected articles used different methodological approaches, with predominance on theoretical research. More important than listing the journals´ subject area, is to analyze the scope of the articles, i.e., the main focus for which the study is directed. There is a clear focus on the impact of DP for companies (small and medium enterprises, entrepreneurship, companies with digital transformation strategies) seeking to grow in the local or international market. Customer experience on digital platforms is also the subject of recent studies. In summary, the analysis of the categories suggests that the themes DP and MSM have generated interest in recent years, focusing on its impact on businesses and consumers. There are opportunities to explore the theme in qualitative and quantitative research, aiding the strategies for new companies or established ones which are applying the digital transformation process.

4. CONTENT ANALYSIS

The reading and analysis of the articles revealed many characteristics of MSM that help to understand not only how each party collaborates with the success of the business model, but also the restrictions and risks for each of them.

4.1 Contributions of the Parties

Marketplace: Marketplace offers many advantages for the sellers. **The infrastructure and usability** factor is composed of the tools made available to sellers to facilitate the sale of its products and services to the final customer (L. Li et al., 2018), like the advanced technical functionalities, especially the data analysis tools, that allow sellers to know more about their businesses and customers. The marketplace also drives the phenomenon of **intermediation**, which allows higher traffic for the sellers (Kenney et al., 2019; Nambisan et al., 2018; Rangaswamy et al., 2020; Rogers, 2019; Seevers et al., 2010). Intermediation happens when a platform builds such a broad customer base and becomes such a valuable interface for customers that other companies cannot afford to waste the opportunity to reach customers through this new intermediation (Rogers, 2019). Another benefit is the **training** offered by the marketplace to sellers, assisting their digital transformation (L. Li et al.,2018). For the customers, marketplace offers **reputation and trust** (Jean et al., 2021; Saberian et al., 2020; Rogers, 2019; Taeuscher, 2019). According to Saberian et al. (2020), customers' level of trust in a platform is a key determinant of whether they will use its platform services. **Customer experience** is believed to be the key competitive advantage for brands, above other factors such as price or product (Saberian et al., 2020; Hänninen et al., 2019; Hänninen & Smedlund, 2019; Verhoef et al., 2009). The final benefit is the **value-added by the platform**, as exclusive attributes and benefits of the platform and free content (Rogers, 2019).

Sellers: Sellers provide **scalability and product diversity** for the MSM ecosystem (Dell'Era et al., 2021; Hagiu & Wright, 2015 ; Rangaswamy et al., 2020; Saberian et al., 2020; Vakeel et al., 2020). According to Saberian et al. (2020), platforms have no warehouse inventory, or as a hybrid platform such as Amazon.com, that combine both warehouse inventory and no warehouse inventory models. They also leverage the **direct network effects**, as a higher number of sellers improve knowledge spillovers among complementors (J. Li et al., 2019). Another important contribution of the sellers is that they provide relevant **seller´s data** for the marketplace regarding product demand, payment conditions and supply information (Hänninen & Smedlund, 2019; Nambisan et al., 2018). Sellers also relate directly with customers providing **services**. In order to ensure end-customer satisfaction in such a dynamic marketplace, suppliers have to become responsive customer service organizations.

Customers: The **customer´s data** is a contribution that the customers give to MSM (Hänninen et al., 2019; Krafft et al., 2021; Mansell, 2015; Rangaswamy et al., 2020; Vakeel et al., 2020; Zaki, 2019). According to Ikeda & Marshall (2019), when used effectively, data enables companies to strategically perform analytics to better predict the experiential wants of their customers. **Consumer crowdsending** denotes the consumer's own contribution of products, services, and content for the MSM (Wichmann et al., 2022). Reviews influence other customers purchasing behavior. Gawer & Cusumano (2014) state that **network effects** can be very powerful, especially when they are direct between the platform and the user of the complementary innovation.

4.2 Risks for the Parties

Marketplace: Platform **governance** provides access, support, guidance, and incentives to various ecosystem participants (Tiwana, 2014 apud J. Li et al., 2019). A recognized challenge in platforms is how to establish governance mechanisms that appropriately bind participant behavior without constraining their innovativeness (Constantinides et al., 2018; Schilling, 2002). **Outside competition** occurs among platforms as they compete to get the users on board their platform (Ardolino et al., 2020; McCarthy et al., 2021; Penttinen et al., 2018). According to McCarthy et al. (2021), the networked nature of the web, combined with the economics of preferential attachment, increasing returns and global trade, suggest that over the long run a small number of competitive giants are likely to dominate each functional market segment. The larger the market power digital platform wields, the greater the responsibility local governments should have in monitoring and preserving market competition. Debates on legitimacy of government lobbying and antitrust policies will become more relevant in public discourse. (Ardolino et al., 2020; Kenney et al., 2019; Nambisan et al., 2018; Song, 2019). New **rules, regulation** and antitrust policies should impact the marketplace.

Sellers: Sellers should be concerned about **internal competition** (Boudreau, 2012; Wichmann et al., 2022), as brands have difficulty differentiating from competitors because aggregation platforms standardize product presentation, limit the use of branding elements and encourage simple comparison on a few key features (Wichmann et al., 2022). **Information asymmetry** between exchange parties can cause an adverse selection, which occurs when the party with better private information about the product quality selectively participates in transactions that benefit itself at the expense of the partner (Jean et al., 2021; Vakeel et al., 2020). The information asymmetry increases the bargaining power of the marketplace. The platform can raise prices for customers, lower payments to providers, overcharge other participants on other sides of the market, and restructure the terms of participation to complementors to capture an inordinate amount of the economic value generated by the ecosystem (Kenney et al., 2019), showing **the dependence** risk for the seller (Kenney et al., 2019; Penttinen et al., 2018; Wichmann et al., 2022; Zacho, 2017). The prices a DP charges its users on one or more sides is the primary mechanism for value appropriation, which we call **cost of affiliation** (Penttinen et al., 2018; Rangaswamy et al., 2020). The price might have different components, such as a membership fee to join the platform, a usage fee based on the number of transactions, or a commission on transactions (Rangaswamy et al., 2020). Finally, the seller must follow many **bureaucratic processes** dictated by the marketplace (Kenney et al., 2019; J. Li et al., 2019).

Customers: Considering the perspective of the customer, **lack of adequate support** can restrict their use of the MSM. Hannah & Eisenhardt (2018) single out bottlenecks as the component that most constrains the growth or performance of the ecosystem due to poor quality, poor performance, or short supply. When customers provide data to the marketplace, they can face **privacy issues** (Mansell, 2015; Evans et al., 2013). Napoli (2014) argues that it is essential to have an insight into the extent to which the changing velocity, volume and value of data supported by intermediaries are encouraging citizens to "embrace algorithmically driven decision-making tools". Many countries are discussing their citizens' rights when using DP.

5. CONCLUSION

The systematic review of the literature allowed the identification of several aspects relevant to the success of MSM. While the increased participation of MSM in retail market and its benefits attract many companies, one should also evaluate the costs and risks before joining or launching an MSM. MSM is a disruptive phenomenon on the retail market, with high impact for the companies, as showed in the study. The understanding of the factors that affect the performance of a MSM and the relationship between players is fundamental for guiding the strategies in this business model. There are, however, some relevant limitations for the study. It is impossible to completely avoid personal bias during the systematic literature review, hence the researcher may have missed some relevant papers.

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Short Papers

AUGMENTED REALITY IN PRIMARY SCHOOL GEOGRAPHY: COGNITIVE GOALS AND USABILITY

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ABSTRACT

The purpose of this study was to examine the application of Augmented Reality (AR) Application in the Geography lesson of Primary School. The application covered the Earth's atmosphere and was evaluated by 71 students in the sixth grade of primary school who completed questionnaires before and after the educational intervention. The results were positive, since most cognitive goals were achieved, and application proved to be interesting and easy to use for students. The significance of this study is twofold. A new ready-to-use digital educational tool was created, while at the same time it is one of the few studies that have investigated the efficiency of AR in terms of cognitive and usability goals with a large sample of students.

KEYWORDS

Augmented Reality (AR), Mobile Learning, Geography Lesson, Primary School, Teacher Support Tools

1. INTRODUCTION

In recent years, augmented reality technology has been used in a variety of sectors. Education, particularly play and learning, is one of them, both in new subjects like computer science and in pre-existing ones like geography lessons (Yavuz et al 2021; Hincapie et al 2021; Schnürer et al 2020). Applications are a powerful tool that can be used to complement and support teaching while enriching learning in the learning process (Ramnarain-Seetohul, Nishesh, & Siddish, 2019). Students more easily understand the concepts that are being taught to them, while at the same time, the usual learning process turns into an exciting experience (Roopa, Prabha, & Senthil, 2021).

According to the New Greek Curriculum, the teaching of Geography lesson in modern primary school's concerns both natural and human geography. Its aims are to raise awareness and cultivate students' curiosity about the world (Fokides 2019; Klonari & Koutaleli, 2017; Labrinos & Bibou, 2006). Based on these innovations that the New Curriculum wants to introduce, a new digital educational material was designed based on Augmented Reality technology for the teaching of the unit entitled "Atmosphere" in the geography course in the 6th grade.

This study investigated the role of augmented reality (AR) in the teaching of geography lesson. Its purpose is to design and study an educational scenario using an AR application (App) combined with the printed material of the school textbook in the lesson of Geography in the 6th grade of primary school. Its aim is also to study the effects of AR on the real dimensions of teaching. The research questions that have arisen from the research in the international literature (Table 1) are the following:

- Can AR be used in the teaching of geography lesson, according to the existing Greek educational conditions?
- Are the cognitive goals of the course achieved with the contribution of AR?
- What is the attitude of students towards the use of the AR application?

The contribution of this study is multiple. First, a new ready-to-use digital educational material based on AR technology was created. The theme "Atmosphere" in the geography lesson has not been researched before. In the last five years, only nine studies have been conducted to exploit AR in geography lesson within the primary school classroom, focusing unilaterally on either the achievement of the cognitive objectives or the evaluation of the usability of the application (App), and only one of them evaluated both factors. This

intervention aims to evaluate both parameters and to enrich the existing literature. Finally, it is the second study international with the most significant research sample. All the above reveal the importance of the present work in relation to the previous studies.

Table 1. Studies

Publications	Sample & Age of users	Goals to achieve
Fokidis & Foniadaki (2017)	60 students aged 11 to 12	Cognitive goals
Palaigeorgiou, Karakostas, & Skenteridou (2018)	58 students aged 9 to 10	App evaluation
Herpich, Nunes, De Lima, & Tarouco (2018)	**75** students aged 11 to 12	Cognitive goals
Fokides (2019)	66 students aged 11 to 12	App evaluation
Salazar, Pacheco-Quispe, Cabeza, Salazar, & Cruzado (2020)	54 students aged 10 to 11	App evaluation
Ng, Lee, Cheng, & Ngan (2020)	11 students aged 6 to 12	Cognitive goals & attitude change
Kumpulainen, Byman, Renlund, & Wong (2020)	62 students aged 7 to 9	App evaluation
Ntrenogianni & Zerva (2021)	15 students aged 11 to 12	Cognitive goals & App evaluation

2. METHOD

The purpose of this paper is to investigate the cognitive achievements and the evaluation of the new digital educational material, created for the course of geography, based on AR technology. The content of the educational software of the Augmented Reality Application (AR App) was based entirely on the schoolbook of the 6th grade geography lesson in primary school. Since students would have only one teaching hour (45') to deal with the software and complete the pre-test and post-test, it was chosen to augment the three images in Chapter 9 entitled "The Atmosphere" in the student's book. This unit has not been taught again in previous classes.

The design of the AR App follows the usability principles of Nielsen (1995). The multimedia elements were gathered from existing media libraries freely available on the internet. The ZapWorks Studio platform was used to create a 3D virtual Earth enclosed by the mantle of the atmosphere (Figure 1), taking its elements from the website "*CGTrader - 3D Models / 3D Designers"* (https://www.cgtrader.com/free-3d-models?keywords=earth). ZapWorks Designer was used to create 2D digital objects, electronic resources, and videos. First, the book images were uploaded to the ZapWorks Designer website and their ZapCodes were generated for "scanning". The size of each graphic object, its position, the time it will appear and disappear, the graphics' movements, and the type required for the display of augmented content were then defined. In addition, to define the movements of the objects and activate the virtual buttons of the application, it was necessary to create short commands. The mobile App, named Zappar, was used to display the augmented digital objects. The App's size is quite small to install (5.7Mb), while the minimum Android software requirements are version 2.3, with a release year of 2019.

The research lasted three weeks and each class needed one teaching hour. 71 students (39 girls and 32 boys) aged 11 to 12 years old interacted with the AR App in May 2020. The didactic intervention was implemented by four teachers from three Greek primary schools. The participants answered questionnaires before and after the invention. The data from the questionnaires, completed by the students, were analyzed.

Participants played with the enhanced digital environment of the Zappar App in groups of three or four to present new knowledge collaboratively, in a 45-minute session, as part of a daily teaching day and hour at the elementary school where the students were attending. The aim was to introduce AR to current educational conditions. Before and after the implementation, students asked to answer a questionnaire (pre-test & post-test). During the intervention, students scanned the images and interact with the content displayed to them.

Firstly, each student completed the pre-test independently, as one of the research tools for collecting research data. It included five closed-ended assessment questions for the student's existing knowledge on the topic which would been discussed. One of them was about their sex. At this point, it should be mentioned that help was given to the students whenever they asked for it.

Then, students were asked to "scan" the ZapCode of the first image in the textbook and then the image itself. After the scan, the Earth appeared in the image of the book and on the screen of the tablet with its

atmosphere in 3D form (Figure 1). In this way, not only were students given the opportunity for a real interaction with her but at the same time, they were transformed into an experience (experiential learning) Kesim, & Ozarslan, 2012). While the students were working on the 3D object, the teacher leads the discussion and informs them that the topic for discussion is the Earth's Atmosphere.

Figure 1. Augmented 3D digital Earth with Zapcode Scan

Figure 2. Augmented 2D object with Zapcode scan

After that, students scanned the second picture of their textbooks. The teacher indicates the students which digital button they must bush to see the video of each layer of atmosphere. Before watching the videos, they had the opportunity to read an article, through the application. When scanning this image, two-dimensional objects appear to pass in front of the application screen. Each object has its position and use. 2D clouds are moving within the boundary of the Troposphere, a plane in the Stratosphere and a rocket pierce the layer of the Exosphere. Thus, students could see tangibly and realistically exactly what is happening in the layers of the Atmosphere. Pressing each button that says the name of each layer opens a new window for students and a video about the layer corresponding to each button was displayed. By scanning the last image in the textbook, students were asked to press the center button on the 2D Earth and watch the video on the importance of the Atmosphere's contribution to sustaining life on planet Earth (Figure 2).

At the end of the intervention, students had five minutes to answer the post-test. It consists of two parts. The first part has the same questions as the pre-test. The other part consists of closed-ended questions and in particular multiple choice to evaluate students the AR App.

In this research, we adopted quantitative methods to compare students' prior knowledge with new ones, their emotions, and experiences at the end of using the AR application. The data collection tools used are:

- Pre-test scores will represent students' prior knowledge about the subject
- Post-test scores will represent students' learning outcomes after the intervention and their attitudes regarding the use of AR application, at the end of the intervention

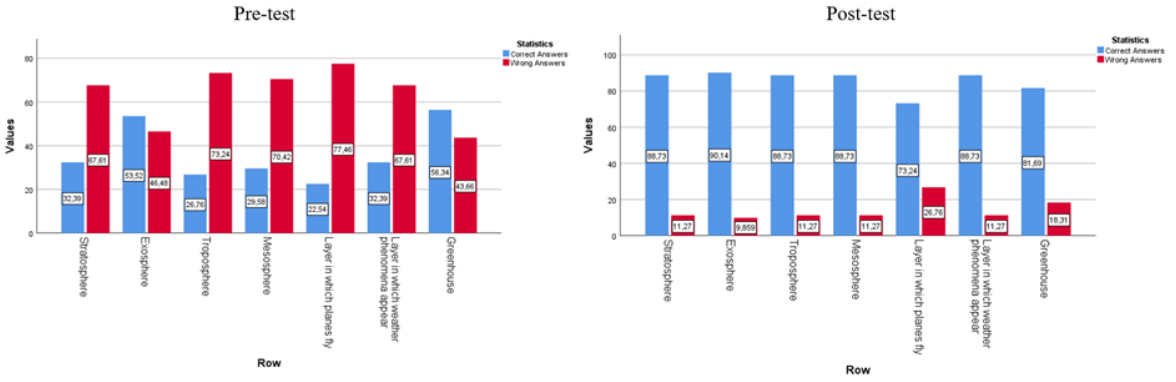
For the collection of research data, children were asked to answer questionnaires before and after the intervention. The questionnaires questions were closed-ended, in the form of single and multiple choice, as well as questions with answers on a 4-point Likert Scale, based on the SUS (System Usability Scale) usability questionnaires, rendered in Greek (Katsanos, Tselios, & Xenos, 2012). In this way, we wanted to evaluate the students' prior knowledge (pre-test) and compare it with the new (post-test). Also, with the questions of the second part of the post-test, our purpose was the evaluation the application and AR in general by the students.

3. RESULTS

The results of the present research prove that the utilization and use of Augmented Reality are suitable for the design of teaching scenarios during Geography because they bring lot of multiple benefits.

To evaluate the achievement of the cognitive goals, a comparison was made between the questionnaires, which were completed by the students before and after the intervention. As we can see in Table 2, in pre-test wrong answers outweigh the right ones, when it comes to knowledge questions. But at post-test, the right answers outweigh the other ones. The software contributed as an aid to the achievement of the cognitive goals that had been set from the beginning, a fact that also confirms the investigations of Fokidis (2019), Palaigeorgiou, Karakostas & Skenteridou (2018), Salazar et al (2020) and Ntrenogianni & Zerva (2021).

Table 2. Questionnaire answers for cognitive goals



According to the last bibliography, AR Apps enhance motivation for learning (Ng et al 2020) and turn teaching into a game (Salazar et al , 2020). The statistics results of the post-test showed that the vast majority stated that class was particularly fun with the help of this AR App (90%), while the 70% of students would enjoy using it frequently outside of class.

Children were thrilled with the use of this AR application, and we noticed that users positively received the app since they stated that they did not have much difficulty while using it. 73.24% of children disagreed with the statement that the application was difficult to use, and correspondingly about 77% stated that it was easy to use. In addition, approximately 74% of students believe that everyone can use it. Also, the students who felt that there is no need to know a lot of new information to use the application range in the percentage of 39.44%, while a percentage of the order of 33.80% declares that they are unsure about this position. At the same time, around 54% of children felt quite confident while using the application.

Therefore, during the evaluation of the application by the students, it was observed that the latter very easily and quickly became familiar with the AR application and how it works. 51% of participants stated that they did not need help while interacting with the application, while 56% of respondents with the rate of complexity, which supports the previous results.

In conclusion, the use of Augmented Reality application, according to the current educational data and needs, proved to be particularly helpful for the learning process. All data are positive for the effectiveness and ease of use of the application by students.

4. CONCLUSION

The results of the present study show that the utilization and use of Augmented Reality is suitable for the design of teaching scenarios in Geography because they bring a lot of learning benefits, enhance motivation for learning and turn teaching into a game. We observed that most of the cognitive goals were successfully achieved. Students understood the function of the atmosphere in terms of its composition, structure, and its role in sustaining life on planet Earth. They were also enthusiastic about the AR App. Overall, the use of Augmented Reality, according to current educational data and needs, proved to be particularly helpful for the learning process.

However, some elements have fostered reflection. The most important of these is the relatively large amount of time spent building applications due to a lack of experience in designing such interactive environments. Despite the difficulties that the use and construction of these applications may have, the necessity of adopting such educationally correct applications during teaching becomes apparent. The sample, although sufficient for statistical analysis and from the largest samples so far, is considered relatively small and unrepresentative, while the possibility of generalizing the results is limited. Therefore, it is necessary to conduct further studies with a larger number of participants to generalize the results.

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SERIOUS VIDEO GAME TO PROMOTE EARTHQUAKE PREVENTION IN CHILDREN

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ABSTRACT

Mexico is a country where seismic events occur in a daily basis. Since 1990, the national seismological service has reported various earthquakes, in some cases they usually imperceptible, it doesn't ensure that the population cannot be injured, there for, it is important to keep the entire population informed and prepared in the event of an earthquake.
This project will present a proposal for a serious videogame with the intention of bringing the young public, between nine and twelve years old, closer to earthquake prevention in a playful way through a narrative based on children studies and official civil protection guidelines. This videogame is developed with de Godot game engine platform, using as the main source of information the research project developed by the students of the master's degree in Information Design and Communication about strategies focused on children to promote informed behavior for safety in the case of seismic related situations (Gros, 2009).
The videogame poses scenarios of elementary school, where a series of challenges are presented to the gamer as simulating real situations with the intention that the player learn how to avoid getting hurt and manage to reach to meeting point safely. This paper shows the related work in the domain of games focused to promote the information about safety during earthquakes, the design and the advances in the development the proposal.

KEYWORDS

Earthquakes, Prevention, Serious Videogame, Children

1. INTRODUCTION

Information on earthquake prevention can be quite difficult for children to understand, as most media tend to target an adult audience. Many occasions texts and images are used to communicate the message, they are not always suitable or attractive for a younger receiver.

Before society, video games have had entertainment as their main function, so many people do not believe that they can provide some learning to those who practice it because they have become popular in recent years, it is sought that from the so-called serious games, education is encouraged, the development of skills and the solution of problems are helped. Serious videogames approach allow to develop useful tools to transmit knowledge (Gros, 2009; Gree, 2004). By means of a serious videogame it is possible to design focused activities for receiving and processing information on a specific topic while increasing the player's motivation to learn. For this reason, it is relevant to develop videogames that include information to promote earthquake prevention information in children. This project, entitled "Simon Sismon: serious videogame to promote the prevention of earthquakes in children", is based on the research "Strategy to encourage the culture of prevention against earthquakes in the child population of Mexico City" carried out by (Alvarez et al., 2021) and focuses its communication premises on a younger audience: children between 9 and 12 years old. On this basis, the game design introduces recreational activities that meet the children needs identified in seismic situations, for the sake of the necessary message is transmitted properly.

Official information provided to children on earthquake prevention in schools and in mass media may be considered as insufficient and inadequate according to what was collected by students, causing the risk of a real event to increase (Alvarez et al., 2021). Serious games, as opposed to commercial games, aimed to disseminate entertainment-mediated knowledge that stimulates a memorable experience (Balmori Olea, et al, 2019). The proposal of a serious videogame aims to transform information about earthquakes into a narrative

that is attractive to children through gamification, in which critical and innovative structures can be introduced to encourage prevention of this natural phenomenon by means of the graphical and communicative resources of a videogame. Furthermore, the proposal presented here, Simon Sismon, is an interdisciplinary initiative where apart from taking social studies as basis, designers and computing profiles work together to produce a coherent product.

1.1 Related Work

This section will delve into the current state of the previous work related to the project presented here. With this, videogames and use for knowledge are better understood. Below are some videogames developed with this type of design on earthquakes and that will be used as a reference for the project. There is a limited number of videogames related to disasters caused by natural phenomena, two categories are established according to the development zone, western and eastern by the difference in language and the difficulty of obtaining information.

- **Tanah:** it is an educational game aimed at a minor audience, in which fun way information is presented about evacuation plans, home preparation, protocols for an earthquake or tsunami, as well as explanations of the function of tsunami alarms, evacuation routes, location of safe spaces, among other topics. From all this information presented, questions are asked to reinforce what has been learned within each scene.
- **Baby Panda Earthquake Safety 1**: It is a game designed for children; it is divided into two sections. The first shows what it is for to prepare a backpack of life and what objects you should carry, while describing what they are for. In the second section, they tell young children short and precise stories about how to do in the event of an earthquake to get safe. Each of these recommendations are presented in different scenarios, at home, at school, supermarket and the street, the player must follow the instructions and respond correctly to get out unscathed.
- **Stop Disasters:** Stop Disasters is an online game created by the United Nations Office for Disaster Risk Reduction. Its main objective is to help understand that the implementation of prevention measures and the reduction of vulnerability are key to saving the population and reducing the impact of disasters. The platform shows us the different types of catastrophes. The player must select some geographical area, where children will build villages and cities with the available resources, so that these are in safe areas (Playerthree and UNDRR, 2018).
- **Treme-Treme:** The Treme-Treme game was created jointly by the Department of Civil Engineering and the Department of Computer Science of the Higher Technical Institute, Dreamstudios and Flaidisaine are three of the institutions involved. It is part of the European project UPStrat-MAFA in urban disaster prevention strategies (Sousa et al., 2015). Through the character, activities will be carried out within the different levels in order to teach the concepts and prevention measures in a fun way, in such a way that the player manages to become aware to prepare for real situations of earthquakes and tsunamis.
- **地震逃生 (earthquake escape):** This videogame aims to put the main character in a safe zone inside the house when an earthquake happens before the end of the 11-second limit to safety.
- **震度6強体験シミュレーション (Seismic intensity 6 strong experience simulation):** It is a role-playing game about the preventive measures and evacuation actions that must be taken in the event of earthquake of magnitude 6 or higher on the Richter scale.
- **居家瓦斯安全小尖兵 (Home shockproof small "answer" person):** It is a game in which questions must be answered about what action to take to prevent earthquakes.
- **地震模擬 (earthquake simulation):** The game shows through a simulation how to prepare before an earthquake and what the immediate response to them should be, by organizing an emergency kit and paying attention to the indications on how to protect yourself.

Table 1 highlights the aspects of a serious game and compares them, each of which was interacted with to obtain the results.

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Table 1. Videogame comparison

Videojuego	Tanah	Baby Panda Earthquake	Stop Disasters	Treme Treme	Earthquake escape	Seismic intensity six strong experience simulation	Home shock proof small "answer" person	Earthquake Simulatión	Simon Sismon
Feedback	✓	✓	✓	✓	✗	✓	✓	✓	✓
Has levels	✓	✓	✓	✓	✓	✗	✗	✓	✓
has explicit instructions	✓	✓	✗	✓	✗	✓	✓	✗	✓
clear sequence of actions	✓	✗	✗	✓	✓	✓	✗	✗	✓
controls usability	✓	✓	✓	✓	✓	✓	✓	✗	✓
advances prompt new actions	✓	✓	✗	✓	✗	✗	✗	✓	✓
distinction between positive and negative actions	✓	✓	✓	✓	✓	✓	✓	✓	✓
elf-defined as a serious videogame	✓	✗	✓	✓	✗	✗	✗	✗	✓
characteristics of video games									
Cost	Free	Free	Free	Free	Pay	Free	Free	Free	Free
Idiom									
Platform			✗		✗	✗	✗	✗	✗
Web	✗	✗	✓	✓	✓	✓	✓	✓	✓
Open source	✗	✗	✗	✗	✗	✗	✗	✗	✓

1.2 Contribution

The mastery of information about earthquakes and the safety directions allows to generate a narrative for the development of a serious videogame on prevention where the interest of children about the subject can be increased and with it, in the long term, contribute to the development of a culture of prevention. As can be seen in the previous paragraphs, there are not enough serious games proposals for Latin-American (especially Mexican) children taking care of the domain of earthquake safety guidelines promotion. furthermore, to promote an interdisciplinary work to recover social and children focused studies and apply them to design technological development is not a common practice. So, the videogame presented here is a proposal to reverse such state of affairs with a double folded contribution: social and technological relevance in the serious videogame field.

2. PROJECT DEVELOPMENT

To develop the project will be divided into four stages, which will be briefly described.

- **Initiation stage:** In the first stage, the following activities will be carried out: research of the previous work and part of the definition of the videogame. The diagram shown in figure 1 presents in a general way the behavior and conditions followed by the videogame system. When starting the game, the main menu will be displayed, when choosing the "start" option, the characters that can be chosen will be displayed on the screen and then start the game in the first level. In case the three lives provided to the player are lost, the game will return to the beginning of the level in which it remained. If in the main menu you choose "options" you will be directed to the screen where you can modify if you want to activate or deactivate the sound, and finally if you choose the option "exit" the program will end.

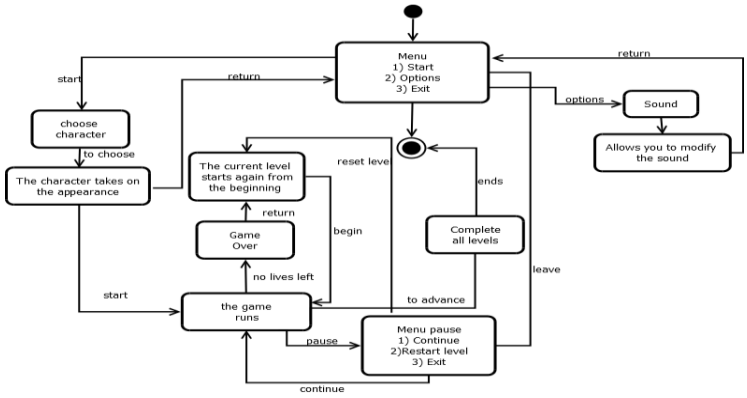

Figure 1. State diagram of the video game Simon Sismon

- **Elaboration stage:** In the second stage the basis for the development of the video game will be made. The activities that are planned in this stage are: develop the narrative, design the interaction diagrams, design the scenarios for the different levels and specify the functions of the characters.
- **Construction stage:** The implementation of the video game on the chosen platform will be developed during this same phase, with the elaboration stage the activities of the interactions between the characters and scenarios will begin. It will help create each of the levels that the game will have. In the development of the algorithm, each of the functions previously assigned to each character will be implemented, and the different parts that make up the video game will be tested.
- **Transition stage:** Finally, in the transition stage, an update of the previous work will be carried out, final tests of the video game will be carried out, in addition to the drafting of the final document. In figure 2 each of the stages mentioned above is observed to illustrate the time intervals in which each of the activities will be carried out.

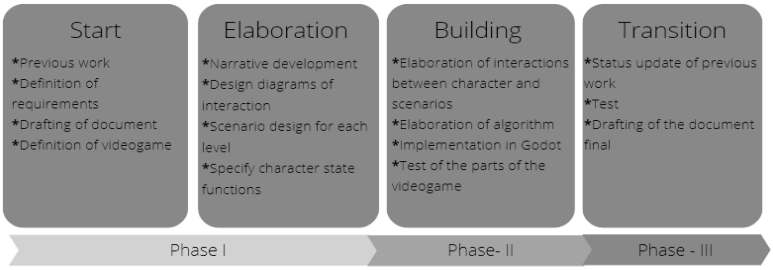

Figure 2. Stages of project development

2.1 Advances

Now it has been possible to make advances on the narrative of each level, the functions that each character will perform, the design of some levels and the design of the characters. Figure 3 shows the character and a scene within a level. On the other hand, figure 4 shows the information about the signal when it encounters it.

Figure 3. Main tutorial scene

Figure 4. Videogame signage

3. CONCLUSION

The development of a serious video game on prevention can increase children's interest in the subject and contribute to the development of a culture of prevention, considering that one of the limitations of the videogame does not address all issues related to prevention against other natural phenomena. It should be noted that in the development of this proposal, there were interdisciplinary interactions, because of the convergence of designers and technologists to adapts the game goals and design it to remain attractive for children. In addition, this game is based on a social study that exploits gamification.

However, the project is still in the process of development and there are some avenues to explore as future work: to end up implementing some features, functions and scenarios in the last two levels, to solve details about the animations of the character and control functions to play the game. Finally, the proposal should be tested with real users to recover feedback and introduce improvements.

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PARENTAL INVOLVEMENT AT THE BEGINNING OF PROGRAMMING EDUCATION

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ABSTRACT

The increased focus on computational thinking has led to the acceptance of computer programming as one of the ways of teaching computational thinking. In 2020, Japan introduced programming education in elementary schools. To understand the current situation of parental involvement at the beginning of programming education, this study aimed to know parents' experience in being involved with programming education and their beliefs that motivated them. Parents with children in elementary school were requested to complete a survey with regard to experience in behaviors related to programming education. The outcome showed parent involvement is minimum in programming learning.

KEYWORDS

Computer Programming, Elementary School, Parental Involvement, Parents' Beliefs

1. INTRODUCTION

There have been widespread attempts to introduce computational thinking in elementary and secondary or K-12 education (Barr and Stephenson 2011; Grover and Pea 2013). The term "computational thinking" was first coined by Papert (1993) and popularized by Wing (2006). According to Wing, "'Computational thinking' involves solving problems, designing systems, and understanding human behavior, by drawing on concepts that are fundamental to computer science" (p. 33). She also stated that computational thinking is a fundamental skill for all and every child should have this analytical ability. The study garnered the attention of many education researchers and educators and led to substantial research studies related to computational thinking in K-12.

As computational thinking increasingly draws attention, computer programming is also being accepted as one of the ways to teach computational thinking. Lye and Koh (2014) state that "programming is more than just coding; for, it exposes students to computational thinking, which involves problem-solving using computer science concepts, and is useful in their daily lives" (p. 51). Relkin et al. (2021) carried out a longitudinal study to examine the changes in computational thinking skills in first- and second-grade students exposed to a developmentally appropriate coding curriculum. The study provided empirical evidence that their curriculum could accelerate the acquisition of computational skills. Moreover, as Zhang and Nouri (2019) reviewed, many studies were conducted that included the visual programming language Scratch in learning computational thinking.

In 2020, Japan introduced programming education in elementary schools. The Central Council for Education in the Ministry of Education, Culture, Sports, Science, and Technology (MEXT) noted that the aim of programming education in elementary schools should not be to teach students how to code but rather to foster the "programming thinking" of students (translated by the author). Programming thinking is a concept similar to and a part of computational thinking. Thus, coding itself is not the aim of programming education in Japan but is considered as a way to achieve the goal of programming education.

As programming education is gaining importance in formal education, children have more opportunities for gaining programming experience informally. According to a report published by the Ministry of Internal Affairs and Communication, there has been an increase in the number of organizations starting programming classes and lectures in Japan since 2013. Gerson et al. (2022) state that graphical and tangible coding systems have led to positive leaning outcomes in studies with school-aged children. Moreover, these coding systems enable a family to experience programming. Parents play an important role in elementary education, and their

attitude towards education has a considerable influence on those of their children. In the field of education related to new technologies such as programming and robotics, a few studies have shown the positive impact of parent-child collaboration in the workshops on children's attitudes and outcomes (Lin and Liu 2012; Cuellar et al. 2013). However, Maruyama (2018KES), in a survey carried out for parents of elementary school children before programming education was introduced in elementary schools in Japan, found that 77% parents responded that they have very less or no confidence for being involved in supplementary instruction at home. Differences in parental involvement, especially in the early stages of programming education, can make a significant impact on a child's future learning. Parents need to be encouraged to become involved in their child's programming education. Therefore, it is necessary to know the current situation of parental involvement at the beginning of programming education. This study aimed to know parents' experience in being involved with programming education and their beliefs that motivated them.

2. METHODS

A quantitative online survey was conducted in October 2021, the year after programming education was introduced in elementary school in Japan. The respondents were the members of an online market research panel of approximately 13 million members. A screening survey narrowed down the target group to those aged 25–59 years with elementary school children. The request to participate in the survey was sent to the members by the online market research company until sufficient responses were received. After collecting the responses, responses with similar answers to all the questions were eliminated. A total of 2987 valid responses were obtained. The demographic data are shown in Tables 1 and 2.

Table 1. Sex of participants

Sex	Frequency
Male	1287
Female	1700

Table 2. Age of participants

Age	Frequency
25–29	117
30–39	1189
40–49	1360
50–59	321
	Average age 40.9

In examining parents' experiences, five items (Table 3) were designed based on Simpkins et al. (2012), who investigated the association between mothers' beliefs and their children's achievement-related behavior. They referred to the Eccles' socialization model (Eccles 1993) and enumerated mothers' behaviors that influenced children's motivational beliefs: a) role modeling, b) encouragement and reinforcement, c) provision of activity-related experiences (e.g., activity-related materials), and d) parent–child activities. This study examines the extent to which parents experienced behaviors in these four domains.

Table 3. Instruments for parents' behaviors

Parental behavior
Please answer the following questions about your child's and your programming experience out of school.
1. Have you participated in a programming class (short-term) outside of school?
2. Have you had programming experiences at home?
Please answer the following questions about how you are doing at home in regard to learning programming.
3. Have you talked with your child about programming learning and education in school at home?
4. Have you bought a book related to programming?
5. Have you bought a learning material related to programming?

Items 1 and 2, which are about experiences related to programming in a class outside of school and at home, were used to measure the extent to which parents experienced behaviors related to role modeling and parent-child activity. Respondents were asked to choose one of the four options, "Parents have experienced with child," "Only child has experienced," "Only parents have experienced," and "Neither has experienced" for these items. "Parents have experienced with child" was considered as a behavior related to parent-child activity. "Only parents have experienced" was considered as a behavior relate to role modeling. As for encouragement, it seems that parents' verbal encouragement influenced their children's beliefs; therefore,

item 3 was considered a behavior related to encouragement. Provision of activity-related experiences was measured by whether parents bought programming related materials; therefore, items 4 and 5 were considered as behaviors related to the provision of activity-related experiences.

Seven items (Table 4) were designed with respect to parents' beliefs and based on the expectancy-value theory (EVT; Wigfield & Eccles 2000; Wigfield & Gladstone, 2019). The EVT has been applied in several studies related to students' interest and achievement in various subjects, as well as in several studies on parental motivation for involvement in children's learning (Zucker et al. 2021, Simpkins et al. 2012, Šimunović and Babarović 2020).

Three items were related to how parents value programming and had 4-point rating scales. Three were related to parents' expectations for children in programming and had 5-point rating scales. One was related to parent's self-efficacy in supporting children and had 4-point rating scales. Responses were analyzed with the Mann-Whitney test to verify whether there were differences between groups divided by experience or lack thereof of the behaviors as mentioned above.

Table 4. Instruments for parents' beliefs

Parents' value
6. Do you think learning programming will help your child in the future?
7. Do you think learning programming will help your child in everyday life?
8. Do you think learning programming will help your child in learning more than just programming in school?
Parents' expectations for child
9. Do you think your child is interested in programming?
10. Do you think your child likes programming?
11. Do you think your child is good at programming?
Parents' self-efficacy
12. If you were involved in supplemental training at home, how confident would you be?

3. RESULTS AND DISCUSSION

Table 5 shows the results for items about parental behaviors. For role modeling and parent-child activity, respondents were considered experienced if they indicated that they learnt programming in a class outside school or at home. For provision of activity-related experiences, respondents were considered experienced if they indicated that they have bought a book or a learning material. The result shows that parents do not involve in programming learning so much. 70.6% of respondents indicated that they had little or no confidence of getting involved in supplementary instruction at home (Item 12). It is possible that the lack of confidence hinders their interest in involvement.

Table 5. Answer to the "parents' behaviors"

	Experienced	Not
Role modeling	197(6.7)	2764(93.3)
Encouragement and reinforcement	1075(36.2)	1892(63.8)
Provision of activity-related experiences	594(20.1)	2356(79.9)
Parent-child activity	515(17.4)	2446(82.6)

Figures 1, 2, and 3 show the responses to questions about parents' value, expectation, and self-efficacy by experiences or lack thereof in involvement behaviors. Since the item about role model had very few responses as "experienced," it was excluded from the analysis. Through the Mann-Whitney test, it was confirmed that there was significant statistical difference ($p < 0.05$) for all items between experienced or not experienced. This suggests that parents who had become involved with children's learning have positive beliefs about programming education than who those did not.

With regard to the parents' value, more than 80% of respondents with experience of involvement in each domain and more than 60% without experience indicated "Very" or "Somewhat" for each item. Overall, it can be assumed that parents recognize the value of learning programming. On the other hand, a small number of them did not recognize the value at all.

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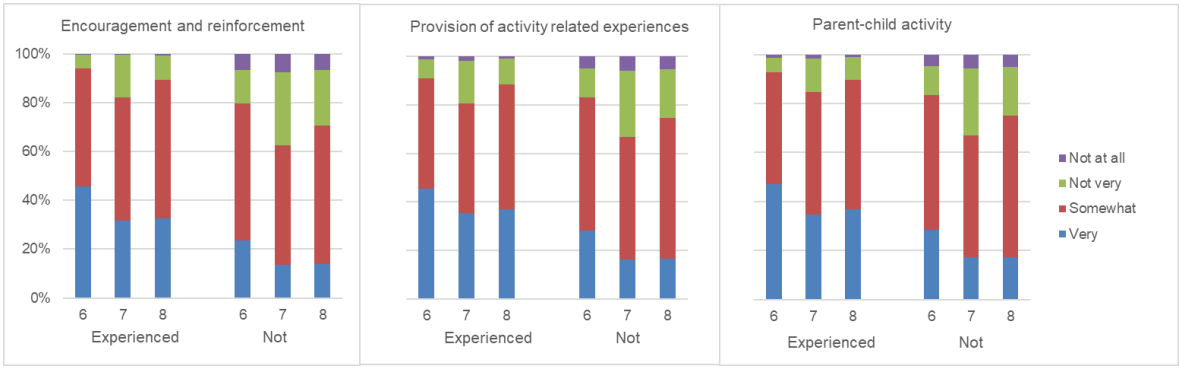

Figure 1. Answer to the "parents' value

With regard to the parents' expectation for children, 70–80% of respondents with experience of involvement in each domain indicated "Very" or "Somewhat" with regards to their children's interest in or their liking of programming. By contrast, less than 40% of respondents without experience indicated similar responses. Expectations for children might lead to parental involvement behaviors.

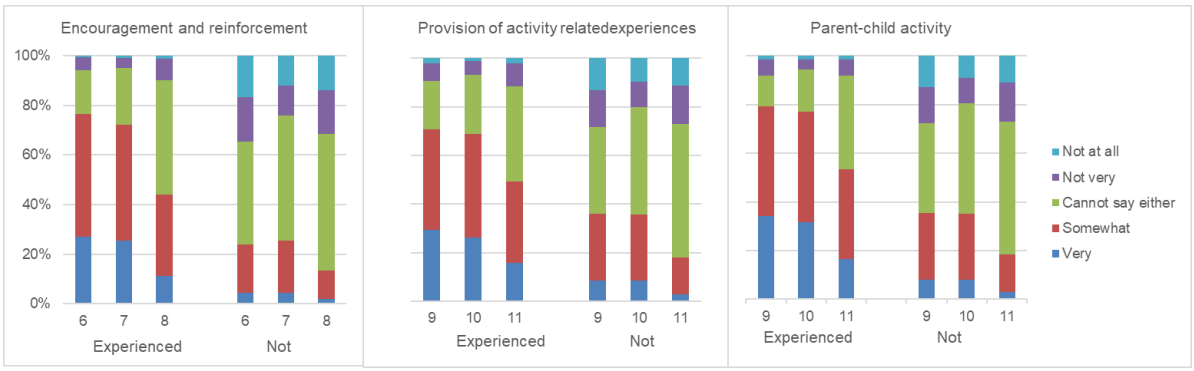

Figure 2. Answer to the "parents' expectations"

With regard to parents' self-efficacy, nearly 80% of respondents without experience of involvement in each domain indicated "very" or "not at all" with regard to if they are confident. Lack of confidence might be hindering parents from becoming involved. On the other hand, of the respondents with experience of involvement in encouragement, those that indicated they were "very," or "somewhat" confident were not so high, at 40%. Talking with children is considered relatively easy for even parents with less confidence.

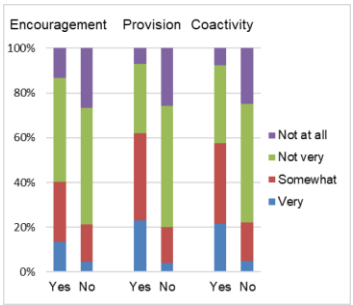

Figure 3. Parents' self-efficacy

4. CONCLUSIONS

To understand the current situation of parental involvement at the beginning of programming education, this study aimed to know parents' experience in being involved with programming education and their beliefs that motivated them.

With regard to parental involvement, parents' experiences were surveyed in four domains, i.e., role modeling, encouragement and reinforcement, provision of activity-related experiences, and parent-child activity. The results showed parents involvement in children's programming education is negligible. Even with regard to encouragement, less than 40% of respondents experienced involvement. It This suggests that parents may need some support to become involved. With regard to parental beliefs, the results showed that parents generally recognize the value of learning programming and their expectations for the child might lead to parental involvement behaviors. A lack of confidence might also be hindering parents from involvement.

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DERSQL, GENERATING SQL FROM AN ENTITY-RELATION DIAGRAM

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ABSTRACT

The automatic code generation is the process of generating source code snippets from a program, i.e., code for generating code. Its importance lies in facilitating software development, particularly important is helping in the implementation of software designs such as engineering diagrams, in such a case, automatic code generation copes with the problem of how to obtain code from a graphic representation, for instance an UML diagram or a Relational Diagram. Some advantages of automatic code generation are: a) to obtain the source code more quickly and to do it with lower margins of error; b) it is promising to be applied in teaching contexts, whilst provide instructors with a tool to teach, the expected results of assignments can be assessed by comparing the results of students and the automatic generated code.
Furthermore, one of the most frequently tasks in classrooms when teaching relational databases is the design of Entity-Relationship Diagrams which eventually become SQL code. The manual transition from an Entity-Relationship Diagram to SQL code is a time-consuming process and requires of a skilled eye to be successfully performed.
In this paper, we present *DerSql*, an extension of the DIA Diagrammer, a well-known free software engineering tool, to automatically generate SQL code from an Entity-Relationship Diagrams. The results are tested for the case of 1 – 1 and 1 – n arities relationships. We consider that *DerSql* represents a remarkable tool for teaching while it is a promising advance in developing DIA as a 4th Generation software engineering application.

KEYWORDS

Automatic Code Generation, Entity-Relationship Data Model

1. INTRODUCTION

In the current society Data Bases (DB) are imprescindible tools and the right design and usage is a critical activity in software development. As in any other software engineering project, in the design of a DB, a methodology is followed starting from knowing the need to be satisfied and to propose a solution for a specific customer. So, DB methodology fulfills different phases such as planning, analysis, and creation.

Once the trouble is defined and identified it is necessary to represent it in a *conceptual model*. The conceptual model provides a clear and more real idea of the problem to be solved. There are many models to represent conceptual model, one of the modeling tools more used by either designers or students that are learning relational databases is the Entity-Relationship Diagram which eventually will be transformed into SQL code.

2. ENTITY RELATIONSHIP MODEL

Entity relationship model is a well-known approach to design DB. Its importance lies in representing data from the real life in an abstract way to understand the user requirements and reach a good representation of the related data which eventually will be transformed into SQL code. One of the main tools of this model is the Entity-Relationship Diagram (ERD) which represents different elements as symbols (Bertone, & Thomas, 2011): a) entity: it is represented by a rectangle, and it refers to an element or object of the real world; b) attribute: it is represented by an ellipse, they reflect characteristics belonging to entities and they are

connected to entities by a line; and c) relationship it is represented by a rhombus, and it means some sort of association between entities.

In accordance with Sanchez (2019), cardinality is the number of relationships in which an entity can appear. Given a set of relationships between entities, the correspondence of the cardinality can be: one to one (1:1), one to many (1:m) and many to many (n:m). Other elements of the ER-D are: Primary key (PK) which is an attribute of an entity that distinguishes it in a particular way. The PK is selected by the designer.

3. RELATED WORK

Every day is more frequently that BD designers use applications to obtain SQL code from a RD because they offer different benefits that make this task easier and quickly, on the other hand the student's use it to understand better the process and for practice purposes.

Currently, there are different applications that translate a Relational Diagram to SQL. Such a diagram differs from ERD mainly because they add more details about data, like data type of the fields, and they are more used in another design approach, i.e., the relational model. So, until the investigated, there are no application generating SQL code directly from an ERD. Consequently, in this project we propose to make an extension to DIA to generate semi–complete SQL code from an ERD.

In Table 1 it can be seen a comparison between the applications that are the more related to the work we presented here, *DerSql*.

Table 1. Comparative table of applications related with automatic SQL code generation from DB design diagrams

Applications	Multi platform capability	Cost	ERD to SQL	Languages used	Diagram used
Rational Rose			✗	?	Relational
MySQL Workbench			✗	C#, C++, Objective C	Relational
DIASQL			✗	Python	Relational
ERD PLUS			✗	?	Relational
DERSQL			✓	Python, XML(VDX)	ERD

4. DERSQL TOOL: DESIGN AND IMPLEMENTATION

So, this section describes and details the design, the components, the architecture, and operations of *DerSql*, our proposal to extend DIA.

Currently, our extension allows to have semi–complete SQL code from an ERD with arities 1 – 1 and 1 – n, and it is available for Windows operative system.

We say that the SQL code obtained is semi–complete because the ERD does not specify some elements about data, because of ERD abstractly represents entities and their attributes, that is to say, the attributes does not represent the data types, neither the Foreign Keys (FK).

Figure 1 shows the sequence diagram. In this diagram it can be seen the user and their interaction with DIA, that can be summarized as the following:

1. User takes an ERD designed in DIA.
2. In the menu of export select *DerSql*.
3. *DerSql* performs the conversion of the ERD to a tabular representation and the SQL code.

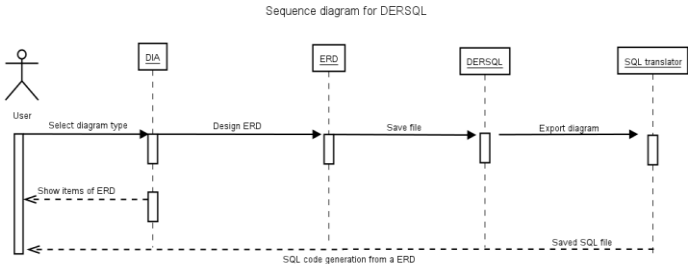

Figure 1. Sequence that user most perform to obtain tabular representation and SQL code from an ERD using DerSql in DIA

A description of the files, the architecture, the integration, and the interaction of the components is provided below.

BatDerSql.py. This Python 2 file is in charge to invoke another file that is called *DerSql.bat*.

DerSql.bat. DIA can be run from the command line. This allows certain DIA capabilities to be used in batch script file (Breit et al., 2007). With a sequence of commands in this file (batch programming) it was possible to export the *.dia* file into another file format, in this case we exported to a *.vdx* format and the file that manages the exportation is *vdx-export.c*.

File.vdx. This file is the result of the exportation of the *vdx-export.c* file. It is the XML representation and contains all the information and structure to represent ERD.

DerSql.py. This file was developed on python 3. It is in charge of extracting, reading and parsing important information from the *.vdx* file.

To read the *.vdx* file we choose and use a python's API named xml.etree.ElementTree (ET in short).

The process performed in *DerSql.py* result in two files:

1. The tabular representation of the ERD designed, and its extension is (.txt). It contains a) for each set of entities, a table that contains their respective attributes; b) The identified PK; b) The creation of FK on their respective tables; and d) A short explication of the identified relations to explain why intermediate tables are not created.
2. The SQL code generated. This process can be seen on Figure 2.

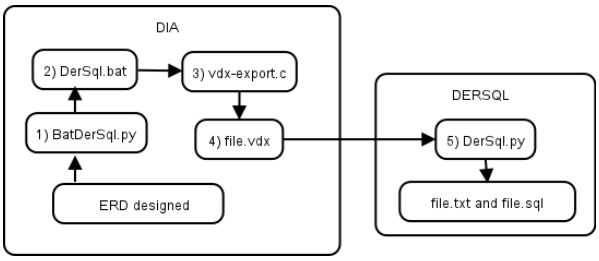

Figure 2. Architecture and interaction between the components of DerSql

The whole procedure and interaction between user and *DerSql* can be seen on Figure 3.

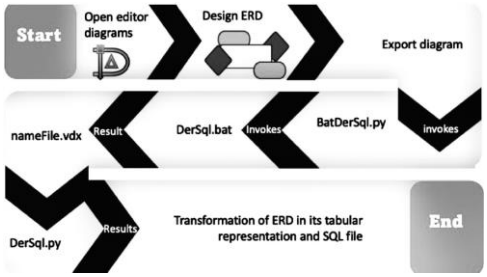

Figure 3. Operating flow and interaction between user and DerSql

5. EXAMPLES

We present here an example to illustrate the using of *DerSql*. To do so, we operate according to the steps described in Figure 4. The outcomes are shown in the next figures.

In Figure 4 on the left side, it is an ERD designed and represents three entities and their attributes. Every entity is connected to each other by a relationship. The arity of every relationship is one-to-many, and every entity has a PK attribute. On the right side it can be seen the tabular representation in a .txt file and a short explanation of the relationships and the SQL code generated. Every table created is the entity with their attributes and the FK created on their respective tables. The users the only thing that must change is dataType to the corresponding data type of the attribute and specify the length.

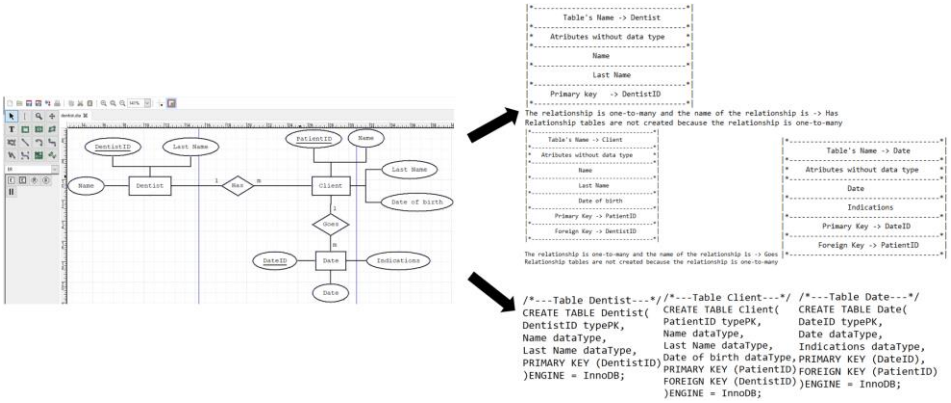

Figure 4. Results after applying DerSql are: the tabular representation and the SQL code from an ERD designed in Dia

6. TESTS AND RESULTS

We pursued a set of user tests with undergraduate students with skills in DB. They were asked to install DerSql on their computers and then to reproduce some ERD given by us. After the test, participants were required to fill in a questionnaire to register their user experience and to assess the obtained results when using DerSql.

The questions we divided in three sections and they are: a) usability; b) competitiveness and c) feedback and some of the questions we asked are: a) How was your experience using *DerSql*?; b) How do you consider the use of DerSql?; c) Do you think DerSql could have been useful in the database class?; c) Did you know the Diagrammer DIA?: d) Do you know any tool that allows you to do what DerSql does?

In Figure 5 we summarize the student's response, in the first graphic most of the user responses considered DerSql as very easy to use, we can deduce that students who does not know DIA find a little bit more difficult to use it. However, as can be seen in the second graphic, most of the user responses answered that their experience was satisfactory.

After running tests with a group of 20 users and every user replicated five different ERD, we consider that we have successful results because most of the students obtained the expected outcome after converting the DER to SQL by using *DerSql*. Additionally, their comments on the user experience were positives. The students commented that they would have liked to have *DerSql* in their DB courses at university. Finally, they stated that having these examples helps them to better understand the SQL sense and syntax when performing the translation from a DER to SQL code. The latter is an important point in helping to teach the design and implementation of DB and the Entity-Relationship Model.

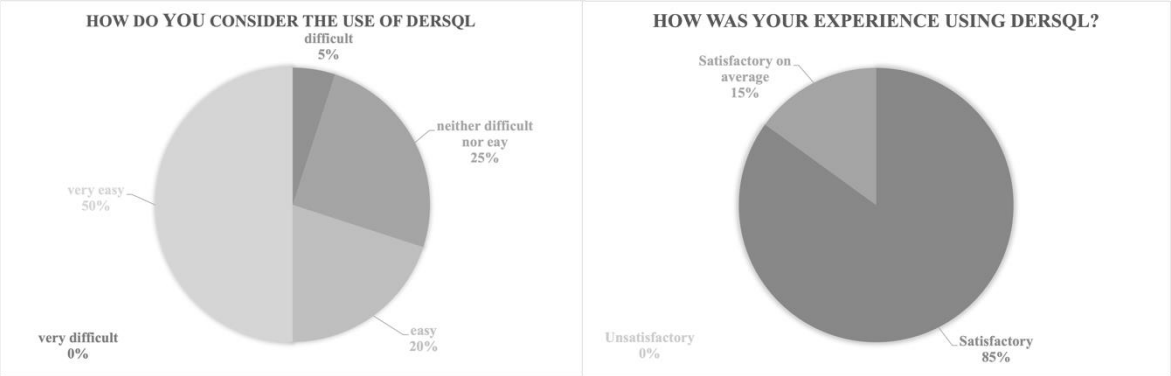

Figure 5. Graphics That Represents the User Experience after Using DerSql

7. CONCLUSION AND FUTURE WORK

In the development of applications, a pattern is followed to achieve an objective that ranges from design, implementation, and the execution. With *DerSql* we reduced time in creating source code from an ERD and allows to obtain the code with a lower margin of error. In addition to benefit software development, this project benefits instructors who teaches subjects related with relational databases because the students will have a better understanding in the process and transitions. *DerSql* allows to trace the entire process of designing and coding, i.e. from the generation of the ERD to the obtention of the SQL code that represents the data restrictions in an appropriate way with a noteworthy possibility: the explanation of the translation of the graphical representation to the tabular one, where the data model is applied.
Accordingly, to the user responses, they considered that *DerSql* could be a useful tool during the DB courses.

With this project we obtained a system integration as we integrated different programming languages, from batch programming to Python and XML. We also performed reengineering because we analyze the XML file, the functions in DIA source code to understand how it works. It was a hard task due the lack of sufficient information or documentation to comprehend its functioning, their scripts, or the existing extensions. Furthermore, we learnt how to run DIA since the source code using Meson (open-source build system). Despite these difficulties, we achieve a successful integration between different scripts.

For future work, there are some avenues to be endeavored: a) to expand the functionality of our tool to allow ERD with many to many cardinalities; b) to be able to read more elaborated ERD's and c) to make *DerSql* available to another operating systems.

ACKNOWLEDGEMENT

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APPROACH TO PREDICT STUDENT ENGAGEMENT IN VIDEO LECTURES

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ABSTRACT

The purpose of this work is to evaluate the quality of instructional materials in the form of instructional videos in an automated way by its linguistic aspects. The approach is designed to provide teachers with feedback on the expected evaluation of the videos by the students. For this purpose, certain features of the videos are used. Using an existing dataset with ratings, an AI algorithm was trained that can then make an evaluation of new videos.

KEYWORDS

Open Education Resources, Student Engagement, Video Lectures, Quality Assurance, Machine Learning

1. INTRODUCTION

Within the last years during the Corona pandemic, it could be seen how important it is to provide digital teaching materials. This paper is specifically about the evaluation of newly created educational videos. The target audience of the instructional videos are elementary school students. Already after the creation of the videos by the teachers, they should receive feedback about the quality of their new teaching material. From this, they could then draw conclusions about what could be improved in the films. Measuring the quality of the videos is problematic. New educational materials are created every day. Evaluating each one on a target group would hardly be feasible. Therefore, we analyzed which criteria could be used to evaluate a newly created educational video. From this, possible solutions for an automated evaluation were developed, which are briefly presented here. We created a model to extract linguistic features of the created instructional material and use them to predict the quality of the instructional material.

2. RELATED WORKS

The VLEngagement dataset, created as part of the work of (Bulathwela, P. et al. 2020), contains extracted features of instructional videos from the Videolectures learning platform (http://www.videolectures.net) on various topics. Since this is data from instructional videos, it seemed appropriate to us. The data is available for public access, and we used it to train our model. The transcripts of VLEngagement's instructional videos were created using the TransLectures project (http://www.translectures.eu), broken down into the individual text modules, and stored in the dataset as multiple features. This is explicitly mentioned here because we will infer conclusions about the quality as described in the work of (Guo, K., Rubin, R. 2014). As a result, the expected rating of the videos by the target audience as well as the target audience itself, in which the instructional video is categorized, can be predicted. This dataset contains data on 12000 videos of the learning platform, which were decomposed into the basic linguistic building blocks, anonymized, and supplemented with further metrics. However, it must also be noted that this learning platform contains instructional videos for students and is not specifically targeted to our audience, elementary school students.

3. EXPERIMENTS

The intention of the project is to improve the linguistic quality of instructional videos by providing automated feedback to instructors on their quality after a video has been uploaded. This gives instructors the opportunity to adjust the video and measure its quality again. For this purpose, an AI system was integrated into the Moodle learning platform, which analyzes and evaluates the uploaded video. When a video is evaluated by its linguistic features, its usefulness for a specific target group is estimated and suggestions for possible improvements are displayed. This evaluation also predicts what the rating of the target group, the elementary school students, will look like. The aim is to inform the teacher where improvements can be made or whether the target group for which the instructional video was created corresponds to the target group for which it was designed.

First, a transcript of the video is analyzed and reduced to basic linguistic building blocks. These are then used to identify similarities to the VLEngagement dataset, which is used to perform prediction on a trained model.

3.1 Used Features

The transcript of the video is examined for certain linguistic features within the analysis. These are recorded and stored for further processing. These include:

- Number of words
- Average duration of speech per word
- Number of repeated words (Document Entropy)
- Readability index (Flesch index)
- Proportion of stop words, prepositions, auxiliary verbs, conjugations, pronouns

The Flesch Index, developed by Rudolph Flesch (Talburt, J. 1985), also tells us how complex the linguistic structure is. From this we can derive for which target group the transcript is suitable. For example, linguistically more complex documents are more suitable for academics. It can also allow the instructor to provide feedback on whether their current work is suitable for their intended audience. The Mean Student Engagement feature is used as a label. This describes, as mentioned in the work of (Guo K., Rubin, R. 2014), how actively the student was engaged with the course material. In the dataset, this feature is stored normalized. So, it is suitable to solve the problem as a regression. We additionally divided this feature into five equally sized classes to be able to model a comparable result with a rating of one to five stars, comparable to another work in this related field (Gupta, N. et al. 2010). This allows feedback to the creator in a different form. The five classes, grouped by percentiles of student engagement, represent the following:

Table 1. Ratings for the videos

Percent	Rating	Stars
0 – 20 %	Very Low	*
20 – 40 %	Low	**
40 – 60 %	Medium	***
60 – 80 %	Good	****
80 – 100 %	Very Good	*****

3.2 Data Pre-Processing Issues

In preliminary, the data were transformed to get a better model after the training. After reviewing the dataset of the teaching videos, problems were found: In the original dataset, some entries for instructional videos exist that have a very low number of ratings. For example, instructional videos that have only a single rating are not included in the training because the risk of manipulation is too high. This is because this single rating could come from the creator himself. These and other entries with missing or invalid values were removed, reducing the size of the dataset from 11568 to 8083 entries.

3.3 Evaluation

Using the data of the mentioned features, a model was trained to perform a prediction for an instructional video (its transcript). The prediction received is the expected student engagement. The results based on the individual regressors can be seen in Table 2.

Table 2. Comparison of the results of the training using different regressors

Regressor	Score	MAE
KNeighbors	0.203	0.122
Random Forest	**0.422**	**0.101**
Decision Tree	0.264	0.112

The training on the data set was performed and compared with different regressors. The best prediction results were achieved with a random forest regressor (Yu, J. 2021). From different decision trees a combination of those is chosen, which can deliver the best prognosis. Given the data set, a good prediction means that, based on the basic linguistic components, the expected rating of the target group is as close as possible to the actual value noted in the data set. Probably the Random Forest Regressor was the most successful method, as it is very suitable for such scores (Singh, A. et al. 2017). Figure 1 shows an output of the predictions.

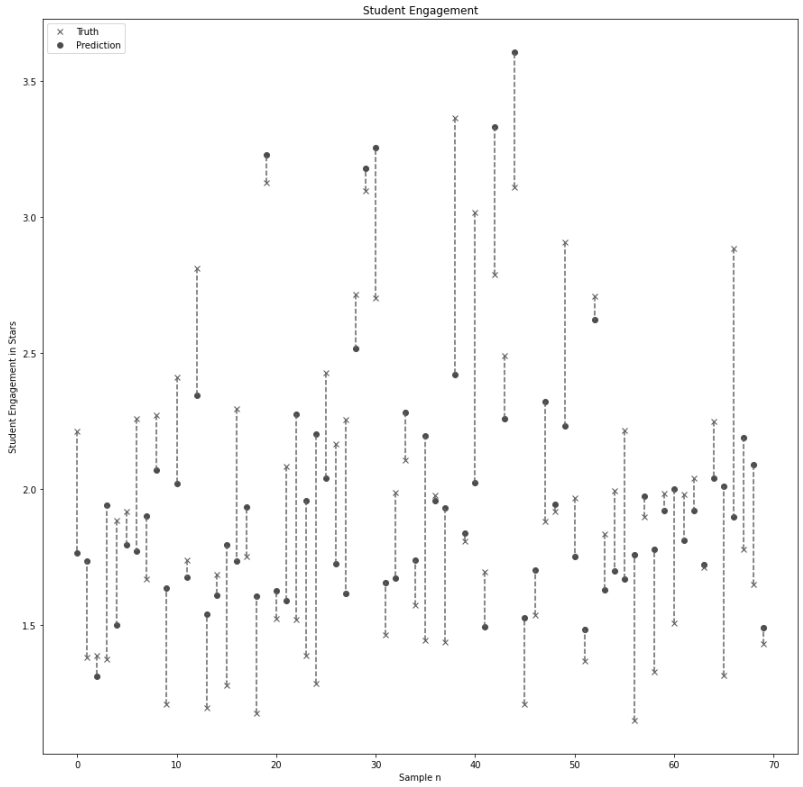

Figure 1. Visualization for some predictions of student engagement

4. RESULTS

When evaluating the results of the predictions of the instructional videos, a Mean Absolute Deviation of approximately 0.101 in the normalized feature could be achieved using the method described above. This means that in the data set based on the linguistic building blocks, the expected score contains an average error of 0.404 stars. While this means that an exact prediction cannot really be performed, one can still perform a rough prediction. For individual instructional videos, it may be that the prediction is very accurate, while for

others a slightly larger deviation exists. This was expected due to the very complex interrelationships in ratings of teaching material based on individual subjective points of views. In addition to the prediction of the target group based on the basic linguistic building blocks and suggestions for improving the transcript, a tool for teachers was examined and developed that can provide a rough guideline.

5. OUTLOOK

Regarding the domain used, it would be necessary to verify if there are differences in prediction in other domains. The dataset VLEngagement is mainly based on video material for students of technical scientific subjects, therefore the model created may not be equally efficient in other domains. Similarly, the dataset is created on English courses, this model might behave differently in other languages. Specialized datasets in different languages and domains would be helpful. In addition, especially the target group used is not diversified. The dataset is mainly intended for students, so it may also be appropriate to consider whether additional datasets for other target groups, specifically elementary school students, might be necessary.

Within the implementation of this project, it has also been noticed that a free, high quality transcription for non-English languages does not exist. For a complete automated analysis of teaching material this will become necessary. Otherwise, the instructor must be advised to manually upload the transcript, which can then be used for prognosis.

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THE IMPACT OF PEER INFLUENCE ON THE ADOPTION OF TWITTER

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ABSTRACT

This study involves the use of Twitter in performing various learning activities in an undergraduate marketing course at an Australian university. The students applied Twitter directly in learning about the subject content, primarily through the sharing and construction of dialogue within an environment of peer interaction. At the end of the semester, student feedback on the above activities was collected using an anonymous on-line survey to see the impact of these activities on student learning. The survey consisted of questions relating to the effectiveness of Twitter in performing the learning activities as well as students' intentions to use Twitter in future. This is followed by individual interviews with a selected group of students with the aim to consolidate survey results. This paper presents some preliminary findings of the study with key focus on the impact of peer influence on students' intentions to use Twitter, using an extended technology adoption model (TAM). The empirical findings confirm the significant impact of social influence on the Twitter usage in this study.

KEYWORDS

Twitter, Social Media, Student Learning, Technology Adoption, Marketing Education

1. INTRODUCTION

Twitter is undoubtedly one of most popular social networking platforms in the world today with nearly 217 million daily active users, and this number is growing steadily. Twitter users send nearly 500 million Tweets every day. The Twitter's advertising revenue had a 24% increase from third to fourth quarter in 2021, which shows clients' confidence in using Twitter for marketing their products and reaching out to millions of potential customers worldwide (Aslam, 2022). Twitter's primary purpose is to connect people and share thoughts with a worldwide audience. Users can get information about current top news and events, follow other users or companies who post content they enjoy consuming, or simply communicate with friends. Additionally, companies use Twitter to connect with their audience in personal and meaningful ways.

The use of social networking platforms (Facebook, Youtube, Twitter, etc) to facilitate student learning is not new in higher education. Several studies have shown the potential of using Twitter in enhancing student engagement and academic performance (George & Dellasega, 2011; Junco et al., 2013). Twitter has been found useful in teaching history, business and language learning (Bista, 2015). In teaching marketing, Twitter allows educators to bring real-world marketing concepts to the class in a timely manner as well as enhance interactivity among participants (Lowe and Laffey, 2011). However, every technology comes with its own challenges. Students' perceptions to adopt a new technology in the learning environment is considered a key challenge. In information systems research, Davis's technology adoption model (TAM) has been widely used for predicting adoption of a variety of technologies (Raaij and Schepers, 2008) including social media platforms (Al-Rahimi et al., 2013; Dhume et al., 2012). TAM posits that user perceptions of usefulness and ease-of-use determine attitudes towards using a technology. An individual's attitude is hypothesised to influence the behavioural intention to use a technology, which in turn leads to actual use.

Since the focus of this study is on the use of Twitter through the sharing and construction of dialogue within an environment of peer interaction, therefore it's important to explore the impact of peer influence while investigating student behaviours towards Twitter usage. Subjective norm is referred as the degree to which a person believes that those who are important to him or her think that he or she should perform the behaviour in question (Fishbein and Ajzen, 1975) and has been used in previous studies to explain the influence of peers and superiors on users' intentions to adopt a new technology (Taylor and Todd, 1995). Thus, we propose an extended TAM to analyse the impact of peer influence on students' use of Twitter in this study (Figure 1).

2. METHODOLOGY

2.1 The use of Twitter for Class Activities

Twitter is used to perform various learning activities in a third-year undergraduate marketing subject in an Australian university. The lecturer led the discussion on class exercises using the subject Twitter platform and reviewed the group contributions using the uniquely identifiable hashtags for each question. Students used these hashtags to attribute a unique identity to their contributions so that it is easily identifiable to specific class exercise questions. Students applied Twitter directly in learning about the subject content, through the sharing and construction of dialogue within an environment of peer interaction.

At the end of the semester, all the students were invited to respond to an anonymous online survey. The survey consists of questions relating to the effectiveness of Twitter in performing the learning activities along with some open-ended questions and suggestions for improvement. The survey also includes questions about the adoption of Twitter and students' intention to use it in future, which is the main focus of this paper.

2.2 Participants and Data Measures

The class comprised of 124 students in total. All students were exposed to Twitter at the start of the semester and were encouraged to use it as part of the weekly class activities, especially for group contributions during class exercises. The usage of Twitter was not assessed but was monitored by the lecturer constantly. A total of 64 students responded to the online survey with a response rate of 51.6%.

The constructs used in the survey were adopted from the previously published scales. All items were measured on a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The scales for perceived ease-of-use (PEU), perceived usefulness (PU) and subjective norms (SN) were adopted from Davis et al (1989) and Igbaria (1990).

2.3 Construct Reliability and Validity

The research model is tested using PLS (partial least squares) which is considered a powerful tool in analysing structural models involving multiple constructs and multiple indicators. Table 1 presents summary of construct reliability measures including mean, factor loadings, composite reliabilities (CR) and average variance extracted (AVE). The factor loadings provide evidence of convergent validity as all our constructs loaded greater than the threshold of 0.60 (Chin,1998). Internal consistency also appears significant for all our constructs since the CR values exceeded the minimum of 0.70 (Nunnally and Bernstein, 1994).

Table 1. Construct reliability measures

Constructs	Mean	Factor loading	CR	AVE
PU (1-6)	3.03	0.831 - 0.918	0.944	0.771
PEU (1-4)	3.50	0.860 - 0.920	0.953	0.807
BI (1-3)	2.73	0.941 - 0.952	0.961	0.891
SN (1-4)	2.60	0.892 – 0.950	0.960	0.859

Discriminant validity is shown through the (Fornell and Larcker, 1981) test. The procedure involves computing square root of the AVE of each construct, which should exceed the correlation shared between the construct and other constructs in the model. Thus, all our constructs demonstrate a good degree of validity and reliability.

Table 2. Discriminant reliability

	PU	PEU	SN	BI
PU	**0.878**			
PEU	0.425	**0.899**		
SN	0.638	0.263	**0.927**	
BI	0.632	0.421	0.636	**0.944**

2.4 Model Testing

Figure 1 below summarises the results of model testing about students' intentions to use Twitter. The strength and significance of each relationship is represented by the t-values. A solid line represents a significant relationship while a dotted line represents an insignificant relationship. R^2 is indicated next to each dependant variable (BI, PU and PEU). The PLS bootstrapping method shows that all proposed relationships are significant except one (between PEU and BI). This result is consistent with Davis (1989) original findings and suggests that non-adopters need to be convinced about Twitter's usefulness in future studies rather than educated about how to use Twitter (Lowe and Laffey, 2011). Subjective norm (SN) appears to be the strongest predictor to influence students' intentions to use Twitter. The positive relationships between subjective norms (SN) and the original TAM constructs (PU and PEU) clearly show that the more the students exhibit influence on their peers the more they will perceive Twitter useful and easy-to-use and ultimately use it. Overall, the proposed structural model explains 52% of students' intentions to use Twitter, which is a significant finding when compared with similar studies of technology acceptance such as Shin and Kim (2008) and Agrifoglio, et al. (2010).

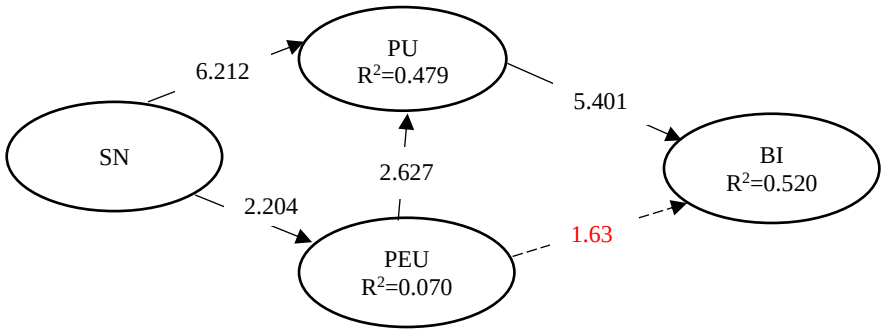

Figure 1. PLS results

3. DISCUSSION

This paper examines the impact of social influence on students' intentions to use Twitter as part of a bigger study to investigate the use of Twitter in performing learning activities in a teaching marketing. This is achieved through Davis's technology acceptance model (TAM) with the inclusion of subjective norms (SN) as a key measure of social influence. The empirical evaluation of the proposed model provides several insightful findings. First, subjective norms found to be the most significant predictor of Twitter usage, implying that the students valued their peers' opinion about the usefulness and ease of using Twitter and ultimately intentions of using Twitter. Some other studies have also reported subjective norms as a key factor in determining the collective intention to use a social networking platform (Cheung & Lee, 2010). Perceived usefulness found to be another significant predictor implying that educators need to convey the benefits of using Twitter to their students in order to enhance its adoption for learning and teaching. The impact of perceived ease-of-use was insignificant in this study implying that the adoption patterns of today's social media technologies are more reliant on social influence rather than just being easy-to-use. Therefore, in order to provide a richer learning experience for students, educators must include social activities as a key ingredient of learning design.

This study also has some limitations. The sample size is small (64) as the study was conducted in a single subject in one semester. But we intend to conduct a similar study with larger cohorts over multiple semesters to strengthen our results. We also aim to extend this study across other higher education institutions within Australia and overseas. Another limitation is the self-reported data which can cause common method bias (CMB) in the study. However, Harman's single factor test did not reveal the presence of any CMB in our data.

4. CONCLUSION AND FUTURE WORK

The study provides some early insights into the usage and adoption of Twitter in teaching Marketing. This paper confirms the significance of social influence on students' usage of Twitter in performing learning activities in a higher education setting thus highlighting the significance of social elements while designing marketing curricula and the use of social media.

In future, we plan to report the findings of students' learning experience data and satisfaction data reported in the online survey to further investigate the usage of Twitter. The qualitative analyses of students' interview data will also be included to consolidate the study findings.

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MOBILE APPLICATION TO ASSIST IN THE PERFORMING COLPOSCOPIES

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ABSTRACT

Cervical cancer is one of the main types of cancer that attack women. Although there are some tests for its early detection, is not frequent that women have their medical studies done because of the process causes them some embarrassment and discomfort. On the other hand, mobile devices have become very popular nowadays, because of them costs have decreased while their computing capacities have been remarkable increased. This makes mobile technology attractive for application development.

This project develops a mobile application that converts the cell phone into a capture device able to assists health service providers in the colposcopy test and to obtain the (timely) diagnosis of cervical cancer. As a result, a mobile application developed for devices with the Android operating system is proposed. In this app the health service providers behave as the main users considering their knowledge on the subject. Additionally, to the social relevance of the application, it conveys some characteristics such portability, orientation to the assistance to the service provider, easy access, and low-cost application.

KEYWORDS

Cervical Cancer, Mobile Devices, Health Service Provider, Android Operating System

1. INTRODUCTION

Cervical cancer (CaCu) is a disorder that originates in the cervix. It manifests itself through precursor lesions of slow and progressive evolution, known as malignant neoplasms. Such lesions progress to two types of cancer: in situ (abnormal cells that can become cancerous) or cancer itself.

One of the gynecological procedures for the detection of cervical cancer is *colposcopy*. This procedure makes it possible to recognize lesions, to indicate the places where it would be most necessary to perform biopsies, and to monitor the cervical lesions found. Acetic acid is a very important ingredient in the practice of *colposcopy*, since when applied it creates a reaction called acetowhitening, which produces a contrast effect with the pink color of the epithelium. Immediately after the application of acetic acid, the areas change to a whitish color; in areas with invasive cancer, it changes to a whitish, dense, thick, and opaque color, this effect disappears slowly. If, when performing the colposcopy test, the personnel who apply it find a malignant lesion that requires special attention, they must ask the patient to perform a biopsy.

2. RELATED WORK AND OBJECTIVES

A support mobile application that assists in obtaining the diagnosis of CaCu would be easily accessible and low cost. Mobile applications have already been developed to support obtaining a diagnosis of CaCu, such as the DYSIS Colposcope, Eva Colpo, and Gynocular applications. However, they have characteristics that are not favorable for different situations, for example, the high price of some of the technologies that they use, are not a support to guide the specialist and are not portable. (See table 1).

Table 1. App Features

	Accessible price	Portability	Storage	Orientation	Image quality
DYSIS Colposcope			✓	✓	✓
Eva Colpo	✓	✓	✓		✓
Gynocular	✓	✓	✓		✓
Proposed app	✓	✓	✓	✓	

In this project, a mobile application was developed that converts a mobile device into a capture device that assists the health service provider with the performance of the colposcopy test and the (timely) diagnosis of the CaCu.

This includes allowing the health care provider to select points of interest in the study application when performing a colposcopy. The application, when obtaining this information, will show a quantitative representation of the acetowhitening reaction (change of color of the tissues from pink to whitish) and will allow to observe the temporal patterns that arise.

The application should also be aimed at facilitating the use of information and experience that is already available on the part of the health service provider who performs colposcopy tests. It is important to note that this must have, mainly, the following characteristics: portability and orientation to assistance to the service provider.

3. METHODOLOGY

The project adopts for its development process the methodology known as Open Up, designed to carry out work in an agile, modifiable, and evolutionary way.

The project is oriented to the development of an application in the Android operating system, which allows to capture images. When you start the application, the image of the cervix and a button on the right side appear, which allows you to capture the image. After this, the service provider selects four regions (ROI of clinical interest) in the captured image. The test is initiated by pressing a button, which captures ten images, which serve as a reference prior to the application of acetic acid.

At the end of this step, a five-to-one second countdown is presented to tell the service provider when to apply the acetic acid solution to recapture the image. Next, a submenu with the four selected ROIs is shown, where you can see the different colorations of the acetowhite temporal patterns (PTA).

$$\%_{change} = (ST - mu_{10}) * 100/255$$

Formula 1. Percentage change in the acetowhite colorations

See in Formula 1 as:

ST: Time series obtained after the application of acetic acid.

mu_10: Average of the ten images obtained prior to the application of acetic acid.

In the interaction with the application, the health service provider (PSS) is defined as a single user. It is the only one that interacts with the system, based on its experience in the subject.

The following describes the use cases to represent how the health care provider (user) should operate with the system and how its component elements interact.

The use cases to design the application are as follows:

a. The PSS starts the application.

b. The PSS stores patient information and PSS data to know who was the PSS that performed the test.
c. The PSS is responsible for indicating the ROIs of clinical interest.
d. The PSS obtains the information generated by the system about the temporal patterns and selects a region from which it has been obtained.
e. The PSS closes the application.
This can be seen in Figure 1.

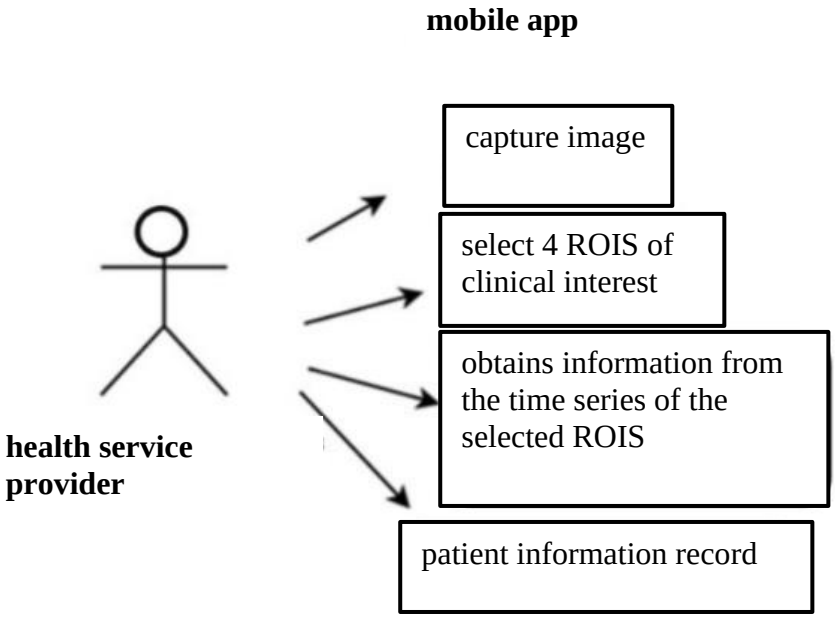

Figure 1. The use cases implemented in the assistant application

4. PROJECT PRESENTATION

A test prototype of the application is presented below. The application is tested on a tablet model Galaxy Tab S6 Lite, with Android operating system, the images and data of the user will be stored on the device. S elements are also added to the device which facilitates the work of the application. A light is added to improve the vision of the image, a cylinder-shaped object to simulate a lens and only see the region that we are showing with the camera and a support for Tablet is used.

We start by opening the application and first it shows us an animation with the name and the temporary icon of the application. Next, it shows us a welcome message and the description of some general instructions for the use of the application. Pressing the next button directs us to the registration screen where the PSS must fill in the data, date on which the test is performed, patient number, full name of the patient and age of the patient. The PSS must also register your data such as: PSS number and your name, this to know who the person was who performed the test. The main interface of the application can be seen in Figure 2.

Figure 2. Main screens of the assistance App: from starting to register user data

For the correct functioning of the application, the patient's number is an important data since with this data a folder is created inside the device where it saves the information of that record, and the images captured throughout the process, this information can help for a medical follow-up.

By saving the information it sends us to an indication screen, this information helps us to describe to the PSS how it should interact with the system at the time it begins to capture the reference images prior to the application of acetic acid.

Pressing the start button opens the camera and displays an initial image to select the region one of interest (ROI1), with the help of the center rectangle and the zoom image captured. Then, it shows a message to indicate that the capture of the images is being carried out, this same process is repeated to capture region two (ROI2), region three (ROI3) and region four (ROI4), it is important that the patient attends the indication not to move so that there is correspondence in the capture of the regions of interest. When the capture of the reference images is finished, the five-second counter begins, which tells the PSS that it is time to apply the acetic acid.

At the end of the account, it sends us to a screen where it gives instructions to now capture the images after the application of acetic acid, pressing on the start button begins the procedure of capturing regions one, two, three and four.

It is important that the patient heeds the indication not to move while the captures are made. When you finish capturing the images of the regions of interest, it shows us a screen with a menu to know the acetowhite temporal patterns of each region. Each region shows its time series, on the X axis the time in seconds and on the Y axis the percentage of change in intensity of the pixels.

At the end of the application, we can see that all the test log was saved on the device inside the Cacu folder. In the folder are the images of the selected regions, main images, and the registry information saved in the Data folder. The images are divided by: images captured for reference and images captured after the application of acetic acid. The time series that are presented can support the PSS because they show us information in percentages of the change in intensity with respect to the initial state, that is, if in any ROI a more pronounced or gradual change is observed.

5. CONCLUSION AND FUTURE WORK

Developing a mobile application to assist in the realization of colposcopies, brings more in portability, since being an application can be installed on any mobile device with Android operating system and take it to several places. Presenting an interface that guides the PSS at each step improves its use and results, for example, in

each step of the application instructions for use are added. The application also complies with low cost, only extra accessories such as light, lens and support are added to make the work of the application easier.

In a future work the application can be developed in other IDE (Integrated Development Environment) other than Android Studio which in this first presentation was used. Working with another programming language to compare its efficiency, perhaps the features presented in this application can improve, such as obtaining, speed in image processing. Just like developing the application for other mobile operating systems such as IOS, Windows phone, etc., and not only developing the application for the Android system.

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HOW EFFECTIVE ARE WEB ACCESSIBILITY REGULATIONS?

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ABSTRACT

Equitable access to the web is a critical element of the Right to Life affirmed by the UN Convention on the Rights of People with Disabilities (CRPD). In response to signing the CRPD, nations from all around the world have enacted web accessibility legislation to eliminate discrimination and to ensure equity of access to the web for people with disabilities. This research aims to understand the scope and maturity of accessibility regulations worldwide and their enforcement. Since the CRPD came into existence in 2008, governments throughout the world have passed or revised their laws guaranteeing disabled people's civil liberties and full participation in society, including full and equal use of information and communications technologies. But a fundamental question that remains is whether such regulations are effective in holding businesses or even governments liable for their violations. Examining a sample of countries across six regions of the world the paper underlines the need for more related action from governments to ensure full participation for people with disabilities in the digital economy.

KEYWORDS

Digital Accessibility, Web Content Accessibility Guidelines, Regulations, Enforcement, Lawsuits

1. INTRODUCTION

The world's population just hit 8 billion mainly due to soaring birthrates and advancements in modern healthcare. Increasingly, we are living in a society critically dependent on information and communication technologies (ICT). The AMA21 conference aims to bring together scholars and practitioners to discuss current issues of the world economy. A pertinent question that arises is whether a significant percentage of the world population, i.e., nearly 15%, that experiences some form of disability, is being left out of the digital economy. The UN Convention on the Rights of People with Disabilities (CRPD) affirmed that persons with disability shall enjoy legal capacity on an equal basis with others in all aspects of life. In furtherance to this, many of the 164 nations that are signatories to the CRPD have made progress in legislative efforts and policy frameworks to eliminate discrimination and to ensure equity of access for people with disabilities to digital technologies such as the world wide web. The proposed research investigates whether such regulatory efforts by nations are effective in holding businesses and other organizations or even governments liable for their violations.

Prior research studies (Loiacono and Djamasbi, 2013; Stuy, 2018) have examined the influence of legislation on corporate decision to provide an accessible website and concluded that there is significant need for legislative amendments for enhanced corporate compliance. A survey of 8057 municipal websites ten years after the enactment of the Stanca Act in Italy, revealed that most websites are not accessible, some failing even very basic tests of accessibility (Barricelli et al., 2018)., Laamanen, et al. (2022)'s study of Finnish higher education institutions' web pages using accessibility checkers revealed an average number of 119 errors per institution (minimum 3 and maximum 1165), despite the European Union's various policies and initiatives aimed at establishing an equal society and Finland's Act 306 of 2019 on the Provision of Digital Services. Motivated by these studies, we pose two research questions. The first research question that we address primarily in this paper is aimed at understanding whether accessibility legislation and policy frameworks have been widely adopted globally in response to the CRPD, particularly for the digital context. To study this we examine the scope and maturity of accessibility regulations in a selected set of countries

representing six regions of the world. Studying the effectiveness of such regulations in ensuring equity for people with disabilities will naturally be a follow up work leading to our second research question. This part of the study will examine effectiveness of regulations from three perspectives: awareness, impact, and enforcement. This will be the subject of our continued research.

2. THE STATE OF WEB ACCESSIBILITY REGULATIONS

The CRPD set the standard for recognizing and preserving the rights of individuals with disabilities across the globe when it went into force in May 2008. The Convention served as a political and legal statement of the international community's commitment to integrating persons with disabilities and the disability perspective into all elements of society and development (United Nations, 2022). It underlined the fact that corporate social responsibility might not be the sole reason for companies to make their websites accessible to a larger audience. Their primary motivation for caring about accessibility may come from the legal perspective, i.e., avoiding lawsuits for non-compliance with regulations and web content accessibility standards. Our study is centered on how the CRPD has influenced changes in existing legislation or creation of new ones related to web accessibility. To ensure we get better coverage, we divided the world into six regions - the Americas, the European Union, Australia, Asia-Pacific, Africa, and the Middle East. We then compiled a list of web accessibility regulations in a sample of countries in each region based on their ranking in Internet penetration. Analyzing these regulations and the efforts by the countries in enforcement resulted in several key observations. Overall digital accessibility laws and guidelines in many countries are very rigorous in their scope, currency, and emphasis on social justice. Although disability regulations were passed much before the advent of the web or the penetration of mobile technologies, many countries, such as Canada, Australia and EU have updated them regularly particularly since they became signatories to the CRPD.

Of all the countries we examined, the European Union (EU) needs special mention for the tremendous progress in implementing its accessibility guidelines throughout its member nations. The development of the European Union's standards for accessible built environments has served as a good illustration of how to put a variety of accessibility-promoting methods into practice. The European Committee for Standardization (CEN) oversees organizing, creating, and approving European standards across the board. The European Union made 2003 the European Year of Persons with Disabilities. In that context, the EU tried to make more organizations aware of the benefits of making things accessible to everyone. They also looked at the legal and political environment to see if it would be possible to set minimum standards for accessibility as part of a "Design for All" approach. Post CRPD, in 2010, the EU conducted an inventory evaluation of accessibility norms in member nations to provide guidelines on the idea of universal design. The European Commission adopted the European Disability Strategy in 2021. Two pieces of legislation that will have an immediate and continuing influence in the coming years are the European Accessibility Act (EAA) and the European Web Accessibility Directive. The European Accessibility Act (EAA) is aimed at establishing new minimum accessibility rules for a variety of goods and services that must be accessible. Its goal is to make it easier for people with disabilities to have access to the products and services that are offered inside the internal market of the European Union. The Act is a Directive, which means that it establishes accessibility objectives that must be met, but it gives the Member States of the European Union the discretion to choose how they will do so. The European Accessibility Act is expected to be incorporated into national law in every EU member state. Companies must make sure that the newly marketed goods and services covered by the Act are accessible as of 28 June 2025. Some exceptions may be made by member states. Specifically, to the web the EAA is applicable to companies that make or create things like computers and operating systems, automated teller machines, e-commerce websites and software applications. The EU Web Accessibility Directive, also known as Directive (EU) 2016/2102, came into effect in 2016. This directive ensures that individuals with disabilities have improved access to the websites and mobile applications of public services by making sure that at least the WCAG 2.1 Levels A and AA accessibility criteria are met. The aim is to develop a socially inclusive European "Union of equality," one in which every European citizen can fully participate in the digital economy and society.

The case of the US, however, is not very promising since the Americans with Disabilities Act (ADA) that came into existence in 1990 is the primary reference on the federal side and others such as the New York State and City Human Rights Laws on the state side. Interestingly, these do not directly address the case of websites or digital accessibility and it is left to the courts to provide interpretations of the law in individual lawsuits brought against governments and various organizations. Specifically, for web accessibility regulations, Section 508 that was adopted in 1998 was an addition to the Rehabilitation Act of 1973. It requires federal agencies to guarantee that their electronic and information technology is accessible to individuals with disabilities on an equitable basis. Section 508 was officially amended in 2018 to provide new requirements that reflect technological advances. It mandates federal agencies to make their information and communication technology (ICT) such as technology, online training, and websites accessible to everyone. It refers to the Web Content Accessibility Guidelines (WCAG), a global accessibility standard as a reference for compliance. In 2022, the Websites and Software Applications Accessibility Act was introduced in the US House of Representatives and the US Senate. Section 2 of this Act aims to affirm that ADA is applicable also to the use of websites, software applications and other digital technologies and that, without equal access to websites and applications, many individuals with disabilities are excluded from equal participation in and equal access to all aspects of society. Canada, on the other hand, has several accessibility regulations in effect, both federal and provincial, demonstrating their dedication to creating a society that is less exclusive and more barrier-free. In 2019, the Accessible Canada Act (ACA) was made into a law aimed at avoiding accessibility hurdles in information and communications technologies (ICT). It is a necessity for all federally regulated enterprises. Through the process of detecting, resolving, and avoiding obstacles, the ACA hopes to make Canada accessibility barrier-free soon.

As awareness and activism for disability rights continued to develop during the 1980s in Australia, that decade marked a significant turning point for disability rights. The Disability Services Act of 1986 was an important piece of legislation because it established a framework for the financing and provision of disability support services. This gave disability rights recognition as a crucial issue that needed to be improved upon. Since then, there have been more advancements to defend the rights of individuals with disabilities, and organizations in both the public and private sectors have a responsibility to be aware of these changes. Equal access is required for individuals with disabilities under the Disability Discrimination Act of 1992, which was passed in Australia. Firms in Australia that operate websites or companies that manage resources that are available to the public from servers located in Australia might be affected. According to Section 5 of the Act, discrimination is defined as treating individuals with disabilities less favorably than those who do not have impairments. If a company's website is not accessible to people with disabilities, the company may be ordered to pay to have the website redesigned and may also be held liable for monetary damages. The Accessibility requirements for ICT products and services were amended and approved in the year 2020. In contrast to the previous version of the standard, which only required WCAG 2.0 Level AA, it now assures that information and communications technology (ICT) goods and services purchased by government agencies in Australia meet with the WCAG 2.1 Level AA standard. Hardware and software, video technology, websites, digital documents, and technologies that give access to emergency services are all included in the scope of the standard under the category of items and services.

Japan started accessibility standardization activities as early as the year 2000 because the country has a rapidly aging society. In 2014, Japan enacted the Elimination of Discrimination Against Persons with Disabilities Act. Japanese Industrial Standard (JIS) X 8341-3, updated in 2016, mandates adherence to the WCAG 2.1, however, compliance with the standard is voluntary. In India, both public and commercial entities are required by law to offer accessible material to individuals with impairments. However, the laws of the country do not provide a common set of requirements for defining accessible material. The Rights of Persons with Disabilities Act (RPWD) was approved by parliament in 2016 where the law supersedes previous regulations and offers clearer guidelines for digital accessibility. The RPWD Act required private organizations two years to comply; beginning June 15, 2019, service providers must offer digital resources that appropriately accommodate individuals with disabilities.

In South Africa, the Promotion of Equality and Prevention of Unfair Discrimination Act (PEPUDA) of 2000, which prohibits unfair discrimination based on disability, continues to be the only legislation that has reference to digital accessibility. The National Strategic Framework on Universal Design, developed in 2021 provides a statutory reference and a prescriptive guide for the promotion and eventual enforcement of universal design and access standards. In 2016, Tunisia passed the Right to Access Information Law Act, wherein all citizens have the right to information so they can learn how decisions affecting them are made,

how public funds are managed, and by what standards institutions operate. It enables civil society organizations to gather the data needed to create efficient programs and strategies and effectively carry out their role as consumer advocates.

The most significant milestone in the digital accessibility regulatory process since the CRPD came into effect is the advent of a central monitoring agency in the European Union. This means that the burden of challenging digital exclusion does not rest solely with the impacted individual or community. Lewthwalte and James (2020) examined the implication of Brexit for disabled people in the UK. The related EU regulations are part of U.K. law, but the UK government will be the monitoring authority, i.e., there will be no independent oversight. Finally, work on updating web accessibility standards has also progressed in tandem, particularly W3C (World Wide Web Consortium) efforts toward the widely anticipated WCAG-Silver standard. This is important because most regulatory efforts depend on the WCAG standard as a reference for compliance purposes.

3. CONCLUSION

The first part of our research study provided glimpses into the legislative process in various countries around the globe following these countries' commitment to the CRPD and the need to integrate people with disabilities into the digital economy. We concluded that the U.S.A is lagging the EU and other developed nations in terms of digital accessibility legislation. Many other parts of the world are making sure and steady progress in achieving the objectives of the CRPD. Our continued research will examine how effective accessibility regulations have been in ensuring equity for people with disabilities. Effectiveness can be studied from three perspectives: awareness, impact, and enforcement. Due to paucity of reliable data related to enforcement actions in many parts of the world, we considered the specific case of digital accessibility lawsuits in the US as an example. A pilot study involving a sample of 30 prominent US organizations divided into six categories – government, restaurants, education, retail, entertainment, and healthcare was conducted. This study revealed that most of such lawsuits involved people with visual disability (77%) followed by hearing disability (20%) and other disabilities (3%). Not surprisingly, most of the lawsuits brought by people with hearing disabilities was in the education sector, with notable examples being Harvard and Berkeley, who were required to take offline their popular online courses. For further study, we intend to conduct interviews to understand the level of awareness of senior management in organizations and factors that lead to building inaccessible websites. We expect our detailed study to yield important insights into both the regulatory process underlying web accessibility and the socio-economic impacts of such regulations on individuals, businesses, and society.

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RESOURCE ORCHESTRATION DURING THE DIGITAL TRANSFORMATION PROCESS

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ABSTRACT

This paper aims to understand how incumbent firms reconfigure their operational resources and capabilities through digital transformation (DT) process. We applied a multiple case study with seven Brazilian firms currently going through or have completed the DT process. Regarding the theoretical contributions, first we discovered how incumbent firms develop operational capabilities (OCs) through the DT process and found a pattern in the OCs developed (e. g., customization and cooperation). Second, customization and cooperation are the means used by these firms to achieve superior operational performance outcomes such as speed and flexibility. From a practical point of view, we make some recommendations for incumbent firms' managers aspiring to engage the DT: (1) They should develop entrepreneurship expertise; (2) They should create an entrepreneurial work environment endowed with autonomy and collaboration; (3) They should seize the existing resources in another role that may have value for the firm's DT.

KEYWORDS

Resource Orchestration, Digital Transformation Process, Operational Capabilities, Operational Performance

1. INTRODUCTION

"The rapid development of digital technologies has facilitated profound changes in the strategies and operations across different industries worldwide. DT has been described as the modern-day fight to survive the existential threat of digital disruption" (Li, 2020). Firms of assorted sizes and operating in various markets have sought to expand or sustain their operations. However, the road that leads to that is quite tricky, since firms must readapt their business models, operations, processes, resources, and culture (Gobble, 2018; Vial, 2019; Heavin & Power, 2018). Despite practitioner and scholarly specialists have addressed DT, academic development has been slow (Ivančić *et al.*, 2019), and most of the studies stem from the field of information technology (Chanias *et al.*, 2019; Ivančić *et al.*, 2019; Vial, 2019). Perhaps the business field should address DT by conducting studies from different perspectives, given the lack of alignment between industry and scholarly research on DT (Nwaiwu, 2018). The DT process features diverse attributes found in the literature on operations management (OM) and strategy, mainly the transformations involving operation and processes (Gobble, 2018; Vial, 2019; Heavin & Power, 2018), continuous process and reinvention (Chanias *et al.*, 2019), integration of functional areas (Ivančić *et al.*, 2019), use of technology information (IT), and the development of new products, services, and solutions for customers (Westerman *et al.*, 2014).

To exam the DT we adopted the resource orchestration (RO) lens, which is a theoretical extension of resource-based theory (RBT). RO deals with how the firm resources are orchestrated to sustain competitive advantage (Sirmon, et al., 2011). This paper proposes that RO can help understand how operational resources and capabilities (Flynn et al., 2010) can be reconfigured through the DT process. New and existing resources will likely be reconfigured by incumbent firms that wish to formulate and implement DT. The process of how operational resources and capabilities are reconfigured and implementing firm strategies is a research opportunity in OM studies that needs to be addressed in detail (Park & Paiva, 2018; Anand & Gray, 2017), because a reactive role by the operations can disturb the strategy implementation. Consequently, our research question is *"How are incumbent firms reconfiguring their resources and operational capabilities in the scope of the digital transformation process?"*.

2. DIGITAL TRANSFORMATION AND RESOURCE ORCHESTRATION

"Digital transformation is an ongoing process of strategic renewal that employs advances in digital technologies to build capabilities that refresh or replace an organization's business model, collaborative approach, and culture" (Warner & Wäger, 2019). Given how novel DT is, scholars have been trying to organize the research on the topic, since the concepts have yet to be consolidated. To achieve this, they are outlining fundamental concepts, frameworks, and theories, which can help with the rigor and quality of future studies. Nevertheless, scholarly studies focus on technology, and it is a challenging task to find DT frameworks based on an organizational perspective (Nwaiwu, 2018). Scholarly studies have grown, generally developed in the fields of information technology (IT) or Systems (Chanias *et al.*, 2019; Ivančić et al., 2019; Vial, 2019). Also, studies have been conducted in the field of strategy and innovation (Nwaiwu, 2018; Warner & Wäger, 2019). Gradually, also other areas have come to address DT, such as manufacturing and operations, which have recently discussed the role of open innovation (Lorenz et al., 2020) and different approaches to managing the transition (Li, 2020). DT has attracted an increasing research interest, as many practitioners as scholars. However, academic efforts have advanced slowly, perhaps because DT frameworks are still evolving (Ivančić *et al.*, 2019). On the other hand, there is a lack of alignment between industry and scholarly research on DT (Nwaiwu, 2018). Furthermore, DT is a new context in which firms have an opportunity to harness and transform their business models, but it is also profuse in challenges and complex questions. Consequently, management scholars need to investigate it by developing frameworks and theories. Therefore, to make these suggestions come true, RBT and their RO extension will be explored following.

Since the early 1990s, RBT has been an influential theory for describing, explaining, and predicting firms' performance, especially regarding their bundle of resources (Barney et al., 2011). The establishment of its capability to examine strategic management, mostly its inner vision was built through subsequent scholarly efforts (e. g., Barney, 1991). Since the 2000s, various academic efforts were undertaken to overcome the restrictions of role management on rare, valuable, and imperfectly imitable resources. Perhaps, the first effort in that direction was undertaken by Sirmon and Hitt (2003), who observed family firms and developed a resource management process. Kraaijenbrink et al. (2010) suggested that future studies examine the context and the deployment process to realize the value of resources. The definitive effort was scrutinized as a special issue on RBT by Sirmon et al. (2011), according to whom, "resource orchestration draws upon both resource management and asset orchestration and focuses on how managers affect a resource-based competitive advantage". The authors proposed a theoretical extension of RBT, addressing the importance of managerial work conceptualized as resource orchestration (Hughes et al., 2018). Sirmon et al. (2011) suggested as a future RO research agenda to examine this theory by focusing on the firm's breadth (scope of the firm), depth (the firm's levels), and life cycle (the various stages of firm maturity). Concerning the core steps, structuring refers to the processes through which firms acquire, accumulate, and divest resources; bundling refers to the processes through which firms construct or alter their capabilities (stabilize, enrich, or pioneer); and finally, leveraging refers to the processes through which firms mobilize, coordinate, and deploy the capabilities to take advantage of specific opportunities in certain markets (Sirmon et al., 2007).

3. METHOD AND DATA ANALYSIS

As a method we adopted the multiple case study design. Seven traditional Brazilian firms currently going through or that have completed the DT process were examined. Also, a group of eight digital experts was interviewed. Totally, 180 data sources were collected (63 interviews, 33 internal data, 76 secondary data, and eight field notes). The seven firms evaluated represent the industries with high (Retail, Technology, Financial, and Telecom) and low levels of digital maturity (Consulting, Publisher, and Chemical) according to Dell (2020), both in Brazil and worldwide. The data collection started in May 2021 and was completed in September 2021. All interviews were guided by a semi-structured protocol and conducted online, given the restrictions caused by the COVID-19 pandemic. All interviews were conducted and recorded by the author using the Teams® platform. The length of the interviews ranged between 40 and 110 minutes. All interviews were conducted in Portuguese language and transcribed automatically using the built-in Teams tool. Later, the transcribed files were edited and compared with the videos of the interviews. The data analysis employed data coding using NVivo®, visual maps, and within and cross-case analysis. Also, discussions, reflections, and the presentation of the preliminary results and findings with other researchers were crucial steps.

4. RESULTS AND DISCUSSION

We proposed that incumbent firms must reconfigure their resources and operational capabilities during the DT process. Our data collection and analysis showed that the RO process, subprocess, and managerial actions help us understand this operationalization. Despite some market differences like Chemical's case, there seems to be a pattern spread over several markets in the case of the firms evaluated here. This pattern refers to developing pioneering operational capabilities (OCs) such as customization and cooperation (Flynn et al., 2010). Indeed, these OCs help the firms to deploy a new business model, new operations, and the NPD process given their integration among other firms' capabilities. Also, the same OCs impact new operational performance, especially speed and flexibility. Customization is achieved by acquiring and accumulating technology and knowledge resources. Firms have developed proprietary technology that allows speed and flexibility in their market's competition by bundling this package with practices such as Agile, Lean, OKRs and routines and leadership such as iterative and horizontal communication and entrepreneurial autonomy. However, this is an OC pertaining to the technology firm department that most incumbent firms have created in-house. What is interesting is that probably because of the customization bundling, firms have also developed cooperation (internally and externally). The first motive is that despite the technology department, the product that will be customized needs to combine the existing firm's products and business knowledge. Thus, the efficacy of proprietary technology development depends on excellent cooperation among areas. On the other hand, the firms cannot produce all resources internally; they must develop some resources through partnerships, which has been a routine in DT, mainly counting on the support of start-ups. When both OCs or just one of them were referred to in our data, we could also observe the prevalence of operational performance regarding speed and flexibility outputs.

Therefore, it follows elaborated propositions derived from these findings. Given the previous results and the high environment uncertainty based on continuous change and the low resources availability (Sirmon et al., 2007) – e. g., technology professionals (know-how) – present in the digital business era, it is possible to propose: *P1. To innovate fast, incumbent firms must develop customization and cooperation OCs.* Incumbent firms have accumulated technology departments internally through managerial acquisition actions (e. g., IT resources, technology professionals, and practices). Generally, the professionals hired already have a previously developed digital mindset. However, for the technology department to work well, collaboration with other firm departments that do not have experience with recent technology and job development is paramount. Thus, the development of cooperation OCs depends on the digital mindset accumulation by the employees of other areas: *P2. Cooperation OC (internally) increases the digital mindset through the incumbent firm.* OCs such as customization and cooperation can be the key for incumbent firms to offer agility (speed and flexibility) and innovation in the scope of DT: P3a. Flexibility and speed is positively associated with the development of the customization OC. / P3b. Flexibility and speed is positively associated with the development of the cooperation OC. / P5a: Innovation is positively associated with the development of the customization OC. / P5b: Innovation is positively associated with the development of the cooperation OC.

Finally, the efficacy of the digital strategy implementation (transformation or optimization) depends on the suitable leveraging process, especially on the capabilities configuration deployment. Thus, given the OCs developed in the scope of the DT process and also the operational performance achieved, the following propositions were postulated: P6. The efficacy of the digital strategy implementation is positively associated with the integration between the firm's existing capabilities and its new operational capabilities. / P7. The efficacy of the digital strategy implementation is positively associated with agility performance (speed and flexibility).

5. CONCLUSION

This study offers both theoretical and practical contributions. As for the first, it validates the potential of RO to analyze comprehensively (Sirmon et al., 2011) the process by which firms bundle their resources to create capabilities to leverage strategies. To achieve DT, incumbent firms must acquire technical knowledge and resources to create pioneering OCs such as cooperation and customization, which support new product development process. Second, incumbent firms have achieved new operational performance outputs through the leverage of these OCs, especially speed and flexibility. Third, the mobilizing RO subprocess plays a core

role in the DT, especially when the incumbent firms could integrate strategy, entrepreneurship, and firm market skills to manage the DT process. Regarding practical contributions, there are some necessary prescriptions for incumbent firms' managers who aspire to implement DT in their firms regardless of their size. Managers must develop entrepreneurship skills to be integrated with strategy and firm market knowledge. These can be developed through one's participation in an innovation environment (e. g., relationships with start-ups, incubators and accelerators). Despite acquiring technology resources, managers must create an entrepreneurial environment for the employees, endowed with autonomy and a collaborative workspace. It is crucial to seize the existing resources in a new way. The people are probably the most important of them, requiring digital mindset acculturation.

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Reflection Papers

PROLOG, A TECHNOLOGICAL APPROACH TO TEACHING: THE CASE OF MATHEMATICS AND PROBLEM SOLVING

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ABSTRACT

A Prolog program consists of a set of facts and rules rather than imperative statements, commonly used in most other programming languages. Therefore, the Prolog language is used to encode logic, from which the inference engine deduces logical conclusions. In this article, we argue that the use of the Prolog language can be useful to help students become familiar with mathematics or more broadly, any problem-solving based discipline.

KEYWORDS

Prolog, Declarative Language, Teaching, Logic

1. INTRODUCTION: THE PROLOG LANGUAGE

Created in the 1970s by Alain Colmerauer and his team (Colmerauer et al., 1972), the Prolog language, whose 50th anniversary we are celebrating in 2022, has its roots in first-order mathematical logic. At first glance, its operation is remarkably simple compared to imperative computer languages: a Prolog program consists of a set of facts and rules - describing a "universe", i.e., a given problem -. The solution principles and the inference engine then allow to "interrogate" this universe to deduce logical conclusions. The philosophy of this unique language can thus be summarized by the motto: describe rather than code.

By its very nature, Prolog is therefore suitable for problems structured in rules and facts. Of course, this covers only a fraction of the types of problems one might be confronted with; but it is far from negligible. Indeed, modern applications of Prolog or Prolog-based languages, despite being few, span over a wide variety of projects such as programming research tools (Garcia-Contreras, Morales, Hermenegildo, 2016; Shumi and Sun, 2022), legal and accounting tools (Satoh et al., 2011) and industrial applications (Wong Chong and Zhang, 2021).

In this article, we argue that Prolog can be useful to help students become familiar with problem-solving methods in scientific disciplines. We will consider the case of mathematics - in particular at secondary school level - as well as the virtues of Prolog in the context of more advanced problem solving. This topic has already been of interest to researchers and teachers. Indeed, several authors have considered the use of Prolog in the teaching of elementary mathematics (Ball, 1987; Bensky, 2021; Buscaroli, et al., 2022; Connes, 1986) as well as more advanced mathematics (Elenbogen & O'Kennon, 1988; Gressier, 2015), and even in domains that are a priori remote, such as history (Weissberg, 1985). These small-scale studies show that despite its shortcomings (sparse user base, lack of interactivity and error reporting, weak optimization), Prolog appears to be a useful pedagogical tool in the teaching of young students.

The 50th anniversary of Prolog offers an opportunity to insist more on its pedagogical virtues, which appear to be underestimated or sometimes poorly known by teachers, and we wish, to place them in a much wider context than just mathematics (this approach is, indeed, applicable to physics, chemistry, for example).

2. CHANGES IN COMPUTER USAGE

In a competitive education environment, the teaching of older programming languages such as Prolog may appear to compete with the use of more widely applied languages such as Python or C++. However, we believe these languages occupy a different space in the education of students.

Indeed, like many computer languages, Prolog has followed an oscillating popularity trajectory. If we refer to the Tiobe Index, which measures the use of computer languages, Prolog went from being the 3rd most used language in 1987, to the 33rd in 2012 before rising slightly to 24th in 2022. Nevertheless, as the case of Pascal attests, (which has declined from the 3rd place in 1992 to the 270th) computer languages are sometimes subject to obsolescence. This is why we feel it is appropriate to specify from the outset that, in an educational context, the pedagogical relevance of a language must take precedence over its present popularity.

Moreover, imperative programming languages such as Python are generally taught to give students a head-start in their career. In this context these languages are then generally viewed as an algorithmic tool to encode the solution of a given problem. Prolog however can be used to teach logic and deductive reasoning, in addition to formulating problems, all of which are a prerequisite to algorithmic reasoning. For that reason, we believe Prolog should be more specifically employed in the context of teaching reasoning to younger students rather than in more applied courses. Moreover, Prolog is a representative of a very particular type of language: to deprive oneself of it would be to renounce a form of reasoning precisely adapted to teaching.

3. PROLOG AND MATHEMATICS EDUCATION

Although the introduction of programming languages in primary and secondary education is now quite old, the trend seems to favor imperative languages to the detriment of declarative languages (such as Prolog). Moreover, this is tantamount to favoring algorithmic reasoning which, while undoubtedly necessary and relevant for many problems, is far from being natural - let alone learnable - or suitable for many of them.

Euclidean geometry, for example, is difficult and unintuitive to approach from an algorithmic point of view. The natural way of reasoning about such problems is to make a series of logical deductions from remarkable propositions, facts or theorems - of which there are relatively few in junior high school or even high school. Here, Prolog is more suitable than languages like Python. Below we give an illustration in which we "translate" two elementary geometry theorems into Prolog.

```
/* a triangle ABC is right-angled at B, if it is inscribed in a circle of which AC is a diameter */
rectangle(B, [A,B,C], Circle) :- diameter([A,C], Circle), inscribed([A,B,C], Circle).
/* AB is perpendicular to EF if there are 2 triangles ABC and ABF rectangles at B */
perpendicular([A,B],[E,F]) :- rectangle(B,[A,B,E], Circle1), rectangle(B,[A,B,F], Circle2).
```

Note that one of the remarkable features of Prolog is its concise syntax, which, incidentally, is close to "natural language". If, now, a student is tasked to solve the following problem:

Let A, B, E and F be four points in the plane. Suppose that the segment [B,E] is a diameter of a circle C1, that [B,F] is the diameter of another circle C2 and, finally, that the triangles BAE and BAF are inscribed in the circles C1 and C2 , respectively. Show that the segments [B,A] and [E,F] are perpendicular.

In addition to the rules (predicates) defined above, it will suffice to declare to Prolog the data of the problem (facts), by writing that: diameter([b,e],c1). diameter([b,f],c2). inscribed([b,a,e],c1). inscribed([b,a,f],c2).

In this way, the student can easily check that "perpendicular([b,a],[e,f])" is true, i.e., Prolog will return the value "TRUE".

Although Prolog is not a substitute for classical problem solving, it appears as a valuable aid in learning to understand and structure problems, which is the first step towards solving them. Learning how to pose a problem correctly is sometimes enough to trivialize its solution; and it is precisely for this reason that Prolog is useful in teaching.

But Prolog's interest is not limited to elementary geometry. Let us consider, for example, the learning of the rudiments of calculus: the computation of derivatives, typically taught in the first year of high school. Although there are libraries for certain imperative languages that can perform symbolic operations (e.g. Sympy, in Python), they function as "black boxes". In Prolog, the computation of a derivative is done by declaring the

rules for its computation (see below), together with some facts such as the derivatives of the usual functions. In doing so, it is possible for the student, by deleting or adding a rule, to see what properties are necessary for the calculation of a given derivative and, thus, to better discern the mechanism that governs them.

```
d(U+V,X,DU+DV) :- d(U,X,DU), d(V,X,DV).
d(U*V,X,DU*V+U*DV) :- d(U,X,DU), d(V,X,DV).
d(U-V,X,DU-DV):- d(U,X,DU), d(V,X,DV).
d(U/V,X,(DU*V-U*DV)/V^2) :- d(U,X,DU),d(V,X,DV).
```

4. PROLOG AND PROBLEM SOLVING: LEARNING TO REASON

Let us add that Prolog is intrinsically (by the principle of SL-resolution) a problem solver. Thus, it differs from traditionally taught languages (Python, C++) in that finding an algorithm is not a necessary goal. A Prolog developer is expected to describe the problem to be solved correctly.

To illustrate this, consider the following problem:
Baptiste has a cat. Julien does not live in a villa. Laurent lives in a flat, but the horse is not there. Everyone lives in a different house and has a different animal. Who lives in the castle and who has the fish?
Solving this problem in Prolog is just a matter of describing it:

```
    /* the 3 dwellings */                    /* the 3 animals */
    housing (castle).                        animal(cat).
    housing (flat).                          animal (fish).
    housing(villa).                          animal (horse).
/* the predicate relation constitutes the relation between a person, his animal and his home */
    relationship(baptiste, L, cat):- accommodation(L).
    relation(julien, L, A):- housing(L), L==villa, animal(A).
    relation(laurent, flat,A):- animal(A), A==horse.
/* the predicate different is true only if its 3 parameters are different */
    different(X,X,_):- !, fail.              different(_,X,X):- !, fail.
    different(X,_,X):- !, fail.              different(_,_,_).
/* the predicate "solve" indicates the 4 unknowns to find */
    solve(LogBaptiste, LogJulien, AnimalJulien, AnimalLaurent) :-
    relation(baptist, LogBaptist, cat).
    relation(julien, LogJulien, AnimalJulien).
    different(LogBaptiste, LogJulien, flat).
    relationship(laurent, flat, AnimalLaurent).
    different(AnimalJulien, AnimalLaurent, cat).
```

Then the user can simply ask Prolog:

"Resolve(LogBaptiste, LogJulien, AnimalJulien, AnimalLaurent)",

which will then return:

```
"AnimalJulien = horse,
AnimalLaurent = fish,
LogBaptiste = villa,
LogJulien = chateau".
```

This example is purposefully simple, as it illustrates the potential of Prolog's built-in solving engine. As we have shown in the case of mathematics, Prolog has the advantage of teaching students to reason and to describe a problem by breaking it down into "unitary" elements. The student does not look for which algorithm is needed but tries to analyze the problem posed and break it down into known information (theorems, axioms or facts) before querying the engine.

A second advantage of the language is its syntactic simplicity, which, following first-order mathematical logic, is written in much the same way as a mathematical assertion: a predicate is "true" if a certain conjunctive or disjunctive normal form is true.

5. CONCLUSION

After a minimal effort to familiarize oneself with its syntax, which, as we have seen, is particularly intuitive, Prolog can be used to solve many problems, simply by describing them. This specificity avoids the need to resort to algorithmic reasoning, which is not always intuitive and requires a certain amount of experience to master.

Describing rather than coding emphasizes, in a pedagogical context, the need to take the time to properly pose a problem and its hypotheses before solving it. Incidentally, it allows a pupil to check for him/herself what rules, facts, propositions and other assertions are necessary to deduce the result; this seems to us to be a playful approach to apprehending the logical-deductive mechanisms in problem solving and to develop the pupil's intuition.

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EDUCATION FOR SUSTAINABLE DEVELOPMENT: EXPERIENCES FROM PUERTO RICO

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ABSTRACT

After the 2017 hurricanes, a private higher education institution in Puerto Rico underwent a process of self-questioning, rethinking its academic pertinence and participation in today's society. An undergraduate program in Sustainable Development was created as a response and part of a transversal academic review in 2018. This educational new offering emerged from the 2015 United Nations Sustainable Development Goals and the 2030 Agenda with a curriculum designed to work towards sustainability in Puerto Rico. This reflection paper will present the program's experience using the mini group technique qualitative method. The findings are intended to set recommendations from the students' perspective for a potential program review and serve as a faculty discussion and reflection tool.

KEYWORDS

Sustainability, SDG, Education, Curriculum, Puerto Rico

1. INTRODUCTION

Hurricanes Irma and María in 2017, category five hurricanes, left a shattered country, not only in infrastructure and more economically challenged but also in need of social solidarity caused by the isolation upon the country’s inability to respond to emergencies. An university in Puerto Rico underwent a process of self-questioning, rethinking its academic pertinence and participation in today's society. Around this time, a group of faculty members in administrative positions started questioning: What does the university community have to do to continue the university's mission and respond to the challenging times? (USC 2019a, 2019b). In response to this question, new core competencies were established: innovation and entrepreneurship, critical thinking, research and exploration, social justice, ethical sense, and communication. A degree in Sustainable Development (DES, by the Spanish acronym) emerged from the 2015 United Nations Sustainable Development Goals. By 2022, no other university in Puerto Rico offered a program like this.

This paper presents the first phase of the faculty's research process. It aims to offer a reflection using the students' experience in the program and their recommendations compiled from a mini group meeting (Beall, 2019). In addition, these findings served as a fundamental tool for faculty discussion and further reflection moving into the following revision phase. The following section explains the context, the method employed, and the study's findings. Finally, the conclusion and recommendations are presented.

2. CONTEXT AND METHOD EMPLOYED

2.1 Local Context

The DES Program seeks to promote the analysis of local and global problems through a transdisciplinary and education for sustainability approach, developing and strengthening critical questioning, communication, research, exploration, innovation, and entrepreneurship, parallel to Probst's (2022) confounding factors in

Higher Education for Sustainability framework. Designing a new academic program dedicated to the analysis, discussion, and appointment to achieve the UN SDGs, and to challenge the status quo silos between disciplines, was another step toward delivering and reaffirming its service and solidarity mission, quality transdisciplinary education, and sustainability outcomes. In this sense, materializing the DES Program is a novel creation offered as part of the bachelor's degrees of the Department of Business Administration. The DES program was designed using the four pillars of sustainability (economics, social, environment, and culture) as a sequential guide.

The first course of the DES program began in 2021, with an enrollment of six students for both the major (3 students) and the minor concentrations (3 students). Of the first cohort, 33% were 19 years old, and 67% were between 20 and 25. 83% were female, and 83% were residents of the metro area, according to data provided by the unit that handles institutional statistics. In addition, 33% had a GPA of 3.51 or higher, 50% between 3.00 and 3.50, and the remaining 17% had a GPA of less than 3.00. The second cohort of five students (3 students in the major and 2 in the minor) includes 40% of females, and 80% of the cohort are metro area residents. Regarding age distribution, 20% are 19 years old, 40% are between the ages of 20 and 25, and the remaining 40% are 26 years and older. Regarding the GPA, 60% had a GPA of 3.51 or higher.

2.2 Methods and Participants

Faculty involvement and commitment are essential to assessment and curriculum changes (Ndoye & Parker, 2010; as cited in Davis et al., 2020). By the second year of the DES program, the faculty proposes to know how the program is doing, what were the students' impressions and encounters about their classes, if the program challenges them intellectually, and their recommendations. In addition, students were interested in discussing various aspects of their program. Therefore, the design method was led by faculty's reflections as an outcome, with the triangulation of group meetings, curricula analysis, labor market perspectives, and a possible academic revision. This paper emphasizes in an initial student meeting findings and reflections.

To give the students space and openness, one of the program's traits, and to promote sustained dialogues, the focus group technique was selected and designed by the faculty. The design of this technique uses a comprehensive student-centered approach to identify areas for focus or improvement, better understand needs, and revise or develop a program to meet those needs. The purpose of a mini group was to understand the meaning behind the data and to discuss perceptions, experiences, and feelings about an issue (Beall, 2019; Fowler, 2014; Leavy, 2017). Therefore, this technique was used to collect and assess student's input.

The researchers prepared a mini group protocol and a moderator guide and sent an invitation with the purpose of the meeting via the institutional email for a hybrid (face-to-face and remote) focus group. A hundred percent of the first cohort in DES participated in this meeting, and 33% of the participants were from the first group in the minor concentration (n = 4). By the time of the focus group in 2022, forty-five percent of the major's and eighty percent of the minor's required courses had been offered. The mini group was divided into six research interests, starting with their motivations for enrolling. The second research focus is related to the curriculum and expectations of the DES program. The third focus is to get the students' feedback on class evaluations and the relevance of topics. The fourth research focus was intended to inquire about their achievements in the courses taken in the DES program and the approach to class topics by the faculty. The fifth part was related to class itineraries and program management. Finally, the sixth part sought to gather their long-term vision of the DES program and the aspects that currently stand out from the program.

According to participants, the university's website was the first source of information about the program. The motivations for enrolling and how they came to the DES program were diverse; among these are 25% of the students transferred from other universities or programs. Students from the minor in DES were looking for a minor that would fit what they wanted to develop and combine with the major. 25% of the students said that the approach of the pillars of sustainability is attractive: the economic, social, environmental, and cultural aspects per class were appealing. Other participants are interested in NGOs, either being part of one or creating an NGO. There is also motivation that the program allows students to have community immersion and work in solving local problems.

2.3 Findings

In this section, the findings are presented and categorized into two areas: strengths and weaknesses.

2.3.1 Strengths

The program has its strengths and potential. The field trips and immersions were valuable for the participants. "What happened in the classroom, we later saw in the field experience." - one participant expressed. They agreed that the faculty is well prepared to handle the topics of the courses, have commitment and initiatives. Students indicated that the discussions awakened them intellectually and have sparked new interests. Other aspects considered strong points of the program by the students are that going through the study and deconstruction of the pillars of sustainable development is relevant – it is like a step-by-step discussion. They also acknowledge the diversity of thoughts and experiences among their peers, which they consider enriches the conversation and promotes real-life debate in class.

2.3.2 Weaknesses

A participant indicated that the purposes do not correspond to the class contents discussed. In their opinion, having two-credit courses makes the program's goals somewhat unrealistic. Moreover, "as students, we have notions and general views of issues, but we are not competent to address them as such," – expressed a participant. "We know the general, but how to apply it to certain organizations, well, no." The group indicated that they feel the program is too broad and need to develop more skills. Other shortcomings revealed by the participants came out as questions: "How can we be professionals in sustainable development? Moreover, what does a sustainability professional do?" - one participant questioned, and the rest agreed. In addition, "What do you do with it?" – It is a frequent question they receive when they talk about the program with other people.

3. CONCLUSION

This exploration raises questions that acted as a ground for faculty discussions and reflections on creating a citizen cognizant of their circumstances and creating a sustainability specialist. A possible answer is to re-configure the program with an academic revision and outcome profile and take into consideration what the country needs. This is where the faculty is at the moment. Other actions have been taken or considered for validation and further discussion. In this section, the conclusion and recommendations are presented. This reflection paper aims to describe the experiences of the program from the student's perspectives and collect their recommendations to form a foundation for the faculty's reflections.

3.1 Conclusions

Knowing how an academic program is going, the student experience in a new and innovative educational program and involving students in its review process is a positive practice. This is because it becomes an inclusive and transparent process; the students feel heard, allows them to reflect on their progress, and puts them in a mirror to visualize themselves in the program and their future. Additionally, it is a reflection for the faculty to review and modify the courses, the teaching-learning methodologies, the types of evaluations, and even the program's study plan. Similarly, this initiative, which was well received by the students participating in the mini group as they felt open to contributing to their program, becomes direct evidence to justify possible changes. Three positive aspects stand out from the students' perspective related to the DES program:

1. The topic of sustainability is attractive as an area of study, with interest in delving into others.
2. The teaching-learning methodologies with a non-traditional view are expected among students.
3. Participants highlight the commitment and preparation of the faculty.

Among the negative aspects from the students' perspective, the following stand out:

1. There is no defined or specific occupation related to sustainability in the local labor market.
2. The program tends to be short in being practical and specialized.

3.2 Recommendations

Institutional program revisions are done based on the program's objectives, aligned with the alumni's desired profile, the university's mission, and the general requirements. The findings presented here bring an opportunity to comprehensively review the requirements or prerequisites in the courses, the teaching-learning

methodologies, the evaluations, and, consequently, the syllabi while taking into consideration the students' views. This should make a more detailed, tailored, engaging, and action-research program, the latter as suggested by Bornstein (2007). This reflection led to composing initial recommendations.

3.2.1 Immediate to Short-Term Recommendations

1. Hold a meeting for guidance, manage expectations and exposed possible tracks.
2. Capitalize on being a pioneer program in Puerto Rico and promote to increase enrollment.
3. Integrate field trips and guests in a coordinated way between courses or topics of interest.
4. Carry out an entry interview to direct the student in selecting minor concentrations or tracks.
5. Answer the question: "How can I work on sustainability from an occupation?" by challenging the labor market and the practical value dichotomy, and design and create the occupation of Sustainable Development Specialist – which does not currently exist in Puerto Rico – as part of the program expectations.

3.2.2 Medium to Long-Term Recommendations

1. Review the syllabi, core contents, credits count and curricular sequence.
2. Include more inter and transdisciplinary and collaborate with other areas to create specializations.
3. Create a sustainability library as a primary source for students to further their research interests.
4. Create liaisons with projects and people working on the SDGs and sustainability.
5. Include students in discussions about the program.

3.3 Final Thoughts

The program's modification requires an adequate allocation of resources, including institutional support, timely hiring of the faculty, and proper promotion (Bell, 2022). The DES program of the Department of Business Administration is new, with a small number of students, yet this does not mean that the program is not interesting or that its topics are irrelevant now. This exercise has led to a reflection on the DES program, presenting the opportunity to value the need to integrate it into the university's other offerings. Nevertheless, it still needs to challenge and answer what a professional in sustainability does, as the students advised. This paper should be considered an open invitation to integrating disciplines, such as social work, education, communications, health, and natural sciences, and considering teaching and learning methodologies, such as co-teaching and content integration—a contemplation of the faculty's reflection meetings at large.

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U.N. SUSTAINABLE DEVELOPMENT GOALS AND PBL IN BUSINESS AND INDUSTRIAL ENGINEERING COURSES DURING THE PANDEMIC IN PUERTO RICO

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ABSTRACT

Education is one of the most powerful and proven vehicles for sustainable development and promoting lifelong learning opportunities. This reflection paper aims to demonstrate the process of reimaging the learning experience for the student and faculty in Puerto Rico during the COVID pandemic, while gaining student engagement and promoting sustainable development goals (SDGs) through the experience of the PBL approach using a 5Ws and 1H framework. Furthermore, this paper will demonstrate how the of technology and faculty development can potentially lead to meeting the SDGs.
Background: Higher education institutions play a critical role in the training of professionals while also having significant effect on the development of socially conscious citizens. Industrial engineering, economics, and business courses are a vehicle for fostering a sustainable development curriculum through research, product design, logistics, optimization, production, marketing, responsible consumption, and service. During the COVID-19 pandemic, higher education institutions faced new challenges due to the need to engage students in a virtual classroom. Puerto Rico's fragile infrastructure and economic predicament, added significantly to the challenges around establishing a sustainable high quality education experience.

KEYWORDS

Sustainability, SDG, PBL, Higher Education, Curriculum, Virtual-Learning

1. INTRODUCTION

Economic growth and societal progress often come at the expense of the environment and society. Organizations must come up with solutions in a sustainable way in order to improve not only production but to foster social and economic development. Understanding and appreciating the need for human progress in a sustainable or environmentally friendly way is core to finding solutions that will enable a better future for humanity. According to the United Nations (UN), the 2030 agenda and the Sustainable Development Goals (SDG) are universal, indivisible, civilized, integral, and transformative. In this sense, the UN SDGs guarantee a plan to work for the prosperity of all and the planet; it is everyone's task to address the local challenges to achieve these goals.

Other challenges are the need for data for effective analysis, implementation, sustainability, and feasibility of local ventures and alliances of private, public, and academic sectors. These alliances are crucial to unifying resources with a common goal: establishing Puerto Rico as an entrepreneurial island with sustainable development platforms. The platforms include developing a generation of well-trained faculty and students as the base of a new social-economic ecosystem that will drive the island to a better future.

This reflection paper aims to answer the following research question: How does PBL manage to achieve SDGs during the COVID-19 pandemic in Puerto Rico? This review of the literature intends to connect the process of reimaging the learning experience for the student and faculty while gaining student engagement and promoting sustainable development goals (SDGs) through the experience of the PBL approach. In addition, this paper will be addressing a 5Ws and 1H framework. This document is structured into three sections: the introduction, the context in Puerto Rico, the pandemic effect on SDGs and higher education, teaching and learning methodologies, and finally, the conclusions.

2. CONTEXT

This section reviews examples of how the pandemic has impacted Puerto Rico's SDGs, the faculty development process, and the educational technologies employed. In addition, several PBL activities are described for business and industrial engineering courses.

2.1 COVID-19 Affecting All SDGs in Puerto Rico

The pandemic has disrupted education and health services and caused labor and business interruptions worldwide. Fiscal and economic challenges have also increased due to the pandemic pressure on the island's nearly 15-year-old recession, public debt, high unemployment and inflation, austerity measures, and corruption. Hurricanes (2017) and earthquakes (2020) have further exacerbated already difficult conditions.

During the pandemic, all SDG goals were affected in Puerto Rico, some more than others. The island has experienced significant setbacks in sustainability, equality, and environment, including other social and economic aspects. The table below presents the 17 affected SDGs in Puerto Rico with examples.

Table 1. Examples of affecting SDGs in Puerto Rico during the pandemic

SDGs	Examples
SDG 1. No Poverty	Increase unemployment claims and new admissions to public health care and the local supplemental nutritional assistance program.
SDG 2. Zero Hunger	Lack of access to nutritional food, food insecurity, the drag of assistance programs, and staple foods scarcity.
SDG 3. Good Health and Well-Being	Collapse in the healthcare system with increased mental health issues. Loss in labor productivity due to remission, fear of getting sick, and extra workload.
SDG 4. Quality Education	Lack of technology access and connectivity for remote learning. Loss in school days for distance learning transition (face-to-face to virtual).
SDG 5: Gender Equality	Increase in gender-domestic acts of violence and vulnerability for female householders with children. This gender and domestic violence crisis brought the island to a state of emergency.
SDG 6: Clear Water and Sanitation	Lack of electrical power disrupt clean water and sanitation access.
SDG 7: Affordable and Clean Energy	Privatizing the distribution and commercialization of electrical power services, shortages of personnel with knowledge, lack of facilities maintenance.
SDG 8: Decent Work and Economic Growth	Suspension of economic and commercial activities generated problems with supply chain, employment, fewer working hours, less income, economic uncertainty, and less productivity.
SDG 9: Industry Innovation and Infrastructure	Hiatus of research and development of innovations in education, university research, and business practices due to lockdown, shortages, and loss of resources. Changes in production and reallocation of resources in manufacturing.
SDG 10. Reduce Inequalities	Increase the gap between income levels. People with fixed-income and low-income in the face of rising inflation see their purchase power shrink.
SDG 11: Sustainable Cities and Communities	Some vaccine resistance, increasing community involvement around pandemic challenges. The island is working towards a more resilient infrastructure and mindset. The island is highly dependent on non-renewable resources; therefore, sustainable cities are a long-term goal.
SDG 12: Responsible Consumption and Production	Higher waste production and management. The new reality brought, consequently, the use of disposable products (disposable face masks generating waste). Public policy is in place for biodegradable bags and other items.
SDG 13. Climate Action	Less environmental footprint due to lockdowns and economic activities. Reduced commitment to climate action due to the focus of the pandemic.
SDG 14. Life Below Water	Reduced usage of bodies of water which allowed organic regeneration. Reservoirs are full of sediments.
SDG 15. Life on Land	Reduced environmental pollution, such as air and noise pollution. Reverse land degradation.
SDG 16. Peace, Justice, and Strong Institutions	Conflicts due to lockdown restrictions and vaccination, an increase in bribery cases, and corruption, including the procurement for Covid-19 testing. Increased violence (illegal appropriations, drug and gun-related violence).
SDG 17. Partnerships for the Goal	Development of public health and global collaborations. Lack of funding for data analysis and current statistics for decision-making.

Source: Own work, 2022.

2.2 Faculty Development and Technologies Employed

The first phase of professional development focused on multiple areas, such as learning management systems (LMS), instructional design, remote teaching, and moving from a face-to-face class to a virtual environment. Other areas concentrated on technology per se, using Teams, Zoom, and Blackboard, among others.

The second phase tried to improve student participation, engagement, evaluations, and assessments. For two years, the priority was to learn and improve business and industrial engineering courses; therefore, the faculty carried out more than 80 workshops and seminars.

In the case of educational technologies employed, the goal was to improve virtual active-learning techniques and activities through tools such as breakout rooms, think-pair-share, peer-reviewed assignments, forum discussions, and polls, among other forms of virtual educational engagement. Webinars were essential for learning new applications like Nearpod for drawing, time to climb, match pairs, and surveys, or Peardeck for opinion polls, social media platforms - e.g., Twitter, TikTok, and for the creation of infographics using Infogram.com, Canva (not to be confused with Canvas LMS). Google applications for collaborative use in the classroom is another tool that has led students to feel more engaged during virtual-remote lessons.

During this analysis, advantages and disadvantages were observed. On the one hand, these educational-technological tools brought many benefits, such as student engagement, active classes, class participation promotion, and effective use of time (when learned and applied satisfactorily). The flipped classroom methodology took a central position in teaching remotely, giving students more responsibility for their learning process. On the other hand, the time spent on workshops and webinars was a disadvantage. The time to practice and apply the new knowledge was time-consuming and overwhelming. In addition, the cost of new educational technologies is high and requires licenses; in some cases, universities do not cover it.

2.3 Project Based Learning

Business and industrial engineering courses are a vehicle to foster sustainable development curricula. Real-life problems in Puerto Rico offered the canvas to encourage students in the analysis and advancement of the SDGs on the island. Based on the well-known teaching-learning methodologies, project-based learning (PBL), combined with active-learning activities and blended learning, was applied to class contents, learning, and the discussions on UN Sustainable Development Goals. PBL activities are designed to create a discussion on real-life scenarios, execute entrepreneurial tasks, and acquire soft skills (Abdul et al., 2022; Martín-Garín et al., 2021).

PBL activities have driven business and industrial engineering students to engage with their projects while applying their new knowledge. In the case of business courses, activities integrated the creation of videos and podcasts, infographics, proposals, and strategic planning, among others, to promote responsible consumption, community involvement, innovation, transparency, call to action, improve overall quality of life, economic and social development, and ethical and green business practices. In addition, to research, data analytics, community, and cultural immersions. These activities are student-centered and problem-based learning using action-oriented curricula, as suggested by Guerra (2017).

Industrial engineering students worked on tasks seeking to improve diverse production areas, standard times, and production rates. Students researched current methods to increase productivity, improve quality management systems, and reduce cycle time. Due to the urgent need for sustainable and innovative projects to address global challenges, students facilitate technology exchange enhancing entrepreneurial education and skills development. At the same time, this allows students to create products to be developed into business proposals.

3. CONCLUSION

This reflection paper aimed to demonstrate the process of reimaging the learning experience for the student and faculty while gaining student engagement and promoting sustainable development goals through the experience of the PBL approach. Through education and innovation, achieving the UN SDGs and the 2030 Agenda is possible. Higher education must be part of the mechanisms to achieve the next step. This section presents the conclusions.

Education is one of the most powerful and proven vehicles for sustainable development and promoting lifelong learning opportunities. Rethinking the course content in an engaging, attractive way to the student and simultaneously achieving the course objectives is challenging. The traditional view of a face-to-face teaching and learning environment for active-learning activities was disrupted, but it does not mean that achieving class objectives and continuing SDGs discussions was impossible. The advantages and disadvantages of technology were also presented, and the reflection is that the benefits outweighed the costs.

Promoting sustainable industries, and investing in scientific research and innovation, are ways to facilitate sustainable development. From this perspective, technological progress is key to finding solutions to economic and environmental challenges, such as providing jobs and promoting energy efficiency in Puerto Rico.

Furthermore, the use of technology and faculty development can potentially lead to meeting the SDGs. PBL activities dedicated to attaining SDGs were shown here as part of the business and industrial engineering experience during the pandemic. The 5Ws and 1H framework permitted the organization, discussing and helping the reflection on the findings on using PBL in SDGs in the classroom. Within this framework, faculty plays a central role, as suggested by Park et al. (2022) in fulfilling the UN's 2030 Agenda through curricula and class projects. At the same time, faculty are responsible for reevaluating and reorganizing their courses to become effective an asset and a vehicle of change.

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FLUTTER: THE FUTURE OF APPLICATION DEVELOPMENT?

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ABSTRACT

At the end of 2018 Google released Flutter, a new framework to program cross-platform apps for Android and iOS. It seems that it could have a similar impact on the digital world as Java technology at the time. This paper gives an overview of the philosophy and architecture of Flutter. The advantages and differences of Flutter compared to other techniques are discussed.

KEYWORDS

Application Development, Frontend, Native Apps

1. INTRODUCTION

Apps are often developed twice and individually ported to the respective platform. Native Apps[1] for the iOS environment, i.e., for Apple mobile devices, are programmed using the programming languages Objective-C or Swift and Apple's frameworks (Rebouças, M. et al. 2016).

Android apps, on the other hand, are usually based on the Java platform with the programming languages Java or Kotlin. If one wants to work with the in-house technology of competing companies, he/she must laboriously translate the code into the other languages by hand. The need for a cross-platform solution, therefore, soon came up and various technologies were developed. Basically, we can distinguish between two approaches: On the one hand, there are frameworks that work with web technologies. However, this should not be confused with web apps. These are merely web pages that adapt as well as possible to the mobile device. For app development, there is the procedure of embedding web pages into the app and presenting them via a browser component that fills the entire screen. The own code is programmed in JavaScript. Via an API, it can talk to native components, which can then address the specific hardware of the device. This approach has two disadvantages: Developers can only use features that are available on both platforms. Furthermore, the performance is limited because, in the end, developers are dealing with a browser application. The advantage is that web developers can also attempt app programming. Well-known frameworks of this kind are React Native from Facebook and Apache Cordova, formerly PhoneGap from Adobe (Heitkötter, H., Hanschke, S., Majchrzak, T. A. 2012).

The other approach is the following: Developers can program with platform-unspecific languages and frameworks, which are then cross-compiled into the desired environment and therefore have a better performance. A well-known representative of this technology is Xamarin from Microsoft (Boushehrinejadmoradi, N. et al. 2015). There, programming is done with C#. The Flutter framework with the programming language Dart also belongs to this category.

[1] These are apps programmed and optimized specifically for a platform

2. DART

Dart is a programming language developed by Google. In addition to Dart, Google developed many other programming languages, including Groovy. This language is compatible with Java and generates code for the Java Virtual Machine. The language Go was released at the same time as Dart. Go is a hardware-oriented language that can be used for system development, similar to C and C++. Go is supposed to be a modern version of these languages and compiles faster.

Dart, in contrast, was designed as a language for application development. Originally, Dart was developed as a language for the web browser Chrome. The reputation of Dart was controversial in the developer community due to its direct competition with JavaScript and ran contrary to efforts to standardize and interoperate web browsers. It was feared that there would be a new browser war like the one in the 2000s when Microsoft introduced Visual Basic as the browser language in competition with JavaScript, the Netscape language of the time. Therefore, the acceptance of the Dart language was rather low, and it became quiet around Dart.

In early 2018 Google announced a new framework for the development of apps, namely Flutter. The development in Flutter should be done exclusively in Dart. At the start of Flutter, Dart was also modernized and is now available in version 2. In the process of this development, Dart changed from an extension of JavaScript to a language, which has strong similarities to C# and Java (Hassan, A. M. 2020). Subsequently, Dart offers dynamic typing as well as static typing.

3. FLUTTER FRAMEWORK

The purpose of Flutter is to develop mobile applications. Target platforms are iOS for Apple devices and Android for the other mobile devices (Rao, P. S. et al. 2022). The focus is on the development for devices with touch-screen, thus cell phones and tablets. However, other devices are also supported, such as desktop computers or Smart TVs. Hardware specific functions are offered as plugins for the respective devices, with a native implementation for each platform. It is possible to program with a single code base for all platforms. The visual appearance is modern because Flutter is based on Google Material Design. However, developers can also use the Cupertino design to have a consistent design for Apple devices. The performance of Flutter is very good, since it is compiled to native ARM code. Flutter also uses its own high-performance rendering engine Skia. This makes the framework performant, unlike other platform-independent app frameworks that are often based on web technologies. The programming philosophy is also modern, where Flutter supports the so-called reactive programming.

Even more platforms are to be supported. There is support for desktop computers and their operating systems Windows, macOS and Linux. Flutter can even be used on Raspberry Pi computers. A web version of Flutter is also available. In addition, smart devices from the IOT area will be supported in the future. When programming on these platforms, it should be noted that the plug-ins available for mobile applications are usually not supported there. Flutter is on the way to become a universal framework. Reminiscences of Java with the slogan Write once, Run Everywhere are coming back to older developers. At that time, Java created the claim that applications realized with it could run via the Java Virtual Machine (Java VM) on all devices on which it was available. The difference to Flutter: On the one hand, native code is generated and not byte code that has to be executed via a VM. On the other hand, the formats of the devices changed considerably, smartphones and tablets did not exist in the early stages of Java. In Flutter, layouts neither are created in XML, as in Android, nor by using a graphical editor, but are described directly in a dart data structure. Here the strengths of Dart become apparent. It is expressive enough to make this possible.

In Flutter everything is a “widget.” Widget is an artificial word made up of “Window” and “Gadget.” These window objects describe everything visible like text or buttons, but also layout formatting like centering *Center(...)* or animation (Singh, M., Shobha, G. 2021). In figure 1, a class diagram shows the important connections (Meiller, D. 2021. p. 64). So, all widgets inherit from the base class *Widget*. In the diagram is shown that there are three types of widgets. Firstly *RenderObjectWidgets*, thus formatting like alignments. Second, *Stateless*- Widgets, thus graphic, immutable elements without a state. Third, *StatefulWidgets*, thus elements that have a state that can change. States are specified separately as a class. These are parameterized classes; the type parameter is the corresponding implementation of the *StatefulWidgets*. In Figure 1 and Figure 2, implementations of *StatefulWidget* “*MyPage*” and of State “*MyPageState*” are shown, but they are not part

of the class library of Flutter. The reason for separating the state from the *StatefulWidget* class is, that the *Widget* superclass is marked with *@immutable*, which means that all widgets are immutable. The mutable state can be created using the *createState()* factory method, which creates an object of type *State<StatefulWidget>*.

Important for the construction of apps is the ability to provide several pages with different content and the ability to navigate between pages. Usually, these pages are called "*Routes*" in Flutter. Any Widget can be used for a route. A *Navigator* can be used to switch between the pages. The design philosophy of Google Material Design is that such routes can be stacked on top of each other and removed from the stack. The transition is usually animated, and new routes are pushed in or out from the page or from the top. The class *Navigator* has the corresponding *methods push(...) and pop(...)*. To create a route, one must generate a route object and pass it to a *WidgetBuilder*. This is a lambda function that returns a widget, for example, *MyPage* in the diagram.

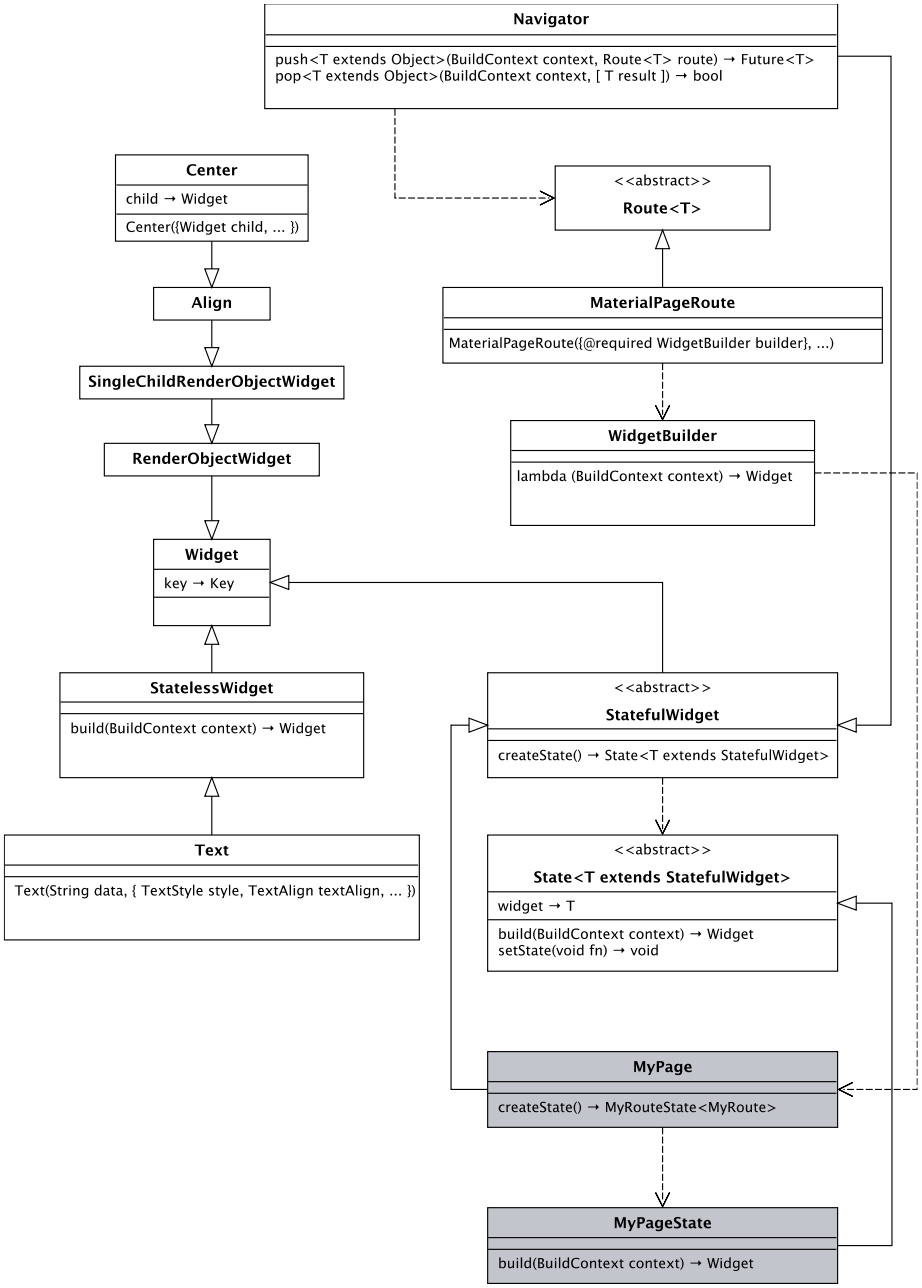

Figure 1. Flutter architecture

```
import 'package:flutter/material.dart';

void main() => runApp(const MyApp());
class MyApp extends StatelessWidget {
  const MyApp({super.key});
  @override
  Widget build(BuildContext context) => const MaterialApp( home: MyPage() );
}
class MyPage extends StatefulWidget {
  const MyPage({super.key});
  @override State<MyPage> createState() => _MyPageState();
}
class _MyPageState extends State<MyPage> {
  int _counter = 0;
  @override Widget build(BuildContext context) => MaterialButton(
      onPressed: () => setState(() => _counter++), child: Text("Nr: $_counter"));
}
```

Figure 2. Minimal flutter example

4. CONCLUSION

Due to the unification of the development for all platforms and the innovative software architecture, there is a strong increase in interest in the Dart language on various statistical pages. Also, when looking at the trends on (StackOverflow 2022), a rapid increase in demand for Flutter technology could be observed. Kotlin (Góis Mateus, B., Martinez, M. 2016), for comparison, which is a language that can be used for Android programming, slowed down its increase. Swift, the language used in iOS development, slowed down. Flutter also made strong gains compared to hybrid frameworks (Singh, M., Shobha, G. 2021).

Based on these statistics, it is assumed that the interest in this relatively new technology will continue, as it offers some advantages over other technologies: Developers can program apps for different target platforms with one language and one framework. The code is fast, easy to read and maintain. In addition, the look is modern as it implements the material design. The documentation is always up to date and very detailed. Additionally, there is a very active community that writes tutorials and articles. The open-source community has also put numerous plug-ins and open-source projects online. Google, as a big player, has often stated that they intend to use the Flutter technology as a graphical framework for various platforms of the future.

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TOWARDS VERIFYING NETWORK TIMELINESS

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ABSTRACT

Today's networks should meet strict real-time requirements. The reliability of emerging computing use cases such as autonomous vehicles, IoT, and cloud-based systems, for example, hinges on the ability of the network to deliver information to devices in the right time frame. Formal reasoning about the timeliness of networks is challenging. Despite significant progress towards building various network verification frameworks, e.g., via applying model checking (exhaustive exploration of an abstract mathematical model of the network), the scale of networks and classes of properties that can be formally verified remain limited. Crucially, the existing network models abstract away the notion of time (essential for verifying real-time properties) and focus instead on a narrower set of logical properties. Real-time properties are strictly stronger—and computationally more expensive—to verify because the events that affect them (such as congestion) can change rapidly and require more refined models of the network. Larger models, in turn, increase the complexity of formal model verification techniques.

In practice, to sidestep the scalability and expressiveness limitations of formal verification, testing is used extensively to check some basic properties (such as reachability) of large-scale networks. Despite its great scalability, testing has well-known shortcomings including low coverage of state space and the postmortem detection of major violations. It is, therefore, not surprising that sweeping network failures and violations of critical invariants regularly transpire despite various testing and monitoring systems being "always-on". Availability and maintaining service level objectives (SLOs)— contingent on meeting real-time requirements—continue to be the biggest challenges facing operators today.

We argue that verifying real-time properties of critical networks requires the strengths of *both* approaches: it requires the coverage of verification techniques such as model checking as well as the speed and scalability of testing. This paper outlines the desired properties for such a hybrid technique and the challenges for achieving them.

KEYWORDS

Real-Time Properties, Networks, Verification, Tests

1. INTRODUCTION

Today's network must satisfy strict *real-time properties*, e.g., service discovery and load distribution networks are useful only if they direct user requests to servers in bounded time, the networks connecting autonomous vehicles are trustworthy only if they deliver information to devices in the right time frame, a cloud computing network is available only if it swiftly responds to user requests, and a datacenter network should consistently deliver packets with sub-millisecond delays to support emerging applications such as distributed machine learning and NVMe (Li, 2019) (Kumar, 2020). Overall, today's high-performance distributed systems continually seek lower latency communication (Marty, 2019). Alas, instances of poor latency and violations of real-time requirement are widely prevalent in today's networks and availability and maintaining service level objectives continue to be the biggest challenges facing operators today (Arzani, 2020).

Formally verifying real-time properties remains out of reach for existing network verifiers.

Although a large number of network verification and testing frameworks have emerged to validate the correctness of networks with respect to various correctness criteria (Xu, 2021) (Guo, 2015) (Kazemian, 2013) (Mai, 2013), such as loop freedom, waypointing, and reachability under link failures, they all leave out an important set of properties: *timing* properties and the ability of the network to meet real-time requirements.

2. UNDERSTANDING THE LANDSCAPE

Existing network verification and validation frameworks can be categorized into two broad groups: (1) dynamic testing which runs the code and observes and observes the validity of some properties such as reachability. These techniques detect bugs by exercising the real system and running the actual code with test cases, and (2) static formal verification techniques that extract a model of the network without running the code. This model of the network is then *exhaustively* explored to verify that it satisfies some desired properties.

Neither of these two groups alone is enough for validating real-time properties. Despite its scalability and ease of use, testing is known to have fundamental shortcomings including its low coverage of the state space and the postmortem detection of major violations (Clarke, 1999) (Alur, 2015). In practice, sweeping network failures and violations of critical invariants regularly transpire (Gao, 2020) *despite* various testing and monitoring systems being "always-on" (Guo, 2015).

Similarly, static formal verification alone is not enough: in theory, in contrast to testing that offers limited and non-conclusive visibility, formal verification can prove the absence of bugs because it exercises *all* execution paths of the model statically without requiring to test them all by sending packets to them. However, in practice, the guarantees that formal verification tools offer are often limited: these tools verify only an *abstract model* of the program under some specific *environment assumptions*. To lower the computational cost of exhaustively exercising all execution paths, existing verifiers (Kazemian, 2013) (Mai, 2013) (Steffen, 2020) (Horn, 2019) (Al-Shaer, 2009) aggressively abstract the network state which limits their expressiveness. The tools that manage to scale to industrial networks, for example, verify limited properties and narrow network functions (e.g., ACLs) to enable scaling, e.g., they verify basic time-abstract reachability (in Amazon AWS (Backes, 2019) and Microsoft Azure (Xu, 2021)) and cannot express general properties. Crucially, they leave out real-time properties that are vital for today's networks.

3. TOWARDS A TIMELINESS VERIFIER

In this section, we discuss the desired properties of a timing verifier.

Property 1. Network Verifiers should be probabilistic. Due to various sources of uncertainties (link and switch failures, congestion, randomized routing such as ECMP, etc.), networks are inherently probabilistic. Their verifiers should be too.

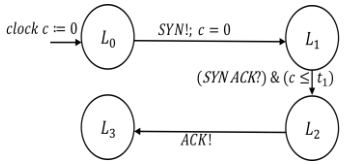

Figure 1. TCP's connection establishment: partial timed automaton

As an illustrative example, consider a partial timed-model TCP in Figure 1 that models a client's connection establishment. TCP is initially in mode L_0 (with a timer c initially=0) and ready to establish a connection. It can send a SYN packet and reset the timer (denoted *SYN!* and $c = 0$) and transition to mode L_1, where it waits for the server's *SYN ACK*. If it receives the acknowledgment (shown as *SYN ACK?*) in a timely fashion, $c \leq t_1$ for some constant t_1, then it will transition to mode L_2, where the connection is established, followed by sending an *ACK* packet (*ACK*!) and transitioning to a new mode as a result.[1]

Suppose the property that the operator wants to verify is that if the client sends a *SYN* packet (i.e., it is in mode L_1, the connection will eventually be established (i.e., the automaton will transition to L_2. Without probabilistic verification, one can only verify logical qualitative properties related to this simple property, e.g., (a) for all execution paths, the connection will be eventually established and (b) there exists an execution path where the connection will eventually be established. The first assertion fails because there exists at least one plausible path where the connection will not be established: a path in which the client never receives a timely

[1] The rest of the timed automaton and other automata such as the server's and the network's are not shown.

acknowledgment that satisfies $c \leq t_1$. The second assertion is true but too weak to be useful—a protocol that establishes one out of a million connections still satisfies (b) as there exists *a* path where the property holds.

In networks, randomness plays a role in validity of many properties, certainly real-time properties. The answer to the query *"will the connection be eventually established?"* should not be a binary yes-or-no; it should be quantitative, e.g., with a 99% confidence level, the proportion of the successfully establishment connection is between 0.91 and 0.92. We share this goal with NetDice (Steffen, 2020).

Property 2. Verifiers should include the notion of time. Verifying time-dependent properties such as latency, and service level agreements require the notion of time in the model. Not explicitly modeling time may result in unreliable results. Probabilistic network verifiers such as NetDice (Steffen, 2020) abstract away the notion of time and compute the probability that a property holds, e.g., the probability that a host is reachable. It is important to note that the computed probabilities show the *fractions of the reachable states* (e.g., in 99.9% of all reachable states, the host is connected)—and not the *fraction of time* that the property holds (i.e., one cannot use these verifiers to conclude that, 99.9% of the time, the host is connected). Verifying the latter requires taking into account the time that the network remains in each state which depends, for instance, on the convergence period (itself a function of the topological location of the failure), failure detection time, and duration of repair.

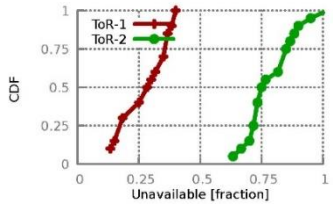

Figure 2. Availability depends on the time-to-repair variable

Can such transient events influence the accuracy of today's verifiers? To answer this question, we simulate a leaf-spine datacenter network with 2 core switches, 2 leaf switches, and 40 hosts connected to each leaf in the *mininet* network emulator and place the network under 40% load where each host communicates with a randomly selected destination (flow sizes and inter-arrival times are from web traffic in (Zhang, 2017)). Host A under one leaf periodically (once every $1ms$) sends heartbeating messages to a monitoring system under a different leaf. The monitoring system tags A as "unavailable" if it does not receive a message for $t > 10ms$. We run two sets of experiments (each for 1 hour, repeated 20 times): in the first set, we assume A 's leaf is a ToR-2 switch ($Pr[failure] = 0.039$, more than 60% of the failures take over an hour to repair (Gill, 2011); in the second set, we assume A 's leaf is a ToR-1 switch ($Pr[failure] = 0.045$, less than 20% of the failures take more than one hour to repair (Gill, 2011)). As expected, the difference in TTR distributions manifests itself in the availability rates in Figure 2. We also verify the reachability of A from the leaf switch connected to the monitoring system with NetDice (Steffen, 2020). For both cases (assuming A 's leaf is ToR-1 and ToR-2), the estimated probability is 0.97. The probabilistic framework in NetDice (Steffen, 2020) is useful for modeling the network and pruning the state space. However, to reliably reason about time-dependent properties such as availability and SLAs, it should be augmented to include the notion of time.

Property 3. Network verifiers should model the timed interactions of the network with its environment. Modeling networking protocols in isolation results in incorrect results. In the previous example of TCP connection establishment, suppose we replace the best-effort network with an ideal loss-less one in which all packets, including the *SYN ACK* packet, are always delivered and we also model a receiver that sends back a *SYN ACK* immediately. We verify with the UPPAAL verifier if in all program paths, if TCP is in the initial state L_0, it will eventually establish a connection. This property still does not hold. This result obviously does not reflect a realistic execution of TCP; assuming the receiver and the network are both responsive, TCP manages to establish a connection. The issue here is the modeling of non-determinism. The model in Figure 2 shows that in the initial state, it is *possible* to send a *SYN* packet and transition to L_1. However, nothing *forces* this transition. If and when the protocol makes the transition is not determined. Although many systems including network protocols are non-deterministic, in reality, their non-determinism is *bounded and controlled*. In practice, we deploy constructs such as timers and counters to offer some flexibility but ultimately enforce progress. The network verifier should model this bounded non-determinism, e.g., via a time constraint on state L_0 that specifies that TCP cannot stay there indefinitely.

Property 4. Network verifiers should scale. To be practical, network verifiers should scale to large-scale networks. This is hard because of the state explosion problem and is the main challenge that many verifiers tackle (Steffen, 2020) (Kazemian, 2013) (Mai, 2013). Adding timing and probabilistic aspects makes the problem harder and, in many cases, undecidable (Alur, 2015).

4. CONCLUSION

The speed and timeliness of networks are critical to the ever more demanding applications that run on them today. Yet, timeliness verification remains out of the scope of today's scalable verifiers. This paper draws attention to this limitation and outlines a path for addressing it via identifying key requirements of such a verifier. Ultimately, meeting these requirements requires the strengths of testing and verification: it requires the *coverage* of verification techniques to prove the absence of bugs and needs selective testing (while non-conclusive) to calculate timing and *probabilistic bounds* for models. Plus, testing can uncover the details that are too fine-grained for formal models (such as transient congestion) faster and in a more scalable fashion.

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SOCIAL MEDIA AND ACADEMIC SCHOLARS: REFLECTIONS ON BUILDING AN ACADEMIC BRAND AND FOLLOWING

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ABSTRACT

Social media has changed how and who we communicate with (Brainard, 2022). It has opened many doors for understanding and communicating domestically and internationally (Brainard, 2022). Through digital platforms, e-societies have become increasingly popular. Through these digital societies, groups of individuals can gather and share information at a moment's notice. Social media has also increased in popularity amongst academics and scholars alike. New-age academic scholars (i.e., millennials and Gen Z) have taken social media by storm. They have made their own freestyle representations and unique brand of what academia is to them. With this increasingly popular format of academic sharing, there is a new form of academic scholarship in which many educated individuals are making a name for themselves This reflection paper focuses on social media's impact on building a personal academic brand, public following, and business mindset. It emphasizes how academic scholars have found a new way to practice research scholarship while just starting or completing their graduate degrees. This reflection shares how social media is benefiting academic scholars and how research is becoming increasingly available and relatable to public and academic audiences.

KEYWORDS

Social Media, Influencers, Academia, Higher Education

1. INTRODUCTION

Navigating any graduate-level program is not one for the faint of heart. The excitement and nerves doctoral students and candidates feel from the first acceptance letter to the first day of class through the completion of their coursework, and then the preparation for qualifying exams is often known to be extremely lonely and confusing. Even if a student has good quality relationships with their academic advisors or mentor and uses the resources made available by the university, each of these phases can be overwhelmingly stressful and hard to navigate without help. Fast-forward to a doctoral candidate preparing for life post-doc and there are many unknowns about potential employment in academia. And while some doctoral candidates hope to go into tenured academic positions, it is becoming harder and harder to secure this level of scholarship. Leaving many research scholars looking at other avenues of career opportunities to potentially teach, coach, and mentor individuals. Social media (i.e., Facebook, Instagram, snap chat, TikTok, etc.) have become platforms for many academics and research scholars alike, to network, share, and create educational information by build their own customized business venture and personal academic brand. This reflection paper will highlight the power of social media as an academic influencer, how academia is becoming an individualized business concept, how academic influencers build their brand and gain followers, how this is done in minimalist conceptual formats, and the impacts this work could have on academia in the future.

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2. BODY OF PAPER

2.1 Social Media and Business

While social media started as an outlet for individuals to connect with family, friends, and other colleagues via virtual spaces. In recent years the expansion of business within e-societies has transformed how society shops, purchases, and even negotiates small and large acquisitions. The COVID-19 global pandemic further enhanced opportunities for businesses to grow their outreach programs and ensure organizational survival through a tumultuous time. Businesses such as retailers, specifically grocers, health care providers, and educational institutions were forced to create stronger virtual platforms connecting their consumers and product online. The pandemic changed how organizations and individuals looked at several areas: learning, connecting, and conducting business online and has since produced a mass increase in revenue for most organizations who took the necessary steps to stay relevant which has now changed many of our normal routine ways of purchasing and networking online.

Conducting business, creating social networks, connectivity, while learning from online platforms have also crossed over into academia, formally and informally. While social media is not a formal or traditional platform of higher educational settings it has become a platform to connect individuals within higher educational settings. E-society or societies are groups of individuals who have certain likes, affiliations, or connections to one another and uses online media as a premise for the relationship (Jayashree & Marthandan, 2010). These online societies have become a way of connecting with others who relate on certain levels and who often share information (Lixandru, 2020). For example, graduate students in master's or doctorate programs are recognized as participants in these groups which have large e-societies and a knowledge base of educational information and experience (Smith, 2017). Now, influencing on social media platforms has begun to evolve into individual opportunities to consult others within their expertise, build a personal brand based around their research practices, and e-commerce their brands and platforms as they grow their audience following. In the past, many academic scholars set their eyes on esteemed positions as an associate or full professor with the dream of tenure, the reality is there are fewer of these opportunities for current post-doc scholars. This is because higher educational organizations are moving away from creating full-time positions due to of a decline of "in-person" learning, increased faculty reaching retirement age, and additional institutional tenure caps (Baldwin & Chronister, 2001). Now a younger generation of Ph.D.'s sees that gone are the days of many "traditional" Ph. D. formats of academic employment and scholarship. Some of these individuals have turned to academic influencing as a form of creating their own brand and following, creating a name for themselves in and out of traditional academic rigor. Academic Influencing has become one of the waves for the future and a strong platform for many post-grad or post-docs who are utilizing social media as a form of employment.

Although social media and online influencing are often associated with celebrity branding or personal branding for specific consumer goods. Academics have been able much like standard business organizations, to connect with other scholarly researchers and academics who were going through similar journeys during the global pandemic. Setting these academic influencers and strategists, as they call themselves, apart from others in their vulnerability and thought processes to create content and share their educational journeys. Many if not all of these journeys have had highs and lows, setbacks and accolades, inform the dos and don'ts based on personal academic experiences and their ability to recognize sexism, ageism, cultural expectation, and many other "isms" which are often experienced in graduate school. By sharing these raw and real experiences it enriches the personal motivation and drive it takes to attain a graduate degree, which is why personal brand building, "branding" for short, is an art of "self-awareness and self-preservation" for many of these influencers who are academic scholars (Johnson, 2019, p. 8). It creates a way for current or incoming scholars to gain a deeper understanding and informative retrospective about the graduate school experience. Therefore, many individuals who are graduate students, candidates, or post-doc's have been taking their knowledge and expertise and building a professional network and academic strategies for others who are experiencing similar experiences. It can also be an informed extension of scholars making themselves known before, during, and after completing their program and then searching for and securing employment. From my own experience, the ability to build a strong group of followers in similar situations (i.e., graduate school scholars, students, and candidates alike) can build an even larger network of potential job opportunities and viable growth in your research specialty or expertise.

2.2 Building a Brand & Following

Branding gives influencers the ability to build an image of exactly what they do as an academic scholar/researcher and design their agenda of information and knowledge base which they focus on, which lets the influencer decide what they do and do not want to share (Johnson, 2019). For example, if the influencer is a social scientist with a specific focus on action research, the influence of action research information is the dominant driver of their shared content/posts. Creating one aspect of influencing which is everyone having their own way of documenting their experiences which they tend to vulnerability share with their audiences. Which is a central driving factor in why they are influential in their platforms. Most content postings and sharing are related to valuable, expressive academic experience, informational content, and outcomes the individual has had and/or learned from those experiences. Essentially, it is a free format of creative storytelling which many traditionalists in academia would argue is not academic. Even though there are influencers who have completed a substantial amount of coursework or research, which translates to having a valuable knowledge base of what it takes to be a successful graduate student. For example, if a doctorate level influencer has already completed course work and is preparing for their qualifying exam those individuals will often speak to their experience about that portion of their academic achievements and maintaining strong work/school/personal life balances throughout their journey. Then setting the stage for audiences/followers to ask questions, and share reflective comments, words of encouragement, or advice.

In general, there is a strong need for individuals to understand the importance of social media outlets and the power they have for building a brand and new business, hence social media presence and the advantages it brings should have a strong presence in an individual or organizations mindset this includes academia (Maxwell & Carboni, 2016). Currently, 40% of college-age students are generation Z (18-24 years old) a generation who does not know a world without internet access or e-society platforms (NCES, 2022; Pew Research, 2019). Within a few years, this is the generation that will continue to expand the job market in their respective fields replacing retirees. If those individuals continue as academic scholars and go further on in higher educational positions, building relationships in e-societies is a primary common factor in their methodology of work. Many academic influences tend to have followings based on which educational level they are at, for some, it then is narrowed down by culture, gender, and overall research or academic focus. For example, women of color in doctoral programs tend to follow one another woman of color or same gender 1) because there is commonality of education level and similar experience sharing, 2) because gender recognition in a field primarily dominated by men is essential, and 3) because lack of representation in their academic settings which is what makes social media platforms perfect arenas to connect with others who are experiencing what very few women of are. It does not go without saying that influencers are limited to only individuals who identify similarly to them but from a consumer perspective one tends to lean towards wanting to connect with an individual who is like them.

2.3 Minimalist Conceptual Concept

Posting is an important part of what makes a good foundation for building a following and a brand name as an academic influencer. There is an intricate social lingo that makes good posts attractive to others needless to say there is power in the #hashtag. Meaning there is just as much influence in the concept of the photo and wording influencers use in their postings. This shows, as we have seen social media management become such a high-commodity job in all organizations because businesses know the power in outreach through social media (Jacobson, 2020). Many organizations have hired full-time individuals to manage their social media because it plays that essential of a part in networking, outreach, and coordination (Jacobson, 2020, Montalvo, 2016, Afshin, et. al., 2022). The text content can be crucial to how many people are reached by these posts and how influential it is on the platform. A hashtag is a symbol followed by an alphabet and/or numbers which implicates what the post is essentially related to (Gerrad, 2018). Social media influencers would argue it is the most important part of a posting because it is used to identify a connection to what an individual is looking for. Think of the # as a search engine or keyword, like what academics use in a library search engine. Think about if you were looking for a book about andragogy, a common topic in higher education, you would use keywords such as graduate degree, higher education, college, or adult learning. Social media postings work the same way, and this is how academic influencers post their content and relate it back to their topic, and build formatting. An important part of understanding how to properly hashtag a

post when related to an educational post can be the difference of reaching ten or ten thousand individuals which build or lose business. A few academic referenced hashtags such as #academics, #scholars, #Latinascholar, #doctoralstudent, #graduateschool, and #Ph.D. are some of the social media search engines commonly used for higher educational posts. And while many traditionalists within academia would say this is not an academically framed way of researching or building an academic career, it is what many are using to do so. Social media has become a new standard for younger scholars graduating with their master's, professional Ph. D., or Ed. D degrees, to name a few. It is through strategic concepts such as personal branding which opens opportunities for academic influencers who are academics, to build and grow their careers in and out of academia. As scholarly researchers, we are taught to develop research that fills the gap and brings valuable information in both scholarly and layman's terms benefiting all audiences and this is also a part of this new experience and research.

2.4 Tenure may not be the Future

Although there is a substantial increase in undergraduates and master's students, individuals seeking doctoral degrees are still substantially lower in the overall degree conferral research data (NCES, 2022). I would like to remind my audience that this is a reflective piece I know academically will be questioned, dismissed, or overlooked by many in academic research. Whether for a lack of "scholarly" approach or data, data which is obsolete or lacking. However, since the start of global pandemic in 2020 the entire world has had to adapt and look for new ways to learn and teach. Understanding the power of social media and what academic influencers and strategists are creating is a vital part of what I like to call the "new" aged scholar approach. As academic influencers continue to post and create content about graduate school and their experiences, we must keep an open mind to what research can look like. While there are academic and research standards there are no right or wrong answers when it comes to story sharing. Often as scholarly individuals we get caught up in being correct or needing the satisfaction of perfection in having solid quantitative approaches, analysis, and synthesis. All of these are elements of developing scholars in the academic field, but we must remember these are individuals who have stories, experiences, and reasons as to why they chose social platforms to develop their academic careers at this point of their academic journey. While some Ph.D.'s will secure positions within universities, sadly others will not be due to a changing view on tenure due to the continual increase of online or remote learning opportunities. Meaning the dreams of professorship are quickly fading and becoming a past reality for many new millennial and gen Z scholars. I can attest to this at my university and academic career experiences, not because I am underqualified, or did not work harder to secure those types of opportunities, as some may use say about their counterparts. The reality is many graduate students find themselves in this position. So, they have adapted and are taking their teaching skills and research abilities as trained scholars and turning those into opportunities to consult, coach, and teach others in similar academic circumstances via social media platforms. These entrepreneurial academic scholars have been creating new ways of connecting with other scholars across the globe, working with them along parallel journeys. Many academic influencers do not get paid although some have been able to make a lucrative business model on private consulting contracts which also include coaching and mentoring sessions. These influential platforms get passed on to others through mass social media networking which grows the professional side sharing information about educational practices. And while a shiny professorship is still the dream job for many doctoral candidates, there is a new generation of scholars re-writing the meaning of scholarship can be or look like and how education can be practiced in and out of the traditional classroom. This new form of scholar professionalism is growing in practice and challenging how other scholars in academia feel about building their personal brand on social media, their professional identity, and what professional tenure as a scholar can looks like for them.

3. CONCLUSION

There are many advantages to social media in academia and business alike. Those advantages range from growing an organization, a motion, or idea. While social media is not an outlet that everyone uses for various reasons, it can help to build or strengthen any idea or organization if the time and effort is put forth. One perspective we must recognize in academia is that many undergraduate, graduate, and professional students are using social media to build their brand, image, and career sooner than later. In a vastly changing world, post global pandemic, many of the old methods of building community have gone away. Virtual spaces are the wave of the future to build a career and name. Being open to these types of platforms is essential but also a recognition that there is more than one way to educate people besides traditional brick and mortar buildings. The advantages of social media use for academic influencers outweigh the limitations. In the future other possible applications could include additional teaching and learning strategies for influencers who are academics and may not be sure what they are going to do in the future or may be questioning their career strategies after graduation. Either way, academic influencing and strategy is one wave happening and will continue to evolve in the future.

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Posters

TEACHING MEDICAL STUDENTS THE CONCEPT OF ARTIFICIAL INTELLIGENCE THROUGH INTERACTIVE VISUALIZATION

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ABSTRACT

Medical students may find that artificial intelligence will be integrated in future workplace, but they may perceive technology concepts too abstract or complex. The objective is to adopt interactive visualization to teach medical students the concept of artificial intelligence. In the learning activity, students may interact with a visualization tool, act as a data science without programming. It is expected that interactive visualization may facilitate students' understanding.

KEYWORDS

Interactive Visualization, Artificial Intelligence, Scientific Inquiry

1. ACTIVITY DESIGN

Educational researchers suggested that interactive visualization may help students understand the concept in STEM, for example, mathematics (Alkhateeb, & Al-Duwairi, 2019), physics (Lontschar, Pietroszek, Humer, & Eckhardt, 2020), chemistry (Fatemah, Rasool, & Habib, 2020), and so on. Through interactive visualization, students may have more controls to explore learning environments more actively. The objective of this study is to adopt interactive visualization to teach medical students the concept of artificial intelligence.

The activity is based on a general education course, *Introduction to Artificial Intelligence*, of which the students was college students in a medical university in Taiwan. In the activity, an online interactive visualization learning resource, *Machine Learning Playground* (https://ml-playground.com/), is adopted. The learning activity includes several stages.

- Mini-lesson (15 mins): The teacher introduces the interactive visualization resource and the work flow of data scientists in order to introduce the standard process of machine learning.
- Individual exploration (15 mins): Teachers ask questions and guide students through interactive visualizations. The guided questions make students more oriented in their personal inquiry.
- Group exploration (20 mins): In the previous step, the students have generated preliminary ideas through individual exploration. In group exploration, the teacher may have students compare their observations with each other to produce a more complete statement.
- Personal conclusion (10 mins): Every student make their own conclusion based on their observation and discussion with group mates.

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‘SECOND-HAND’ VS ‘COUNTERFEIT’ LUXURY FASHION GOODS: CONSUMER MOTIVES AND PREFERENCES IN A CROSS-CULTURAL INVESTIGATION

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ABSTRACT

The research in luxury goods usually focuses on exploring one type of luxury products: new luxury, counterfeit luxury or, more recently, second-hand luxury. More studies in the marketing literature have focused on new (i.e., first-hand) luxury goods exploring consumer’s as well as retailer’s perspectives. Hence, consumer’s preference between “alternative” types of luxury products (e.g., second-hand luxury vs counterfeit luxury) have been largely neglected and the role of culture (Easter vs Western) as a moderator on this decision is yet rather unknown. This research uncovers the perceived luxury values that drive consumer preferences for second-hand vs counterfeit luxury fashion products and tests whether these values are contingent upon consumers’ cultural characteristics: level of collectivism vs level of individualism.

KEYWORDS

Second-Hand Luxury, Counterfeit Luxury, Collectivism, Individualism

1. DESIGN/METHODOLOGY/APPROACH:

An online survey (N = 141) was conducted to (i) identify differences in luxury value perceptions between consumers in a *collectivist* culture (Saudi Arabia) and those in an *individualist* culture (UK) and (ii) explore how these differences affect consumers’ purchase intentions for second-hand over counterfeit luxury fashion products (women handbags). The participants (Saudi Arabia = 82; United Kingdom = 59) are female consumers, between 19 to 60 years old, 96% of whom were well-educated. Structural equation modelling (SEM) using AMOS was used to analyse the hypothesised relationships between variables and to test the model fit.

2. FINDINGS

Two consumer groups with different levels of individualism were selected. Specifically, Saudis scored 37 and Britons scored 89 on Hofstede culture dimensions model that measures level of individualism – which agrees with initial suppositions that people from Saudi Arabia are more collectivists while people in the United Kingdom are more individualistic. As existing literature suggests, the present study confirms that consumers in Saudi Arabia prefer counterfeit luxury over second-hand luxury (have high intention to buy counterfeit luxury). The opposite found to be the case among British consumers (preference for second-hand over counterfeits). No statistically significant difference was found in the perceived luxury values affecting the purchase intentions for second-hand vs counterfeit luxury fashion products between Saudi Arabian and British participants (except hedonism and materialism). However, materialistic and hedonic luxury values significantly explained the preference for both second-hand luxury and counterfeit luxury in the Saudi Arabian sample only. Specifically, it has confirmed that materialistic value has a positive relationship with both luxury alternatives "second-hand luxury and counterfeit luxury" (P value < 0.01). In contrast, hedonic value has a negative relationship with both luxury alternatives, more specifically it is significantly negative for second-hand luxury in Saudis participants ((P value < 0.02).

3. ORIGINALITY/VALUE

By considering cross-cultural difference in luxury consumption, this study provides important theoretical and practical implications. Specifically, extending luxury value perceptions (e.g., Wiedmann et al. 2009) model to validate consumer preferences for second-hand and counterfeit luxury fashion which is normally employed in new luxury. Through understanding the consumers values perceptions that associated with both luxury alternatives, this study may constitute insights for managers in developing strategies for second-hand luxury products.

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