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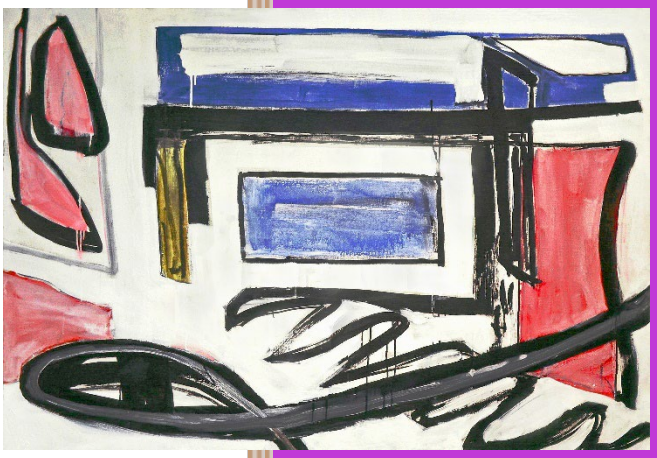

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An Overview of Arabic Language Open Educational Resources (OER) for Primary and Secondary Education and Their Use in Offline Environments

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Abstract: Open educational resource (OER) initiatives have opened new avenues for educational opportunities, yet OER adoption levels globally remain low. Two significant obstacles to more widespread adoption of OER are the challenge of internet connectivity that nearly half the world's population still faces, and the lack of locally-relevant (e.g. in terms of language and curricula) OER resources. This article's contribution is twofold. First, it presents a qualitative landscape analysis of existing primary- and secondary-level Arabic-language digital OERs and of the initiatives that provide these resources. Second, it details applied research via a case study, wherein appropriate resources identified in the analysis were subsequently curated for inclusion in an offline digital library currently being used in schools in Northeast Syria that offers all Open resources. Results from the landscape analysis indicate a limited quantity of Arabic-language OER content available for primary and secondary education. Furthermore, multiple challenges hinder the adoption of OER in resource-constrained settings. Accordingly, recommendations are made that could help to improve these resources' ability to be used, particularly drawing from the article's applied case study for examples. Given the case study's application of providing locally-relevant OER resources in an offline setting, this article provides a real-world example of furthering open e-learning, despite infrastructural, linguistic, and socio-political challenges. As such, it advances research supporting innovative e-learning practice, and should be of interest for scholars and practitioners interested in furthering the adoption of open e-learning in low-resource settings globally.

Keywords: Open educational resources (OER), Open access (OA), Offline, Libraries, Arab region, Arabic language

1. Introduction

Open Educational Resources (OERs) are often advocated as a means to increase educational opportunities and advance educational equity, helping educators and students overcome barriers such as physical distance, affordability, and other socio-economic and cultural challenges (Willems and Bossu, 2012). Nonetheless, uptake and acceptance of OERs globally have remained at low levels, particularly outside of English-speaking communities (Karakaya and Karakaya, 2020). Multiple barriers to adoption have been identified, including lack of awareness, policy issues, infrastructural capabilities, (perceptions of) quality, and localization factors such as language and cultural considerations (Abbad, Morris and de Nahlik, 2009; Uzuner, 2009; Hassler and Jackson, 2010; Karakaya and Karakaya, 2020; Peneder and Walcher, 2020; Tlili, et al., 2020).

Given the diversity of economic, political, cultural, geographic, and infrastructural realities, the Arab region is a particularly interesting case study of the successes and limitations of OERs (Eshet-Alkalai and Aydin, 2009) with *multiple* countries in the Arab region raking in *both* the top-10 *and* lowest-10 GDP per capita lists (World Bank, 2023). Not surprisingly, literacy and educational attainment rates vary widely within the region (United Nations Development Program [UNDP], 2023). One potential outcome, which partially motivated the present study, arises from the disparity seen within the region, contrasted with the potential to address one of the most identified barriers to adoption—a commonly spoken language. In other words, since Arabic is spoken by over 260 million people, and is the major language used across the entire Arab world (Kaye, 2018), the opportunity would seem to exist for the creation of OERs in Arabic, by the Arab countries with very high per capita GDPs and educational attainment, that could also benefit those less well-off across the region.

Moreover, while the Arab region accounts for 5% of the global population, its people represent 32% of global refugees and 38% of people internally displaced due to conflict (United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2019). Since displacement and conflict have negative effects overall on

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educational continuity and attainment, a strong argument can be made for harnessing the advantages of OER in the Arab region, in terms of cost savings and enabling distance learning. However, OERs are generally shared and disseminated digitally, via the Internet, which presents its own barriers in reaching those who are most in need of accessible, free educational materials. Approximately half of the adult population across the Arab States region does not use the internet, which places the region overall in line with global levels of internet use (International Telecommunications Union [ITU], 2020). The percentage of internet users is even lower among rural, less literate, and lower income populations across the region (ITU, 2020), not to mention for those displaced by civil unrest or conflict. Mustafa (2013) reports that online Arabic materials in general (not just OER) make up barely 3% of total Internet content. This demonstrates the critical need for more Arabic information to be published online in general, and as open content in particular.

Given internet connectivity challenges for nearly half the world's population, exploring strategies for reaching offline populations was the second motivating factor in our research. Here are the research questions addressed in this article: (1) What are the prospects and challenges of utilizing Arabic-language Open Educational Resources (OER) for primary and secondary education in the Arab region, particularly in offline environments; and (2) How can these resources be effectively curated and implemented to address educational disparities and connectivity issues?

To address these research questions, the study informing this article undertook a landscape analysis of OER initiatives and resources, that were online, in Arabic, or originating from the Arab region, and that were targeting primary and secondary educational levels. Further analysis was performed to determine the geographic location of the initiatives, whether they were public or private, and whether the content they produced was copyrighted, open, OER, or something in-between, and finally, assessed the resources' suitability for offline use. The article makes a further original contribution to the literature with applied research by curating the identified content into an offline digital library for use in schools in Northeast Syria.

While there have been a limited number of studies of the current status of OER adoption and use in the Arab region (see e.g. Eshet-Alkalai and Aydin, 2009; Jemni and Khribi, 2016; Tlili, et al., 2020; Adil, et al, 2024; Elnaqlah and Abbas, 2024) all of these studies are focused at the university level, which mirrors the academic-level emphasis within the scholarly literature on OERs more generally. Therefore, to the best of our knowledge this is the first study to focus on OER intended for primary and secondary level education across the entire Arab region, or to examine OER's potential to be used in an offline environment. It takes a further novel step by utilizing the discovered resources in a real-world application, not only adding to the scholarly literature but also contributing to the dissemination and use of OER/Open Access resources in the Arab region, and doing so with real-world examples that Ministries of Education could emulate or adopt. Given the absence of scholarly study of OERs in Arabic at the primary and secondary level, combined with the novel presentation of real-world application of OERs at the primary and secondary level, this paper makes a significant contribution to the gap in the literature in this area.

The remainder of the article is organized as follows: after an overview of the literature on OER and its challenges in the Arab context, the methodology and findings section are presented and discussed. The article concludes with recommendations, based on the findings.

2. Review of Relevant Literature

While developed countries have faced challenges in adopting OERs, the challenges are proving even greater for developing countries, where OER adoption is significantly lower (Hatakka, 2009; Karakaya and Karakaya, 2020; Peneder and Walcher, 2020). One fundamental challenge facing the OER movement in developing countries is the absence of infrastructure needed to access them, including electricity and internet connectivity. Data show that across the Least Developed Countries (LDCs), only one-third of primary schools have electricity, and an even greater number lack the internet connections and the information and communications technologies (ICTs) that could be used for pedagogical purposes (United Nations [UN], 2023). Approximately two-thirds of the world's primary and secondary school-age children have no internet access in their households, which left 1.3 billion children disconnected and out of schools during the COVID-19 pandemic era (United Nations Children's Fund [UNICEF], 2020).

Still, utilizing OERs requires more than mere availability of connectivity and ICTs, as *meaningful* usage of technology requires more than access (Hosman and Pérez Comisso, 2020), as there are human, socio-cultural, pedagogical, and support issues to be taken into account in addition to infrastructural considerations (Mirzamohammadi, 2017). In addition to mere access, specific skill-sets must be present in order for users to

discover, use, distribute, and adapt these resources. These skill-sets encompass both information literacy and digital literacy. Information literacy, as defined by the American Library Association, is the ability to identify, locate, evaluate, and use information. Digital literacy is the ability to meaningfully use digital tools, such as smartphones, computers, and the internet. Neither information literacy nor digital literacy is likely to be developed in offline, low-resource settings where access to relevant, trustworthy information is a challenge, nor is it likely to be fostered by profit-motivated internet providers.

2.1 Literature on OERs and the Challenge of Localization

Literacy skills have traditionally been built in an educational setting, underscoring the importance of training teachers in order to build these skills among the burgeoning youth population across the developing world (Hosman, Gómez-Zermeño, and Alemán de la Garza, 2020). To create a more just future, Tang and Bao (2020) emphasize the importance of building teachers' digital skills in order to be able to adapt OERs to fit their teaching context, while Sa'di et al. (2022) assert that students' skill-sets, learning styles and study habits also need transformation to smooth their transition to digital forms of learning. These empowering skill sets--digital and information literacy--require higher order capabilities that can only be developed over time, with practice, and with access to relevant, useful information (Hosman and Pérez Comisso, 2020).

Digital and information literacy capabilities influence educators' ability to make use of OERs to serve their learners' educational needs. Researchers use the term "localization" or "contextualization" to describe the ability to modify an OER to meet language, cultural, or educational levels, so that an OER is useful in a particular context (Smith, 2009). The creation of OERs in and for one context may result in social and cultural barriers that prevent educators and learners in other contexts from using and adapting OERs (Richter and McPherson, 2012; Willems and Bossu, 2012; Cobo, 2013). Those barriers are often rooted in areas of language, history, and socio-economic realities.

Contextualization is one of the most significant and complex challenges facing OERs' global adoption (Kanwar, Kodhandaraman and Umar, 2010; Wiley, Bliss and McEwen, 2014; Karakaya and Karakaya, 2020; Peneder and Walcher, 2020). It raises the challenging question of *who* is doing the localization. For example, translation into other languages is a good starting point for localizing OERs. Yet, as Karakaya and Karakaya (2020) point out, mere translation may be insufficient if it lacks cultural nuance. To wit, Arabic is an official or co-official language across 25+ countries, each with their own unique cultures. In an ideal scenario, being the experts on their own communities, end-users of OERs would be able to change and adapt them to meet their own needs. However, *using* OERs and *creating or adapting* OERs require two very distinct skill sets, with the latter requiring high levels of digital and information literacy skills. This presents a dilemma, as the skill sets required to localize OERs are difficult to develop in low-resource contexts where OERs stand to have the most impact.

Thus, the process of localizing a resource depends a great deal on the skills of the users. Ivins (2011) explored the factors most salient to the process of localizing OERs in Nepal, concluding that only a local can localize, and highlighted the difficulty of addressing social and cultural aspects through localizing foreign resources. Cobo (2013) analyzed English, Spanish, and Portuguese OER queries from 2007-2011, and while he identified a growing interest in OER from non-English speaking sources, he also found a widening language gap—the quantity of English-language OER is growing at a much faster pace than in any other language. In fact, Klemke et al. (2010) argue that the massive focus on improving English/Western OERs without investing in building the capacities of local educators in developing countries could relegate developing countries to the role of knowledge consumers instead of knowledge contributors.

2.2 Literature on OERs in the Arab Region

To date, a limited number of scholarly studies have focused specifically on OER in the Arab region. Hoosen (2012) reported the results of a survey on governments' OER policies conducted by the Commonwealth of Learning (COL) and UNESCO. The survey results were gathered from 82 countries through their ministries of education. The results showed that language, cultural diversity, and understanding of copyrights are the main challenges for OER utilization in Arab countries (Hoosen, 2012). Yet, applying these findings to the entirety of the Arab region is problematic since only nine responses were received from eight Arab states.

Five years after Hoosen's report, Jemni and Khribi (2017) documented the Arab League Educational, Cultural and Scientific Organization (ALECSO)'s ongoing and planned activities to prompt the creation and use of OERs by and for people in the Arab region. They reported an absence of policy to encourage an OER emphasis across the Arab region, as well as the lack of OER development and use in Arab countries, especially in the Arabic

language (Jemni and Khribi, 2017). Moreover, they cited the low levels of requisite skill sets for using ICTs as hindrances to OER resource creation and use.

Three years subsequent to Jemni and Khribi's study, Tlili et al. (2020) conducted a similar study focusing on the Arab region, which was sponsored by ALECSO. The main goal of the study was to identify gaps in creating and adopting OERs in the Arab region and to provide recommendations for the future. The data was collected through a survey that was disseminated by ALECSO to all Arab countries. The research collected 735 responses from 22 Arab countries, with 57% of the responses coming from Palestine, Saudi Arabia, and Bahrain. It is important to note that due to the methods used, responses were collected from individuals who were already interested in OER adoption.

Tlili et al. (2020) highlighted the unequal progression of the OER movement within Arab countries. They stressed the importance of raising awareness around OERs, specifically around open licenses and their role in protecting OER publishers. Eight years after Hoosen's 2012 survey, Tlili et al. (2020) still found a scarcity in initiatives and policies that support OER adoption in the Arab region. They identified 11 initiatives that contribute to the OER movement by either creating open universities or developing OER repositories and Massive Open Online Course (MOOC) providers. Most of these initiatives serve higher education. Furthermore, their results showed that OERs are most often used in their original form, without any localization or contextualization taking place (Tlili, et al., 2020). This finding should not come as a surprise, given the Catch-22-style challenge described above.

Addressing the localization challenge raised above is a complex endeavor: How can a local localize if they lack the requisite technology and skill sets? How can these skill sets be built in resource-constrained locations? These are precisely the challenges that the SolarSPELL initiative, highlighted in this article, seeks to address (Hosman, 2018). Given the paucity of research around OERs in the Arab region, the present article adds to this literature by exploring and analyzing the available open access primary and secondary school-level resources in Arabic.

3. Context and Application of the Study: SolarSPELL offline Digital Library for Northeast Syria

The SolarSPELL Library Initiative at Arizona State University (ASU) aims to address educational challenges facing remote communities globally with a unique approach: combining ultra-portable, solar-powered, localized, offline digital libraries with teacher-training to build both digital skills and information literacy. SolarSPELL libraries enable offline access to a collection of curated localized resources, all of which are open-access or permission has been obtained add them to the library and redistribute them. SolarSPELL's activities also emphasize impact evaluation to inform continual improvement of all aspects of the initiative (Hosman, et al., 2020; Hosman, Gómez-Zermeño, and Alemán de la Garza, 2020).

In all cases, the SolarSPELL initiative works closely with local partners to determine the appropriate content to meet the educational needs of the libraries' users. In 2021, the SolarSPELL team began working with the Department of Education in the Autonomous Administration of North and East Syria (AANES), and together, they began identifying and co-curating content for a library that is currently being piloted in secondary schools in the AANES region as of 2023.

The SolarSPELL library for use in AANES was to be trilingual to match the languages spoken in the region: Arabic, Kurdish, and Syriac. Nonetheless, given the significantly larger number of digital resources available in Arabic, and the ability for the team to identify Arabic-speakers among ASU students who contribute to every aspect of the university-based initiative, both teams agreed to begin the OER/Open Access resource-identification process with a survey of the existing initiatives offering resources in Arabic. This survey of existing Arabic language OER/Open Access initiatives constitutes the original research informing this article. The second stage of the research activity--the applied portion--was the curating of the identified content into the SolarSPELL library for use in AANES schools.

4. Methodology

The research informing this article was exploratory in nature and novel as a landscape analysis of existing Arabic language OER/Open Access initiatives and resources available. In contrast, all of the other articles cited in this paper that focused on the Arab region administered surveys to government officials and other experts to inform their research. While there is value in taking a top-down approach, surveying experts and officials relies on their generosity of time, knowledge of existing resources, and presents a different vantage point from the aim of the present study, which is directly identifying and curating available resources.

This article makes a further contribution by focusing on identifying OER/Open Access content in Arabic that serves primary and secondary level learners and educators, as opposed to serving higher education-level learners. The process of identifying initiatives, and subsequently curating the available digital Arabic resources constitutes the original applied research contribution of this article.

Our research stands on Hilton III et al's (2010) conceptual assumption that the openness of educational resources is not a binary concept, but rather is a gradual, multidimensional concept that depends on several legal, technical, and social factors. Hence, to bring a clear understanding of the available Arabic OERs, we explored both the resources and initiatives that provide at least free open access to Arabic primary and secondary school-level educational content.

As Frith (2009) laments, there is no comprehensive database or other existing system that would allow for an exhaustive search of open access resources, and this has not changed in the intervening 15 years. Because there is no database that would give signals about the nature of the resources, Smith (2012) exhorts researchers that the next step must be evaluation of identified resources as an integral part of the search process, particularly given the uncontrolled environment of the internet.

Therefore, in identifying OER/Open Access educational resources, part of the curation process involved assessing the creators of this content to understand where and by whom it was produced. Subsequently, the identified initiatives were categorized according to: sector (i.e. public, private, or nonprofit/non-governmental organization [NGO]); country of origin; type of contribution (creation or curation); and business model (non-profit or for-profit). The resources provided by the initiatives were categorized by: topical/focal area; format or type; and intended audience. The resources were subsequently evaluated as to whether they were at least open access in terms of copyright, and therefore could be added to the SolarSPELL Middle East Education Library.

The twofold process included first identifying any websites or repositories with OER/Open Access Arabic language content. Next, the resources that were determined to be open access, educational, and culturally-appropriate were curated, cataloged, and meta-data tagged, in order to be added to the SolarSPELL offline digital library for use in AANES schools. The search for this information was conducted from October to November 2021 and the database containing the search results can be accessed at the following URL (Resources Database), also accessible in Appendix A.

4.1 Data Collection

The data which this research draws upon were collected through the following steps. First, a list was created of the OER/Open Access initiatives that are well known for their primary and secondary school-aged, educational, online free resources. Then, Google Search was used as the main platform to search for other OER/Open Access initiatives. Google Search is the world's most popular website and search engine, holding a 92% dominance of the global search engine industry, with over 4.5 billion daily searches (Google Search Statistics, 2021). Google's search engine has detected more than 30 trillion unique URLs on the Web, scans 20 billion sites each day, and processes 100 billion searches per month (Google Search Statistics, 2021). While not frequently employed as the search engine of choice to inform academic studies, in this case it was appropriate, given both Google's ability to locate more sites than any other search engine, and the fact that the subject of our search itself was not scholarly in nature.

Seven main queries were used to search the Google platform. Queries are the words or phrases entered into search engines and directories to find specific results (Cobo, 2013). The queries were formulated and conducted in Arabic and reflect the appropriate terminology in the Arabic language that do not directly translate to the English terminology that would be used to describe similar resources. These queries were created by the native Arabic speakers among the authors of this article and were designed to thoroughly scour the available resources in Arabic that are discoverable via Google search. Table 1 reveals the Arabic queries and their translations into English.

Table 1: Arabic queries used in searching for open educational resources and their translations into English

English Translation	Arabic Queries
Open learning platforms in Arabic	منصات التعليم المفتوح باللغة العربية
Free e-learning platforms in Arabic	منصات مجانية للتعليم الإلكتروني باللغة العربية
Free educational courses	دورات تعليمية مجانية
Scholarships for distance learning	منح دراسية للدراسة عن بعد

English Translation	Arabic Queries
Open learning initiatives	مبادرات للتعليم المفتوح
School learning resources	موارد تعليمية مدرسية
School Education Tools	أدوات للتعليم المدرسي

The Google search results were examined to identify the initiatives that met all of the following criteria:

- Provide Arabic language content
- Offer resources that serve primary and secondary school-age learners and/or their educators
- Provide free access to educational resources

This study elected not to include educational tools such as applications, open source software, or licensing tools, as they were beyond the scope of this research and the SolarSPELL initiative's work. Peer-reviewed resources were also reviewed for additional initiatives that were not discovered using Google search.

Subsequently, from the final list of identified initiatives, further meta-data were specified in two main categories. The first category was related to the initiative itself. This included the name of the initiative, the nature of the initiative (is it a resource-creating or resource-curating initiative), and the name and type of the organization that sponsors this initiative (governmental, NGO, private, grassroots social initiative). The other category was related to the resources themselves, including topics, audience, format, and license.

5. Results

The high-level takeaways from this research are herein described, whilst the subsequent sections provide more detail and discussion of the findings. Using the methods discussed, 33 initiatives providing "at least free access" for Arabic educational resources that serve primary and secondary school-level learners or educators were identified. The identified initiatives come from 9 out of 22 Arab countries. Most of the initiatives identified were private sector (either for-profit entities or non-profit NGOs), while the number of government initiatives contributing to OER/Open Access resources was much smaller.

The majority of initiatives identified are *creating* teaching and learning materials, as opposed to *curating* such materials. Among the 33 initiatives identified, there were several focus areas. Most of the initiatives focused on curriculum support, followed by content focused on language and reading. Additionally, most of the initiatives focused on content for primary and secondary students, while fewer focused on educators' professional development.

5.1 Landscape Analysis of Arabic Language OER/Open Access Initiatives

While most of the 33 Arabic OER/Open Access initiatives originated from within the Arab region, there are some initiatives originating from non-Arab states, while other initiatives are global in their makeup (Figure 1). In this case, "global" comprises primarily intergovernmental or interagency organizations, such as the United Nations High Commissioner for Refugees (UNHCR).

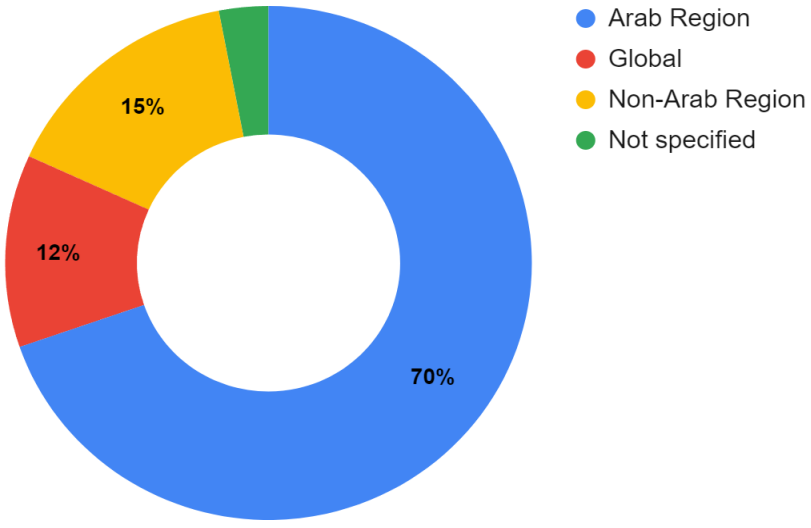

Figure 1: Percentage of initiatives according to their region of origin

The distribution of initiatives originating from an Arab country or region are shown in Table 2. The initiatives come from just 9 out of 22 Arab countries, which may reflect the economic and political challenges facing the development of education systems in some Arab countries. For example, in this research, there were no initiatives identified that originated from Iraq, Yemen, or Libya. The largest number of initiatives from any one Arab country originated from Saudi Arabia (with 6, or 26%).

Table 2: Number of OER/open access initiatives from Arab states or region

Origin country	Number of initiatives
Saudi Arabia	6
Jordan	4
UAE	3
Egypt	2
Lebanon	2
Arab Region	2
Algeria, Bahrain, Syria, Palestine	1 each
Total	23

Most of the initiatives are private sector organizations (for-profit or NGOs). There is some state involvement in sponsoring and launching the initiatives; however, the number of state-sponsored initiatives is significantly lower than private sector initiatives. Figure 2 provides a detailed illustration of the distribution of the initiatives between the different sectors and the type of contribution (creating vs. curating content), which will be defined and discussed in more detail in the next section.

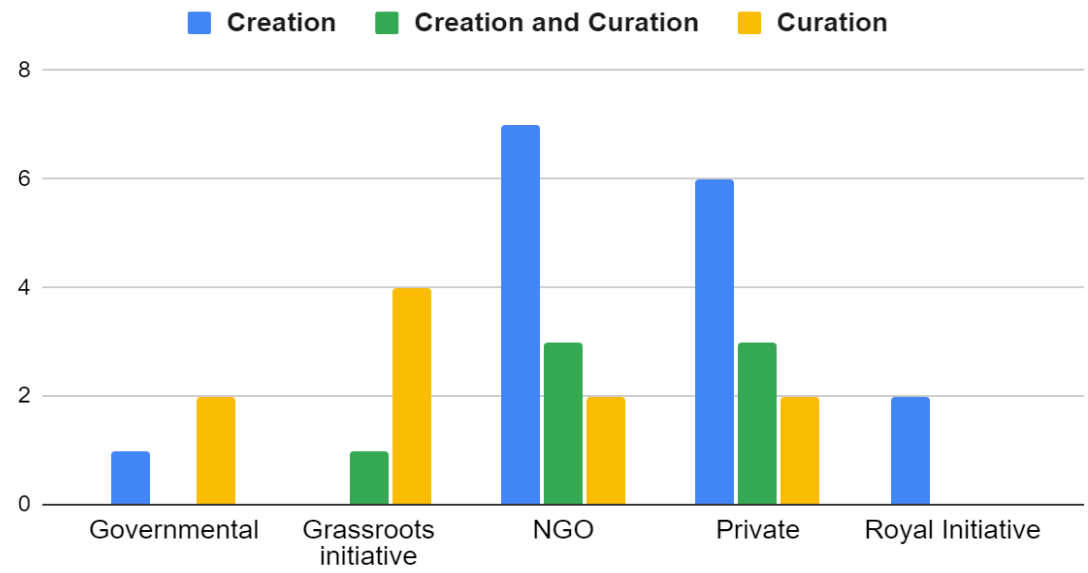

Figure 2: Distribution of Arabic language OER/open access initiatives between sectors and by type of contribution (creation vs. curation)

We categorize the types of initiatives based on the source of funding and/or their legal status. Five types of initiatives were identified:

- Governmental initiatives: State governments - most often ministries of education
- Grassroots initiatives: Community-based organizations or groups of teachers
- NGO: Nonprofit organizations that operate independently of any government
- Private: For-profit organizations
- Royal initiatives: Arab Royal families (of United Arab Emirates and Jordan)

5.2 Creating and Curating Arabic OERs

There is a distinction between creating and curating content. Creating involves generating new teaching and learning materials. Curating means collecting (including from individuals and educators), organizing, and sharing existing resources with a specific audience in mind, via a website, blog, social media platform, or any other platform. The curation process focuses on facilitating the discovery and availability of resources.

As illustrated in Figure 2, the greatest number (48%) of the initiatives exclusively create teaching and learning resources, with NGOs taking the lead over government-led initiatives in content creation. By contrast, 30% of the initiatives curate available resources, with grassroots initiatives doing so more frequently than other initiatives. Finally, 21% of the initiatives adopted a hybrid style where they both created and curated their teaching and learning materials with a majority of these resources coming from the non-profit and private sectors (Figures 2 and 3).

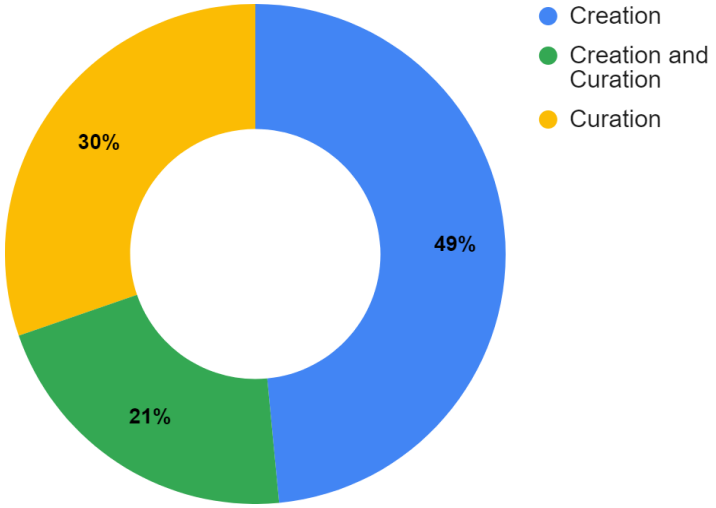

Figure 3: Initiatives' contribution to Arabic language OERs by type (creation vs curation)

5.3 Focus Areas and Topics

The 33 initiatives identified have several focus areas, with curriculum support constituting nearly half (14, or 42%). The second most common topic is language and reading, with 4 (12%) of the initiatives. There are also several resources focused on topics related to teaching in emergencies that address the critical needs of refugees and war survivors, such as trauma-informed teaching, child protection, and education for peacebuilding. These resources are mainly developed by global organizations. Other initiatives focus on several different subject areas such as science and math, digital literacy, educational training, and more (Table 3).

Table 3: Main topics/focus areas of Arabic language OER/open access initiatives

OER/open access focus areas	Number of initiatives
Curriculum support	14
Language and reading	4
Science and math	1
Social science	1
Digital literacy	1
Educational training	1
Teaching in emergencies	4
Miscellaneous	7
Total	33

OERs included in this landscape analysis are digital in format, which eases their use, reuse, and distribution in a variety of educational contexts, often at a lower cost. Additionally, they can support a variety of learning styles. In terms of resource type, the majority of Arabic OER/Open Access initiatives offer MOOCs or other curriculum-

related documents such as textbooks, worksheets, and lesson plans (Table 4). The remaining resources vary between audio stories, articles, games, infographics, simulation, and other non-textbook books.

Table 4: Types of OER/open access resources

Resource type	Number of initiatives
MOOCs	8
Textbooks, worksheets, lesson plans	8
Educational videos	5
Books	3
TV shows	3
Articles	2
Audio stories	2
Toolkits and standards	2
Games	2
Infographics	1
Simulations	1

5.4 Target Audiences

Figure 4 illustrates that the largest percentage of resources are designed for students, with 38%, aimed towards secondary students and 37% for primary students. Comparatively fewer resources (25%) were designed specifically for teachers.

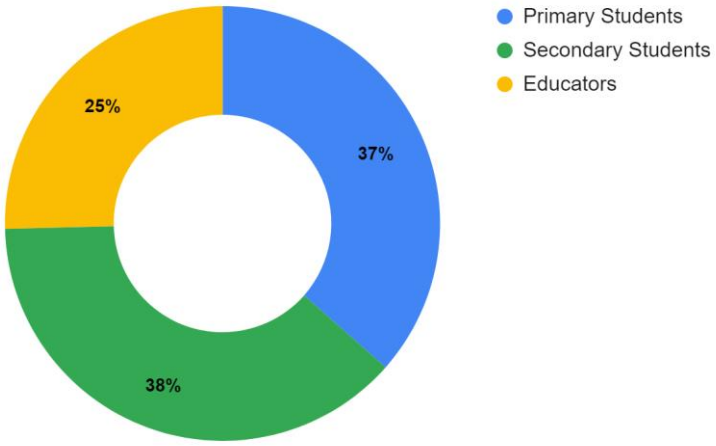

Figure 4: Target audiences for Arabic OER/open access initiatives

6. Challenges of OERs/Open Access Initiatives

The challenges of Arabic language OERs are multifaceted, most prominently a lack of available resources that are localized to meet the varying cultural and pedagogical needs across the region. Indeed, similar obstacles face OER adoption across the entire non-English speaking world (Karakaya and Karakaya, 2020). In the spirit of providing guidance to others seeking to improve educational equity via OER/Open Access resources, after describing some of the pressing challenges below, the SolarSPELL initiative's approach to addressing these challenges is also presented. The SolarSPELL initiative provides an action-oriented, field-tested approach to addressing a number of the challenges that prevent the creation, dissemination, and use of OER/Open Access resources around the world.

6.1 Challenges Defining and Certifying OERs/Open Access Initiatives

Although many of the Arabic language OER/Open Access initiatives are designed to facilitate free access to digital educational resources, these resources often are not explicitly licensed under an open license, such as Creative Commons (2020). If the resource creators have given thought to copyright and want the resources to be shared,

the most common Creative Commons copyright level is that of "Open Access." Figure 5 shows that only 33% of the initiatives identified in this study are licensed as Creative Commons. This challenge is, in fact, a global issue, which Hoosen (2012) attributes at least partially to confusion in the understanding of the concept and potential of OER.

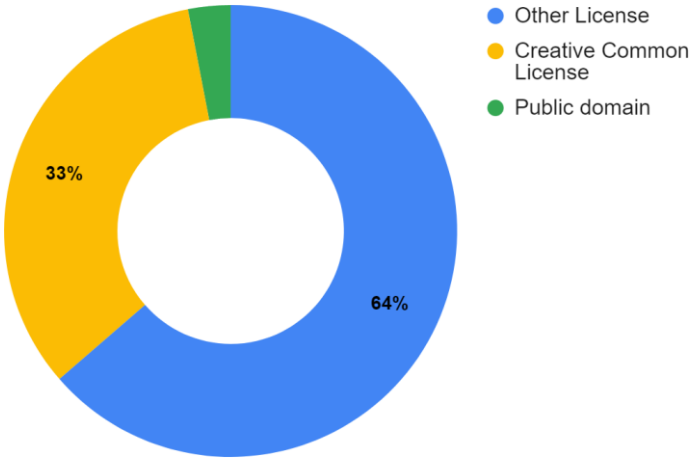

Figure 5: Arabic OER/open access resource licenses

On the other hand, many of the initiatives in this study do not clearly state the legal license for their resources, or they have several types of resources with no clear statement on "terms of usage" for each type of resource. In such cases, we reached out to inquire about resources' copyright and terms of usage. This process often involved waiting several weeks and making multiple outreach attempts, which only sometimes resulted in a positive response to confirm possible use of the resources.

Recognizing the challenge of understanding, defining, and certifying what constitutes OER, SolarSPELL only curates content into the digital library that is at least Open Access in terms of its copyright status. When the copyright status is unclear, SolarSPELL curators reach out to request permission to add creators' content to the library, making clear that it will be considered Open Access.

6.2 Technical Challenges

From a technical perspective, significant challenges relate to resource format and file size. Hassler and Jackson (2010) argued that allowing OERs to grow in size limits the usage of such resources, especially in offline or low bandwidth environments, and/or where income levels mean connectivity or data is expensive. Their warning has proven well-founded but ill-addressed in the years since then. While newer devices have increased storage to accommodate correspondingly increasing file sizes, these new devices are often not available to those who would most benefit from OERs and rely on older, less expensive technology. Furthermore, many people globally rely on internet service that is purchased by the byte, driving them to purposefully avoid large--and therefore costly--files and websites. Hassler and Jackson (2010) propose several strategies to improve the low-bandwidth accessibility of OERs, including offering different formats of a resource (i.e. offering a transcript download for a video) and user training.

In the applied context of this study, the SolarSPELL library's digital content is limited to MP4, MP3, PDF, and html files in order to ensure accessibility on any device type (computer, tablet, or smartphone), without the user needing to download any additional software or applications. SolarSPELL digital library resources, especially videos, are generally kept (or downsized to) below 150 MB in size; this ensures that the video will open and may be downloaded by library users, whose devices may not have significant storage capacity.

6.3 Regional Localization and Political Considerations

The civil conflict that has been taking place in Syria since 2011 has had a disastrous effect on the educational system. The impact of the conflict includes school closures, student displacement leading to interrupted education, reduction in returns to education, and reduced educational expenditures due to an overall reduction in resources and shifting priorities (Ndaruhutse and West, 2015). This situation has also affected neighboring countries, as Turkey, Lebanon, Jordan, Iraq, and Egypt have each taken in hundreds of thousands of Syrian refugees fleeing the unrest.

Given the multiple challenging sociopolitical situations across the Arab region causing mass displacement, with ⅓ of global refugees and over ⅓ of internally displaced people globally (UNESCO, 2019), it is perhaps not surprising that our study revealed a scarcity of OER/Open Access resources tailored to support local school curricula in conflict-affected states. We did, however, find regional resources focused on topics related to teaching in emergencies, with topics such as mental and physical health, social-emotional learning, and aiding traumatized children. Most of these resources were provided by global IGOs, such as UNHCR and the United Nations Relief and Works Agency for Palestine Refugees in the Near East (UNRWA). Nonetheless, the lack of local school curricula available in Northeast Syria is one of the challenges the SolarSPELL initiative directly addresses.

7. Discussion and Conclusion

Open Educational Resources serve a critical function in promoting inclusive and equitable quality education and creating possibilities for lifelong learning for all. Despite the fact that many countries have made progress in OER adoption, developing countries, including those in the Arab region, still face substantial hurdles that must be addressed in order to achieve potential benefits. This study addressed a gap in the research literature on OERs in the Arab world, with a goal of understanding the current landscape of existing OER/Open Access primary and secondary school-level Arabic language resources and providing a case study of an initiative promoting the dissemination and use of said resources in Northeast Syria.

Undertaking the landscape analysis provided insights to address the first research question: What are the prospects and challenges of utilizing Arabic-language Open Educational Resources (OER) for primary and secondary education in the Arab region, particularly in offline environments? This study identified 33 OER/Open Access Arabic-language initiatives, of which 22 originated from 9 Arab countries, with the greatest number of initiatives originating from Saudi Arabia. Most of these initiatives originated from the private sector or from NGOs, while there were few government-sponsored initiatives. The largest number of these initiatives contributed teaching and learning materials, with major emphases on curriculum support as well as on language and reading. The majority of Arabic OER/Open Access initiatives focus on primary and secondary students, while there were fewer resources to support educators.

Collecting and curating resources for an offline digital library yields some recommendations for OER initiative leaders and organizations committed to enhancing global educational equity. First, the authors call for increasing efforts to raise awareness of OERs by clarifying their concept and benefits, encouraging the OER community, including users, creators, and curators, to ensure proper and clear communication for resource licenses to ease interorganizational sharing and localization efforts. Second, collaboration between the private and public sectors is essential for making progress in promoting quality education for all. Third, it is vital to engage educators in becoming more active participants in creating and using OER/Open Access content. As members of diverse and inclusive knowledge societies, they can help cover local educational topics that are aligned with community needs. Fourth, in the interest of promoting equitable access for those with limited or no connectivity, we recommend offering several formats and sizes for resources, whenever possible. Fifth, offline approaches are oftentimes the only way to reach remote or displaced people and that indeed in some circumstances, offline is preferable to online. All of these recommendations are achievable, as evidenced by the SolarSPELL initiative's work outlined in this article.

While this article does not assert that the majority of OERs should be created by government agencies, governments--and ministries of education in particular--could play a significant role in promoting OER initiatives to ensure equal and quality education for everyone. When OERs are funded by private interests and hosted on platforms controlled by oligopolies, the metadata and personal data of their users are fed to these organizations. This may not serve to support or promote local educational resource production. A global commons built on the terms of for-profit transnational companies will fail to address the actual needs of local school communities, educators, and students around the Arab region, which bolsters the argument (at least, in an ideal world) for a public entity promoting the creation, hosting, and provision of OERs. Still, collaboration between the private and public sectors remains essential for making progress in promoting quality education for all.

The applied component of this research, the SolarSPELL Initiative, addresses the article's second research question: How can these resources be effectively curated and implemented to address educational disparities and connectivity issues? The SolarSPELL initiative is currently working with the Department of Education in the AANES to co-create and co-curate OER/Open Access resources to an offline digital library that is currently being used in local secondary schools. In other words, this article's case study presents an actionable, real-world initiative that other entities, from ministries of education to NGOs in charge of educational operations, could

adopt as policy. This type of partnership, one that facilitates local creation, curation, and dissemination of open educational resources, should be supported and replicated.

In terms of limitations, this study only explored the existence of Arabic OER/Open Access resources and did not assess the resources for quality, accessibility, applicability, or cultural relevance. Assessing the quality of available OERs that are provided by these initiatives would contribute to the scholarly body of literature on this topic. More importantly, it may lead to greater levels of adoption and improved educational outcomes.

The challenges of creating and adopting Arabic language OERs are multifaceted, encompassing a lack of localized resources, unclear licensing, technical limitations, and regional sociopolitical instability. Despite these obstacles, the SolarSPELL initiative has developed a comprehensive approach addressing these issues. By ensuring resources are at least Open Access and reaching out for permissions where necessary, SolarSPELL curates a digital library accessible offline to WiFi-enabled devices without additional software. Moreover, the scarcity of localized educational content in conflict-affected areas like Northeast Syria is addressed by SolarSPELL's focus on partnerships that enable creation of resources aligned with local curricula, addressing an essential need for displaced and refugee populations. Such initiatives could collectively contribute to improving educational equity via OER/Open Access resources in the Arab region and beyond.

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AI statement: No AI was used at any point in the research, writing, or creating of this paper.

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Appendix 1: Arabic OER/Open Access Initiatives Database

Website link	Initiative name	Orgnization name	Intiative countr	Initative type	creation/curati	Business m	Resource topic	Resourses focus	Resource type	Resouce forma	Audience	Licence
https://3asafeer.com/info#one	3asafeer	3asafeer	UAE	Private	Creation and Cu	For Profit	Language & Readi	Language & Read	Books	pdf	Primary Student,	Creative Common License
http://raneenmedia.org/index.php/er	Raneen	Raneem	Jordan	NGO/NPO	Creation	Non-profit	Language & Readi	Language & Read	Audio Stories	mp3	Primary Student	Other License
https://madrasa.org/	Madrasa	The Mohammed b	UAE	Royal Initiative	Creation	Non-profit	Math, Science, Lan	Curriculum Suppor	MOOC	mp4	Primary Student,	Other License
https://middleschool.tabshoura.com/	Tabshoura	Lebanese Alternat	Lebanon	NGO/NPO	Creation and Cu	Non-profit	Math, Science, Lan	Curriculum Suppor	MOOC	html	Primary Student	Creative Common License
https://kindergarten.tabshoura.com/'	Tabshoura	Lebanese Alternat	Lebanon	NGO/NPO	Creation and Cu	Non-profit	Math, Science, Lan	Curriculum Suppor	MOOC	html	Secondary Stude	Creative Common License
https://www.edraak.org/en/k12/	Edrak	The Queen Rania	Jordan	Royal Initiative	Creation	Non-profit	Math, English	Curriculum Suppor	MOOC	html	Primary Student,	Creative Common License
https://www.rwaq.org/	Rewaq	Rewaq	Saudi Arabia	Private	Creation	For Profit	Educational trainin	Educational Trainii	MOOC	html	Educators	Other License
https://inee.org/collections	INEE	Inter-Agency Netw	Global	NGO/NPO	Curation	Non-profit	Teaching in Emerg	Teaching in Emerg	Toolkits & Stanc	pdf, mp4	Educators	Other License
https://www.unhcr.org/ar/5b5718bc4	UNHCR	UNHCR	Global	NGO/NPO	Creation	Non-profit	Teaching in Emerg	Teaching in Emerg	Toolkits & Stanc	pdf, mp4	Educators	Other License
https://ahlansimsim.org/	Ahlan Simsim	Sesame street	US	Private	Creation	Non-profit	Social Emotianal Le	Teaching in Emerg	Activities, Books	pdf, mp4	Primary Student	Other License
https://arabic.oercommons.org/AR/b	OER common	OER common	US	NGO/NPO	Curation	Non-profit	Miscellaneous	Miscellaneous	Repository	Non specific	Educators	Creative Common License
http://al-hakawati.net/stories/	AL hakawati	Arab Cultural Trust	Arab Region	NGO/NPO	Creation and Cu	Non-profit	Language & Readi	Social Science	Books	pdf	Secondary Stude	Public domain
http://arabiareaders.com/audio/	Silva Education	Arabia Readers	England	Private	Curation	For Profit	Language & Readi	Language & Read	Audible Stories	mp3	Primary Student	Other License
Learning with Angela	angela	learning arabic wit	Not specified	Private	Creation	For Profit	Language & Readi	Language & Read	Flash-Cards, Wc	pdf, mp4	Primary Student	Other License
https://mrsae.com/	mrsae	mrsae	UAE	Private	Creation	Non-profit	Curriculum Support	Curriculum Suppor	Repository (loca	pdf, html	Primary Student,	Other License
https://shms.sa/	Shms	Saudi OER Netwo	Saudi Arabia	Govermental	Curation	Non-profit	Miscellaneous	Miscellaneous	Repository	pdf, html	Primary Student,	Creative Common License
http://eteacher.edunet.bh/course/vie	my digital library	Digital Empowerme	Bahrain	Govermental	Curation	Non-profit	Curriculum Support	Curriculum Suppor	Repository (loca	pdf, ppt, mp4	Primary Student,	Creative Common License
https://www.youtube.com/channel/U	UNRWA TV	UNRWA	Global	NGO/NPO	Creation	Non-profit	Miscellaneous	Miscellaneous	TV Shows	mp4	Primary Student,	Other License
https://baytdz.com/	Bayt DZ	Unknown	Algeria	Grassroot initiati	Curation	Non-profit	Miscellaneous	Miscellaneous	Articles	ppt, pdf	Secondary Stude	Other License
https://phet.colorado.edu/ar_SA/sim	PhET	PENDA	US	Private	Creation and Cu	Non-profit	interactive math an	Science & Math	Interactive Simu	html, mp4	Secondary Stude	Creative Common License
https://digitalschoolsy.com/	Digital school	Digital school	Syria	Private	Creation	Non-profit	Curriculum Support	Curriculum Suppor	Educational Vid	pdf, mp3, html, i	Primary Student,	Other License
https://www.wepal.net/library/	The Education I	No info	Palestine	Grassroot initiati	Curation	Non-profit	Curriculum Support	Curriculum Suppor	Repository (loca	pdf, doc	Primary Student,	Creative Common License
https://www.unicef.org/jordan/ar/%D8	Learning Bridge	unicef-Jordan	Jordan	NGO/NPO	Creation	Non-profit	Teaching in Emerg	Teaching in Emerg	Worksheets	pdf	Primary Student,	Other License
https://www.nafham.com/	Nafham	Nafham	Arab Region	Grassroot initiati	Creation and Cu	Non-profit	Curriculum Support	Curriculum Suppor	Repository	pdf, mp4	Primary Student,	Other License
https://masaderinfographic.blogspot	Masader infogra	masader infograph	Saudi Arabia	Grassroot initiati	Curation	Non-profit	Miscellaneous	Miscellaneous	Infographics	pdf	Primary Student,	Other License
https://ktby.net/	ktby	ktby	Saudi Arabia	Grassroot initiati	Curation	Non-profit	Curriculum Support	Curriculum Suppor	Lessons, Textbc	Html	Primary Student,	Other License
https://hulul.online/	hulul	hulul	Saudi Arabia	Private	Curation	Non-profit	Curriculum Support	Curriculum Suppor	Educational Vid	pdf, mp4	Primary Student,	Other License
https://ar.khanacademy.org/	Khan Academy	Khan Academy	Global	NGO/NPO	Creation	Non-profit	Miscellaneous	Miscellaneous	Educational vide	mp4	Primary Student,	Other License
https://www.awa2el.net/ar/search/tyr	Awa2el	Awa2el	Jordan	Private	Creation and Cu	For Profit	Curriculum Support	Curriculum Suppor	Educational Vid	mp4,pdf	Primary Student,	Other License
http://en.tahriracademy.net/	tahrir academy	tahrir academy	Egypt	NGO/NPO	Creation	Non-profit	Curriculum Support	Curriculum Suppor	MOOC	mp4, html	Primary Student,	Creative Common License
https://aldarayn.com/mod/page/view	Aldarayn Found	Aldarayn Foundati	Egypt	NGO/NPO	Creation	Non-profit	Miscellaneous	Miscellaneous	MOOC		Secondary Stude	Other License
https://academy.hsoub.com/	Hsoub	Hsoub	UK	Private	Creation	For Profit	Digital litracy	Digital literacy	MOOC, books	pdf, html	Secondary Stude	Creative Common License
https://www.ien.edu.sa/#/	iEN Ithraia	Ministry of Educati	Saudi Arabia	Govermental	Creation	Non-profit	Curriculum Support	Curriculum Suppor	Educational Vid	pdf, mp4, html	Primary Student,	Other License

From Emergency Remote Teaching to an Online Educational Ecosystem: An Ecuadorian University Case Study

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Abstract: This case study examines the experience of Universidad Andina Simón Bolívar (UASB-E), a traditionally face-to-face institution in Ecuador, as it transitioned to online learning during and after the COVID-19 pandemic. Drawing on data from interviews, surveys, and document analysis, the study explores the challenges and opportunities associated with this rapid shift, offering insights for rethinking and redesigning higher education in the post-pandemic world. Prior to the pandemic, UASB-E primarily relied on face-to-face teaching with limited use of its virtual learning environment. In response to the crisis, the university quickly mobilized to migrate its entire educational offering online, initially adopting an emergency remote teaching approach focused on synchronous videoconferencing. However, student preferences and the need for a sustainable solution prompted UASB-E to rethink its online learning model. The study identifies six key dimensions of UASB-E's improvement in its capacity to deliver online education: (1) Technological Infrastructure and Digital Processes: Enhanced technological infrastructure and streamlined digital processes in management, administration, and academics, laying the foundation for a robust online learning environment. (2) Pedagogical Innovation: Recognizing the limitations of replicating face-to-face teaching online, UASB-E embraced activity-based instructional design, asynchronous online education, and collaborative learning strategies, promoting deeper engagement and personalized learning experiences. (3) Accessibility and Inclusivity: By leveraging the flexibility of online learning, UASB-E expanded its reach beyond its physical campus, reaching students across Ecuador who might not have otherwise accessed higher education, demonstrating the potential of online learning to democratize access to quality education. (4) Programme Diversification: Beyond emergency measures, UASB-E is strategically diversifying its academic offerings, developing new face-to-face, blended, and fully online programmes, allowing for flexibility and catering to diverse student needs and learning preferences. (5) Faculty Training and Development: Implemented a comprehensive training programme focusing on both the instrumental skills of managing online platforms and the pedagogical aspects of designing engaging and effective online learning experiences. (6) Assessment and Feedback: The study highlights the need for a more reflective and analytical approach to assessment and feedback in online environments, with efforts to improve feedback timeliness, individual support, and communication providing valuable lessons for other institutions. Beyond UASB-E's specific experience, the study emphasizes the importance of collaboration and cross-sectoral strategies in building resilient and comprehensive education systems for the future. It also underscores the need for new approaches to learning ecologies that leverage technology effectively while ensuring equitable, inclusive, and high-quality education for all. This case study offers valuable insights for higher education institutions navigating the rapidly evolving landscape of online learning. By understanding the challenges and opportunities that emerged from UASB-E's experience, other institutions can make informed decisions about their own online learning strategies and contribute to shaping a more resilient and flexible future for higher education.

Keywords: COVID-19 outbreak, Emergency remote teaching, Higher education, Online learning ecosystem, Capacity development

1. Introduction

In the early 2020s, the COVID-19 pandemic confined much of the world's population to their homes and paralysed activity in virtually all areas of human endeavour, forcing the educational community to quickly rethink its approach. This unprecedented situation led to the widespread closure of schools and universities, compelling educators to adopt alternative methods to sustain the educational process. As a result, distance learning in a variety of formats and on different online platforms was rapidly deployed to replace traditional educational processes. Experts have dubbed this sudden and unforeseen shift from face-to-face to online 'emergency remote teaching' (Hodges et al., 2020): emergency, because it arose as an immediate, palliative solution to an unexpected lockdown; remote, as opposed to face-to-face, although not necessarily based on sound e-learning models; and teaching, because it focused mainly on instruction rather than learning. In this sense, unlike e-learning models that are designed from the ground up to create a robust online educational ecosystem, emergency remote teaching was a provisional shift of traditional education to an alternative mode of delivery

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in order to continue providing access to education by transferring face-to-face practices to online settings, while maintaining their conventional forms in terms of methodologies, teacher and student roles, types of activities, assessment models, and so on.

Years of research into e-learning have shown that its quality and effectiveness result from a systematic process of design, planning and development grounded in evidence-based theories, models and standards (Hodges et al., 2020; Means et al., 2013). Unlike these robust e-learning models, emergency remote teaching was a provisional shift of traditional education to an alternative mode of delivery to continue providing access to education by transferring face-to-face practices to online settings. Swan (2003) suggests that effective online learning in higher education should provide: (a) clear goals and expectations for learners; (b) multiple representations of course content; (c) frequent opportunities for active learning; (d) frequent and constructive feedback; (e) flexibility and choice in satisfying course objectives; and (f) instructor guidance and support. In turn, Means, Bakia and Murphy (2014) highlight the complexity of the design and decision-making process in online learning through nine dimensions: modality, pacing, student-instructor ratio, pedagogy, instructor role online, student role online, online communication synchrony, the role of online assessments, and source of feedback. The transition to emergency remote teaching forced educational institutions to quickly adapt to maintain instructional continuity. However, despite this rapid adaptation, there is a significant gap in understanding the impacts of this change on educational quality and policies.

The main objective of the present study is to analyse the experience of a traditionally face-to-face Ecuadorian higher education institution in its transition to online learning during the COVID-19 pandemic. The research questions guiding this study are: (1) How effectively did UASB-E implement emergency remote teaching, and what were the key challenges and successes? (2) What strategies and practices emerged as critical for the development of a sustainable online learning ecosystem? (3) How can these strategies inform future higher education policies and practices, particularly in contexts requiring rapid adaptation to unforeseen circumstances?

This paper draws on some of these aspects and dimensions to analyse the process followed by Ecuador's Universidad Andina Simón Bolivar (UASB-E), which was fully face-to-face at the onset of the pandemic, to implement a high-quality and effective online learning ecosystem, a process which initially involved emergency remote teaching. Through a mixed-methods analysis of data collected during and after the state of emergency caused by the pandemic, the paper offers a comprehensive understanding of the complexity of the changes adopted across six dimensions: mode, instructional design, learning environment, interaction and collaboration, assessment and feedback, and students' and teachers' digital literacy. The paper also examines some of the challenges and opportunities of the strategies implemented and their implications for long-term higher education policy, with a particular focus on aspects of capacity building that will be applicable going forwards and may be transferable to other contexts.

2. Research Background

The COVID-19 crisis had a profound impact on all sectors of society, deepening structural inequalities and creating new ones. In higher education, the abrupt shift to emergency remote teaching had various consequences in areas such as teaching, socio-emotional well-being, labour, finance and academic mobility (Pedró, 2021). These were particularly acute in countries with historically high levels of inequality, such as Latin America and the Caribbean (LAC). A UNESCO report (UNESCO IESALC, 2020) estimated that by the end of March 2020, the temporary closure of higher education institutions had affected some 23.4 million students and 1.4 million teachers in LAC countries.

In terms of teaching, the limited access to internet connectivity and technological equipment (52% of LAC households in 2020), the incipient and extremely uneven provision of distance higher education among LAC countries (15.3% in 2017) and the limited digital literacy of academic staff and students suggest a negative balance in terms of quality of learning and equity in access (Pedró, 2021).

During the health crisis, countries such as Ecuador, Colombia and Peru had to make important regulatory changes to authorise their universities to develop and deliver distance education courses. The reason why distance higher education occupied such a peripheral position was that the public, including most teachers and students, perceived it as a substitute (and not necessarily a quality one) for face-to-face higher education (Pedró, 2021), despite research showing otherwise.

The educational tools and applications used for emergency remote teaching, including videoconferencing platforms and virtual learning environments, posed a challenge to educators with no previous experience of

online teaching and learning, as they were suddenly expected to teach in a new way without the appropriate training. Teachers and students alike soon discovered that the online spaces that had been hastily created in response to the emergency lockdown could not satisfactorily replicate face-to-face practices.

Some of these negative effects could have been mitigated by adopting a more reflective model of online education, based on previous experience with e-learning (CEPAL-UNESCO, 2021). This would have allowed institutions to address not only continuity criteria, but also those of equity and inclusion.

2.1 The Situation in Ecuador

The first reported case of COVID-19 in Ecuador occurred on 29 February 2020. Fifteen days later, the Ministry of Education ordered the nationwide suspension of face-to-face classes. This measure represented a major challenge for the educational community, which had to design and implement strategies to guarantee the universal right to education remotely in a country with unequal access to information and communication technologies (UNICEF, 2022). According to the National Institute of Statistics and Censuses of Ecuador (INEC, 2021), in 2019 only 45.5% of the country's population had access to the internet, with a large gap between urban (56.1%) and rural (21.6%) areas. Furthermore, only 23.3% of the population had access to a desktop computer and only 28.5% to a laptop or tablet. Although these figures have improved in the years since the pandemic, education indicators also show that the pandemic widened the education gap, particularly in rural areas and certain Amazonian provinces.

Given the incipient, sporadic and unsystematic penetration of online learning in higher education institutions across the country, the shift from face-to-face to remote teaching posed multiple challenges. There were also pre-pandemic structural challenges and shortcomings at play that have not been fully resolved and continue to exist at different levels and intensities in different institutions. As Araujo Silva, Ochoa Mogrovejo and Vélez Verdugo (2020) point out, these challenges relate to areas such as management models, disconnection from the professional world, diversification of supply, inequalities in access, conflicts between research and teaching, and gender inequalities.

In October 2020, the Higher Education Council (Consejo de Educación Superior, 2020), which regulates higher education in Ecuador and was aware of these limitations, issued a regulation to allow higher education institutions to adapt to the reality of successive lockdowns. This regulation, which is still in force, made it possible to move programmes online or to modify the hours allocated to teaching. It created a hybrid model that combined features of blended, online and distance learning and prioritised autonomous student work. This regulation also provided for the creation of a repository of recordings of synchronous videoconferencing lessons, introduced study guides for autonomous learning for students who did not have access to technological means, and made professional practices, timetables, student/classroom ratios and attendance requirements more flexible.

This regulation has given higher education institutions in Ecuador a great deal of freedom over the last three years, particularly in terms of how programmes are taught. However, in the next academic year, this regulation will be phased out and the exemption will end, forcing institutions to take action to continue offering online programmes that were originally designed and approved for face-to-face delivery.

3. Research Design and Method

This case study focuses on the transformation process undertaken by Ecuador's Universidad Andina Simón Bolivar (UASB-E) to implement an online learning ecosystem in response to the educational needs arising from the pandemic. The UASB-E specialises in postgraduate, master's, and doctoral programmes. In fact, it has the largest catalogue of postgraduate courses in Ecuador, with extensive international cooperation and exchanges of teachers, researchers and students from the Andean subregion, Latin America, North America, and Europe. At the outbreak of the pandemic, it offered a total of 14 postgraduate degrees, 27 profession-focused master's degrees, seven research-focused master's degrees, seven doctoral degrees and two postdoctoral degrees. These degrees are divided into nine faculties: Environment and Sustainability, Letters and Cultural Studies, Law, History, Health, Education, Social and Global Studies, Communication and Management. This scenario has changed significantly in the years following the pandemic.

The study utilised a mixed-methods approach, integrating a phenomenological perspective with quantitative methods, to thoroughly understand the transformation process at UASB-E. This approach merged qualitative and quantitative techniques to collect data from various stakeholders involved in the educational process. The mixed-methods design was selected to offer a robust analysis by triangulating data from multiple sources,

thereby enhancing the reliability and depth of the findings. Five techniques were used to collect data from the perspective of different educational stakeholders and decision-makers (Table 1): (1) interviews with academic directors; (2) institutional documentary analysis; (3) a synchronous online focus group; and (4) surveys of teachers and students, (5) analysis of online classroom instructional design an academic data.

Table 1: Summary of methodology

Research questions	Research techniques	Actors/Sources	Data collection		
			2021	2022	2023
RQ1. How effectively did UASB-E implement emergency remote teaching, and what were the key challenges and successes?	Institutional documentary analysis	Guidelines for non-face-to-face education			
		Pedagogical model of distance education			
		Guidelines for an educational process in remote modes			
	Surveys of students	Students from all faculties			
	Secondary data analysis	Academic data			
	Online classroom analysis	The virtual learning environment classrooms of the Faculty of Education's programmes			
RQ2. What strategies and practices emerged as critical for the development of a sustainable online learning ecosystem? **RQ3. How can these strategies inform future higher education policies and practices, particularly in contexts requiring rapid adaptation to unforeseen circumstances?**	Interviews with academic directors	The general academic director.			
		The director of the Virtual Education Management Department			
		The dean of the Faculty of Education			
	Synchronous online focus group	2 teachers from the Faculty of Education			
		2 students from the Faculty of Education			
	Surveys of students	Students from three master's degree programmes at the Faculty of Education			
	Surveys of teachers	Teachers from all Faculties			

The aim of the interviews was to identify the opportunities and obstacles encountered in the process of moving the university's programmes online in response to the needs created by the pandemic, from the point of view of three key decision-makers: the general academic director of the UASB-E, the director of the Virtual Education Management Department and the dean of the Faculty of Education.

The documentary analysis focused on the documents that set out the guidelines and regulations for emergency remote teaching after the outbreak of the pandemic and the subsequent proposal of a pedagogical model for online learning in the new normal. Three documents were analysed for this paper: (1) *Guidelines for non-face-to-face education*, developed by the Virtual Education Management Department to define the actions, strategies and measures to be implemented for non-face-to-face education in times of contingency; (2) *Pedagogical model of distance education*, which defines the UASB-E's model of distance education as a technological ecosystem of services, resources, networks and virtual learning environments that interact with each other; and (3) *Guidelines for an educational process in remote modes*, developed for the Faculty of Education.

The synchronous online focus group involved two teachers and two students from the Faculty of Education. It helped to explore various aspects of the lived experience of teaching and learning remotely, including the required skills and the pros and cons of online education. The focus group was conducted via videoconferencing and recorded for later analysis.

Several types of surveys were conducted: (1) a survey administered to a sample of 166 students from three master's degree programmes at the Faculty of Education, which was answered by a total of 129 students (78% of the sample); (2) institutional surveys administered to students in the 2020/2021 and 2021/2022 academic years, which asked about the teaching process and the mode of study and included dimensions related to

teaching, learning activities and learning tools; and (3) institutional surveys administered to teachers regarding their capacity building needs.

Finally, we also analysed the design of classroom instruction for the Faculty of Education's programmes in the virtual learning environment in the 2020/2021 academic year, and academic data for 2020/2021, 2021/2022 and 2022/2023.

4. Findings and Discussion

Although the UASB-E was a 100% face-to-face university before the pandemic, it maintained a virtual learning environment for occasional use as a support space for face-to-face teaching and eventually for professional training events and open courses. Essentially, the virtual learning environment was used as a repository of materials to support teaching and learning.

4.1 Evolution and Enhancement of Techno-Pedagogical Model at UASB-E

In October 2019, the Virtual Education Management Department carried out an internal review and validation of the instructional and graphic design of the university's virtual learning environments (collectively referred to as Andina Virtual). The new model described the design of virtual courses based on the generic ADDIE methodology. This model made it possible to specify the design processes of the learning environments in the Andina Virtual system and the principles that would be applied in each phase, such as 'Merrill's (2002) first principles of instruction, Gagné's learning events (Chen and Johannesmeyer, 2021) and Kirkpatrick's evaluation model (Cahapay, 2021). This design led to several proposals for virtual classrooms for postgraduate programmes and other training activities, such as extension courses, professional training and MOOCs.

The model distinguished between four types of virtual classroom: (1) link classrooms, designed for courses whose main resources are reading materials such as digital documents, e-books, handbooks and tutorials; (2) lecture classrooms, designed for courses that use multimedia elements such as audio, video, simple animations, handbooks and interactive tutorials, complemented by other tools outside of Moodle; (3) iconographic classrooms, designed for self-study courses, with dynamic content structured according to a visual scheme using familiar icons associated with the subject of the course; and (4) interaction classrooms, where instruction is synchronous, allowing webinars, seminars, master classes, conferences and the like to take place live and encourage real-time interaction.

When the pandemic broke out in the 2019/2020 academic year, the UASB-E had 1,295 students with whom it undertook to continue all educational activities remotely, according to the possibilities of each teacher, either by using videoconferencing tools, virtual classrooms, email and telephone communication or by requesting the delivery of final papers. These remedial solutions required many decisions and actions to be taken in a very short period of time, especially those related to technological infrastructure, training and support for academic staff and students, and administrative management. This period was also characterised by the widespread adoption of the synchronous model based on videoconferencing (Herrera-Pavo, Amuchástegui and Balladres, 2020), although other models were also explored, including the asynchronous collaborative model. It was clear to the academic community that the shift was not to an e-learning model, but to emergency remote teaching.

During the pandemic, the UASB-E strengthened its technological infrastructure and digital processes in the areas of management, administration and academics. These new strengths, as well as the experience of emergency remote teaching, allowed it to rethink its pedagogical model and make it more complex. During this period, it began to promote activity-based instructional design, asynchronous online education and collaborative learning strategies.

The spread of the pandemic made it clear to the academic community that it would continue to operate online during the following academic years (2021/2022 and 2022/2023). The UASB-E was therefore compelled to take steps to digitalise processes that would facilitate its operation as an online university. These steps included the design of a techno-pedagogical ecosystem for online learning that would ensure quality and inclusive education in various non-face-to-face modes, thereby promoting a new learning ecology (Estévez, Souto-Seijo, and Romero Rey, 2021). Below is a discussion of the main dimensions of the techno-pedagogical ecosystem implemented by the UASB-E (Figure 1): mode, instructional design, learning environment, interaction and collaboration, assessment and feedback, and students' and teachers' digital literacy.

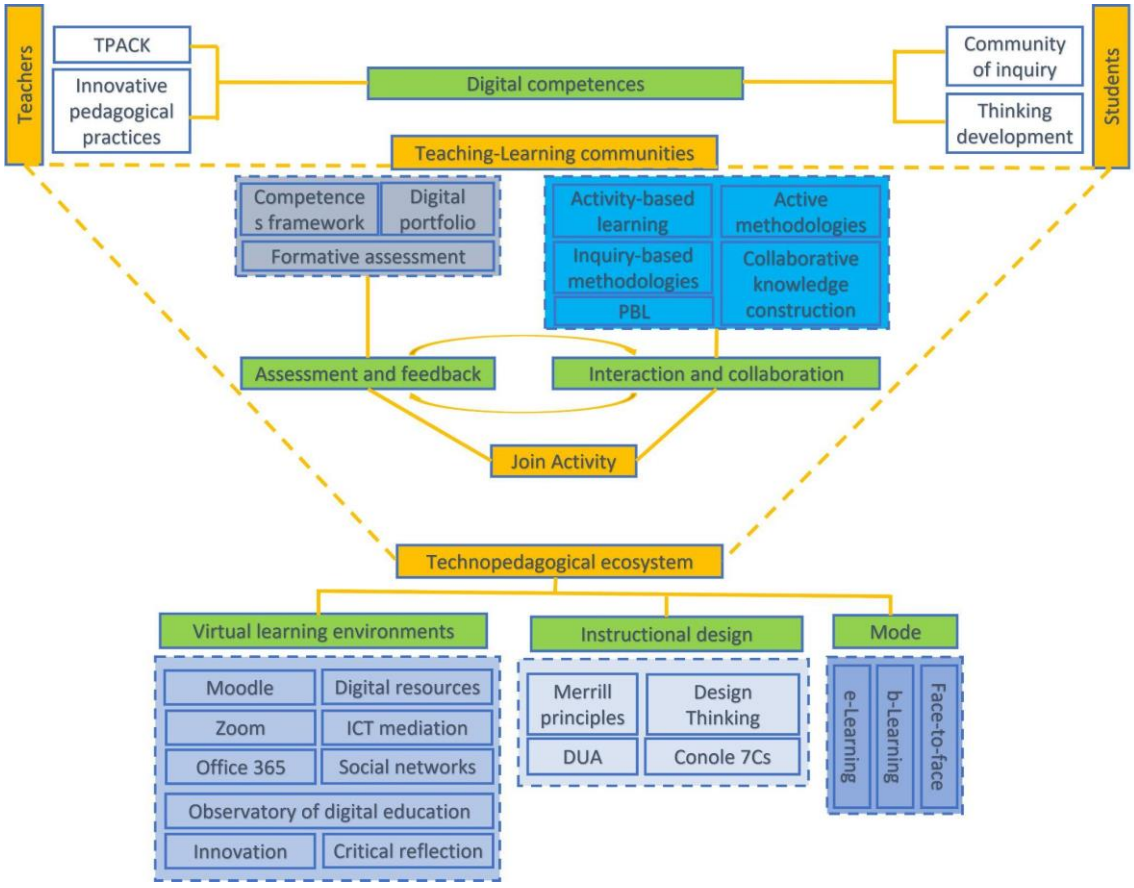

Figure 1: Andina Virtual techno-pedagogical model

4.2 Evolution of Educational Delivery Modes at UASB-E: From Pre-Pandemic to new Realities

The UASB-E gradually returned to face-to-face teaching in 2023. However, only 90 students from eight programmes (three doctoral programmes, four research-focused master's degrees and one profession-focused master's degree) returned to campus, while the rest (1,205 students from the other 42 programmes offered by the university in 2023) remained online, taking advantage of the exceptional measures decreed by the Higher Education Council (CES) to deal with the pandemic, which were still in force.

In a survey of students in March 2023, only 15.9% said they preferred the face-to-face mode; the rest preferred some degree of online education: fully online learning (32.4%); blended learning, understood as a combination of online and face-to-face learning (28.28%); or hybrid learning, combining simultaneously different modes (21.3%).

Faced with this reality, the Office of the General Academic Director proposed greater flexibility in the educational model (Veletsianos and Houlden, 2019) to ensure that the UASB-E would maintain its vocation as an institution that gives an important place to face-to-face teaching, especially in programmes with a strong research component, while also venturing firmly into online education by organising online courses and using all available technological resources to support face-to-face and blended programmes (Chaw and Tang, 2023), thus leaving no student behind.

Although the pandemic took its toll on higher education in general, by continuing to offer its courses remotely through videoconferencing platforms and its Andina Virtual system, the UASB-E was able to reach all the provinces in Ecuador, including students who would not normally be able to travel to the Quito campus. In this regard, it is aware that it must not lose the ground it has gained when the situation returns to normal, and must therefore diversify its catalogue of academic degrees through different modes that are compatible with the field of study and the specific content of each programme. The result will be face-to-face, blended and online programmes.

In 2023, the UASB-E officially offers only seven degrees with some amount of online learning, five of which are offered by the Faculty of Education. In 2024, after the end of the pandemic regulatory exception, all programmes must be offered again in the mode in which they were approved by the CES, in accordance with the provisions of this regulatory body. Faced with this reality, in March 2023, the Office of the General Academic Director asked the faculties to make adjustments to their programmes in order to obtain approval from the CES before the start of the next academic year. In turn, the faculties requested adjustments in order to increase the proportion of online teaching in 51 of the 60 programmes that make up the 2024 course catalogue. Of the 41 face-to-face programmes, 22 requested to continue as face-to-face programmes, maximising the margin of online teaching up to the 49% allowed by the regulations; 14 requested to be blended, with 65% online teaching; and five requested to become 100% online. Of the ten blended programmes, nine are increasing online teaching to 65% to reach the maximum allowed by the regulations, and one is becoming 100% online (Figure 2).

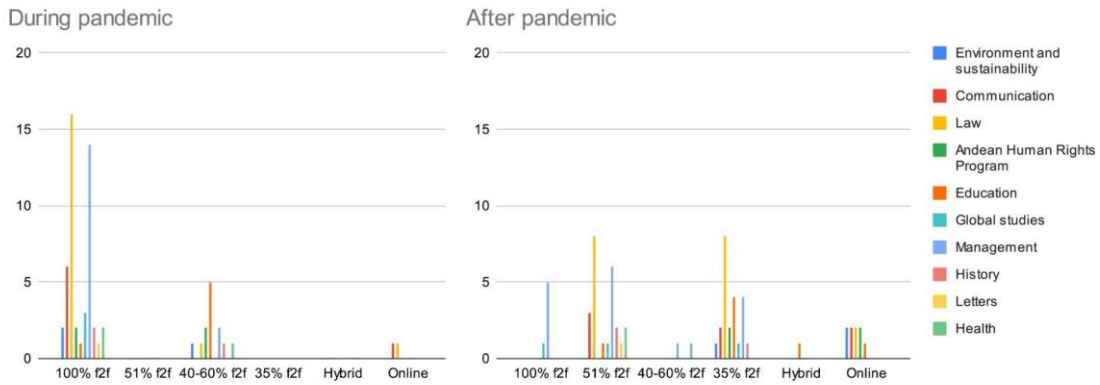

Figure 2: Online education during and after the pandemic

In summary, nine programmes will be 100% face-to-face, 22 will be 49% online, 23 will be 65% online and six will be fully online. By next academic year, the UASB-E will have gone from 100% face-to-face before the pandemic to 42% face-to-face, with more than half of its courses officially moving online.

Additionally, the UASB-E recognises that its venture into new modes requires the development of an e-learning model, together with initiatives for the professional development of teachers on online education issues. The asynchronous model based on collaborative activities promoted by the Faculty of Education and the Virtual Education Management Department itself is gaining ground in the discussion of the new model.

4.3 Instructional Design

The university programmes' clear shift towards online learning implies decisions related to instructional design, as the relevant regulations require that online programmes and courses have a virtual classroom, a complete learning guide and pre-designed educational resources (Arghode, Brieger, and Wang, 2018).

During emergency remote teaching, these requirements were flexible, allowing traditional face-to-face education models to be transferred to synchronous online classes delivered using videoconferencing tools. However, for programmes that are to be officially approved for online delivery, there needs to be an instructional design process in place to ensure that the requirements of the regulatory body and the expectations of the university community are adequately met.

In 2022, in order to assess the Faculty of Education's instructional design practices, an analysis was carried out on the 163 course classrooms that it had created in Moodle during the 2021/2022 academic year for its postgraduate programmes. The results showed that 18.4% of the virtual classrooms were empty, meaning that the courses were taught using tools outside of Moodle; 5.5% of the classrooms were designed for the presentation and distribution of study materials only; 30.7% of the classrooms were designed for the distribution of materials and the performance of compulsory individual activities; 8% of the classrooms were designed for the distribution of materials and the performance of compulsory individual and/or group activities; and 37.4% of the classrooms were designed for the distribution of materials and the performance of individual and/or group activities, including compulsory collaborative work.

These courses and their classrooms were designed by 54 teachers, of whom 22.2% did not use the virtual classroom for teaching. In comparison, 7.4% used the classroom only to present and distribute materials, 37%

integrated study materials and individual assignments into their virtual classrooms, and 27.4% integrated materials and group work and interwove them with individual activities. Only 5.6% proposed collaborative group activities.

From this analysis, it is possible to identify the training and support needs of teachers, as well as the coordination needs of the programmes, so that those being redesigned for online delivery in 2023 can be rethought according to an e-learning model based on collaborative work that fully exploits the potential of online education.

In this sense, the Office of the General Academic Director, the Virtual Education Management Department and the Faculty of Education have set up an advisory process for the techno-pedagogical design of each of the programmes that will be offered online in the next academic year. This process consists of five phases: (1) creation of the programme's competency framework; (2) techno-pedagogical design of the programme; (3) creation of learning guides; (4) creation of learning resources; and (5) classroom design. The aim of this process is to develop an e-learning model based on collaborative work with a high degree of asynchrony, in which videoconferencing is used occasionally and mainly for tutoring processes.

4.4 Learning Environment

Andina Virtual organises the teaching-learning interaction process around personalised Moodle and videoconferencing tools. The system hosts the virtual classrooms of postgraduate courses, the faculties' online courses and the workshops.

According to teachers and students, 79% of postgraduate courses in 2022 were delivered using the Zoom videoconferencing platform. The use of Zoom for synchronous teaching focused on five main resources: screen sharing (89%), audio sharing (79%), video sharing and class recording (77%) and the creation of breakout groups (70%), while the digital whiteboard, integrated applications and support services options were used by less than 54%. Only 35% of teachers used the Moodle platform to manage asynchronous classes and share study materials. Moodle resources for content management were concentrated in files (86%), folders (79%) and links (71%), while activities were mainly carried out as tasks (85%) or forums (65%). In addition, 11% of teachers integrated the Office 365 platform into their teaching. These practices align with those identified in other studies, including the research conducted by Bernardo and Duarte (2020).

The Moodle environment was updated at the end of 2022 to improve the student experience in terms of activity performance, accessibility and anti-plagiarism support. It also introduced tools to encourage interaction and collaboration, as well as formative assessment and feedback. These included Board, a collaborative bulletin board; Learning Map, a resource for creating a map-like learning path format; and Exabis ePortfolio, a tool for creating a portfolio from competency frameworks. This improvement took into consideration students learning characteristics to improve their overall learning experience (Chaw and Tang, 2023).

4.5 Interaction and Collaboration

According to Hodges et al. (2020), careful planning of online learning involves not only the delivery of specific content, but also a focus on how to support the different types of interaction that are essential to the learning process, including student-to-content, student-to-student and student-to-teacher. This approach recognises that learning is both a social and a cognitive process, not just a matter of information transfer.

At the beginning of the pandemic, face-to-face course plans were transferred directly online, resulting in a kind of diminished face-to-face teaching-learning experience, with videoconferencing lectures dominating. Some changes were made once emergency remote teaching became less urgent and teachers had the opportunity to train, but lectures and videoconferencing remain at the heart of the UASB-E's teaching offer (Figure 3). Work is under way to change this in order to encourage synchronous and asynchronous interaction and, therefore, learning.

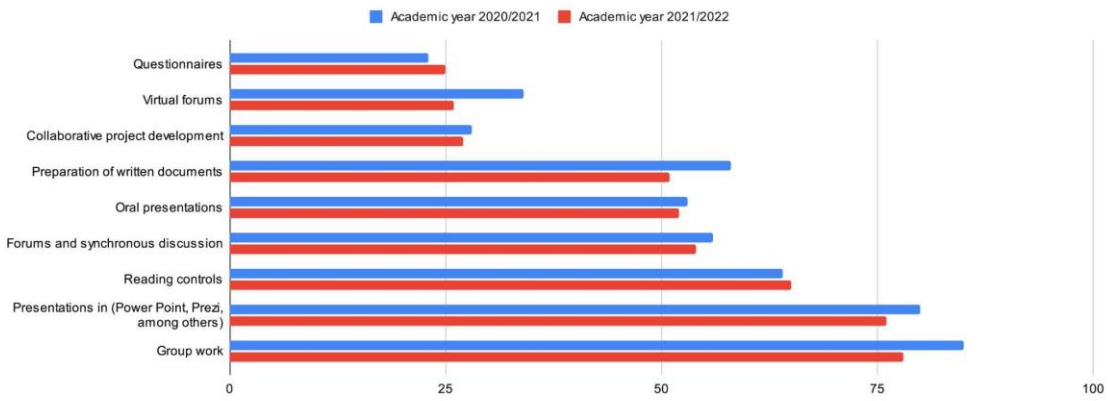

Figure 3: Most common learning activities according to students

The learning activities that teachers provide for students in the synchronous model consist of reading, debates, essays and presentations. However, as shown in Figure 4, this is all based on group work, a classic approach in higher education. This means that there is room for collaborative work based on projects and asynchronous interaction through virtual forums. The university wants to encourage this trend by providing training and support in the instructional design processes of the new programmes.

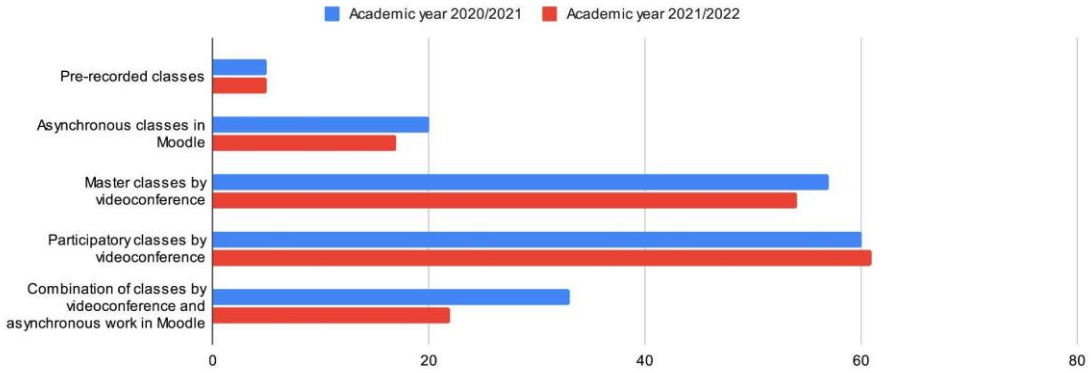

Figure 4: Teachers' main instructional proposals, according to the students

Students agree with this approach. They think it is necessary to make lessons more participatory, to diversify teaching strategies and to balance individual and collaborative work dynamics. However, collaborative work requires not only trained teachers to implement it, but also training for students who are overly accustomed to individual work dynamics (Herrera-Pavo, 2021).

4.6 Assessment and Feedback

The restrictions imposed by the pandemic also affected traditional assessment practices, which are mostly based on summative models, by making it impossible for assessors and those being assessed to be in the same physical space. One of the main challenges for higher education institutions in this regard was how to replace place-based assessment with technology-mediated remote assessment (Whitelock et al., 2021).

Most of the programmes at the UASB-E employ a combination of formative assessment and final projects in each course, with exams being a marginal practice. Although the assessment of students' mid-course activities and final projects has not been an issue, the loss of face-to-face contact has hindered feedback processes. This is because these have traditionally been dialogue- and classroom-based and have proved unwelcoming to the move online, whether to synchronous or asynchronous formats.

In the survey on the teaching process carried out in the 2020/2021 academic year, 53% (359) of students considered the assessment of learning to be adequate, followed by 36% (244) who considered it to be very adequate, while the remaining 11% (77) indicated that it was not very adequate or inadequate. In terms of feedback, 50% (339) of students found the guidance provided by their teachers during this period to be

adequate, 41% (277) found it to be very adequate and the remaining 9% (64) found it to be not very adequate or inadequate. For the 2021/2022 academic year, the results are very similar: 51% (198) of the students surveyed said the assessment was adequate, 43% (167) said it was very adequate and 6% (21) said it was not very adequate. We also found similar data in relation to teacher guidance during this period: 49% (191) of students found it adequate, 46% (177) found it very adequate and 5% (19) found it not very adequate or inadequate.

These figures show that most students were satisfied with the assessment model and teacher guidance introduced during emergency remote teaching and its subsequent development, which aligns with the findings of the study by Tejedor, Cervi, Pérez-Escoda, and Tusa Jumbo (2020). However, in the comments collected through these surveys, students asked for faster turnaround times in terms of assessment and feedback before starting new topics, for more teacher involvement in individual student support, for better communication and for better coordination to avoid overlapping assessment processes in different courses. Where there were exams, students asked for appropriate feedback, not just a mark.

The figures suggest a high level of student satisfaction with the assessment and feedback processes. However, our conversation with students and teachers in the online focus group revealed that there is a need to explore feedback, guidance and assessment alternatives in synchronous and asynchronous online scenarios. This was one of the most prominent training needs expressed by teachers in the training needs survey. It is also one of the most critical factors when it comes to defining an educational model, instructional design and the development of learning environments.

4.7 Teachers' and Students' Digital Literacy

When the pandemic began, most UASB-E teachers lacked experience with online teaching and the virtual learning environment, consistent with findings from studies such as the one conducted by Tejedor, Cervi, Pérez-Escoda, and Tusa Jumbo (2020). The Virtual Education Management Department's initial challenge was to equip teachers with the skills needed to use the Moodle platform and other online education tools. This included training for synchronous teaching with Zoom, enabling features such as breakout groups for collaboration, and for asynchronous teaching using Moodle for communication and collaboration.

Before 2019, postgraduate teacher training on virtual platform management was conducted in-person and on demand. Due to the pandemic, all training shifted online, and in 2020, a permanent training process was established to address the needs arising from emergency remote education. By 2021, with most teachers proficient in virtual platform management, training became more personalised, with induction workshops at the start of each academic cycle, small group sessions by faculty, and individual training.

The Virtual Education Management Department developed a Digital Education Resources website, providing tutorials, recorded lessons, and a Teachers' guide to managing virtual platforms, which includes advanced tutorials on classroom management. In 2022, a catalogue of training and advisory services was launched, operational from January 2023, dividing services into planned training for online education methodologies and on-demand advice for digital resource development and course design. In 2022, 73 teachers participated in nine training and 30 advisory sessions.

In February 2022, UASB-E issued its Instruction on Common Provisions for Blended or Online Programmes, requiring teachers to have 120 hours of certified online education training. A corresponding training course and competency assessment test, based on the European Framework for the Digital Competence of Educators (DigCompEdu), were introduced, covering digital resources, pedagogy, assessment, and student empowerment.

A June 2022 training needs survey revealed that 58% of teachers were not using the virtual classroom, with identified needs in creating e-activities (15%), using feedback and tracking tools (15%), and setting up the grader (17%). Conversely, 78% of teachers used videoconferencing platforms, with 54% needing training on managing integrated applications. Managing digital videoconferencing platforms (Zoom, Teams, and Google Meet) was the top training need (38.57%).

Based on these findings, the Virtual Education Management Department continued training in videoconferencing tools and the virtual learning environment, organising open micro-training for other tools. In 2023, an individualised collaborative advisory process was established to support the virtual and techno-pedagogical design of online programmes for the next academic year.

For students, UASB-E initiated an induction course on academic honesty, the Code of Ethics, and gender and intercultural issues in 2019. Previously, induction for managing virtual platforms was in-person, requested by teachers of face-to-face courses with virtual classroom support. From 2020, as teaching moved online, more

extensive and continuous induction processes were required, including live sessions during the first or second week of each academic cycle, complemented by recordings and tutorials in the digital resource repository.

In 2022, the induction course for new students expanded to cover digital library services, the academic management system, and the virtual classroom. A preparatory course for blended and online degrees was introduced to instruct students on using Andina Virtual resources and activities. Additionally, a support service was established to provide guidance on platform use, technical support, and registration assistance.

5. Conclusions

This study examined the rapid transition of Universidad Andina Simón Bolívar (UASB-E) from a fully face-to-face institution to a robust online learning ecosystem during and after the COVID-19 pandemic, identifying six key dimensions that enhanced the delivery of online education: (1) technological infrastructure and digital processes, (2) pedagogical innovation, (3) accessibility and inclusivity, (4) programme diversification, (5) faculty training and development, and (6) assessment and feedback.

With respect to the first key dimension, UASB-E's response to the pandemic and its subsequent development included significant enhancements. Before the pandemic, UASB-E primarily used its virtual learning environment as a supplementary tool for face-to-face instruction and professional training events. However, the outbreak necessitated a swift and comprehensive shift to remote education. The actions taken involved the construction of a complex, adapted, and enriched virtual environment tailored to the needs of online educational processes, along with the simplification of digital processes in management, administration, and academics to support teaching and learning, thereby laying the foundation for a robust online learning environment.

Regarding pedagogical innovation, by promoting an activity-based instructional design model and collaborative learning strategies, UASB-E ensured that its online learning environment incorporated essential elements of effective online learning: clear goals and expectations for learners, multiple representations of course content, frequent opportunities for active learning, frequent and constructive feedback, flexibility and choice in meeting course objectives, and strong instructor guidance and support. This comprehensive approach ensured a high-quality online learning experience. It supported the university’s goal of maintaining a strong presence in both face-to-face and online education, providing a balanced and inclusive educational model.

Concerning accessibility and inclusivity, the shift to online learning and the introduction of new digital services (library, administrative offices, support departments, etc.) not only facilitated the continuity of education but also improved accessibility for students who would otherwise be unable to study. This accommodated diverse needs and learning preferences, demonstrating the potential of online learning to democratize access to quality education.

Based on this premise, the university expanded its academic offerings to include a diverse range of face-to-face, blended, and online programmes, promoting flexibility. This programme diversification allowed UASB-E to cater to a wide array of student needs and preferences, further strengthening its educational model and ensuring it could adapt to various learning scenarios.

Concerning teacher training and professional development, the university's Virtual Education Management Department played a crucial role in the transition. Initially, it focused on equipping teachers with the necessary skills to use online tools such as Moodle and Zoom for synchronous and asynchronous teaching. The department later created a Digital Education Resources website and a robust programme for developing and certifying digital skills among teaching staff, ensuring they were well-prepared for the new mode of instruction.

Finally, this case study underscores the importance of exploring alternatives for feedback and assessment in synchronous and asynchronous online scenarios, improving feedback timeliness, individual support, and communication for a more effective educational model. In this regard, a more reflective and analytical approach to these processes is necessary to provide a more appropriate instructional design.

The pandemic highlighted the importance of flexible and resilient educational models, and UASB-E's experience drew attention to several key practical and theoretical implications for higher education. Practically, institutions should invest in robust technological infrastructure and embrace flexible learning models that can accommodate diverse student needs. Developing comprehensive digital literacy programmes for teachers and students is essential for effective online education. Theoretically, the success of UASB-E's transition illustrates the complexity of the design and decision-making process in online learning, which involves multiple dimensions: modality, pacing, student-instructor ratio, pedagogy, instructor role online, student role online, online

communication synchrony, the role of online assessments, and source of feedback. Addressing these aspects ensures a comprehensive and effective online education framework.

UASB-E's experience presented and analysed in this case study provides valuable insights into building resilient and inclusive education systems capable of adapting to unforeseen circumstances. The university's strategic enhancements in technological infrastructure, instructional design, and digital competency development have not only ensured the continuity of education during the pandemic but have also set a foundation for future growth and innovation. By prioritising flexible learning models and collaborative strategies, UASB-E has demonstrated the potential for higher education institutions to maintain high-quality education across various delivery modes. These efforts have equipped the university to meet the evolving needs of its student body and to contribute to the broader discourse on effective online education practices. This study underscores the importance of a systematic and adaptable approach to online education, which is essential for fostering a resilient and inclusive learning environment in the face of future challenges. The lessons learned show the need to build collaborative alliances as part of an interdisciplinary and cross-sectoral strategy to achieve a resilient and comprehensive education system at all levels in the face of future contingencies. Educational technology plays a fundamental role in this agenda, but new approaches to learning ecologies are required to ensure equitable, inclusive and high-quality education and to support personalised learning.

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The Analysis of Learning Performance Satisfaction for Physical and Online Learning: A Case Study from Taiwan

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Abstract: Management education, continuously evolving since the 1990s, recognizes the need to develop proficient management professional's adept at strategic decision-making. The present research delves into the effectiveness of a management course for first-year students at a chosen School of Management, underlining its paramount importance in ensuring student retention and bolstering departmental stability. The purpose of this research is to evaluate the effectiveness of traditional physical and online learning methods in a management course for first-year students at a university in Taiwan, focusing on students' satisfaction with their learning performance. The study aims to compare the educational efficacy of these two instructional modes and analyze the variations in student performance and satisfaction. The methodology involved a longitudinal design with data collection from first-year students in 2022 (online learning) and 2023 (physical learning). The research employed pre-test and post-test evaluations, regression analysis, and Importance-Performance Analysis (IPA) to assess the impact of course units on students' learning satisfaction. This study employed regression analysis to determine the influence of enhancing "Management Basis" and "Management Operations" on satisfaction. The results revealed that online learning outperformed physical learning in terms of overall student satisfaction, particularly in understanding "Management Basis" and "Management Operations." However, physical learning demonstrated higher improvements in student scores and satisfaction, particularly in areas requiring detailed explanations and hands-on engagement, such as "Control Tools.". The novelty of this research lies in its comparative approach to evaluating two distinct learning environments during a critical period marked by the COVID-19 pandemic. The findings offer valuable insights into how different teaching modalities impact student satisfaction and learning outcomes, providing guidance for educators to refine instructional strategies to enhance student learning efficacy across different formats. The study underscores the importance of adapting teaching methods to suit the specific demands of online and physical learning environments.

Keywords: Satisfaction, Learning performance, Physical learning, Online learning, Importance-Performance analysis

1. Introduction

In 2022, the COVID-19 pandemic significantly altered the educational landscape in Taiwan, leading to a widespread transition to online teaching methods, a shift that echoed global trends in higher education. This change prompted a widespread transition to online teaching methods in the latter half of 2022, reflecting a broader shift observed in higher education institutions throughout the world as well as in Taiwan. Online education is characterized by a learning environment within a digital platform, eliminating direct interactions between teachers and students (Agrawal and Krishna, 2021). This mode of learning became particularly vital for first-year college students, who had to adapt to the challenges of distance education as they began their higher education journey. According to Danchikov et al. (2021), online learning allows students and teachers to collaborate and interact through the Internet. This method of education depends on platforms that can support teaching and learning activities conducted remotely rather than physical learning.

Given the newness and relative unfamiliarity of the online learning setting, evaluating the effectiveness of students' academic efforts was crucial—the emerging educational environment called for a thorough analysis to understand the students' achievements and progress. Later, as the effects of the COVID-19 outbreak started to lessen, the second semester of 2023 marked a return to traditional face-to-face classroom settings. While initially set in the online mode, the learning approach is now transitioning back to physical education. The move towards physical instruction began from the stated session, following a series of prior online classes.

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Physical learning involves a face-to-face educational method where educators and students interact directly within a physical environment (Kundu and Bej, 2021). While internet usage supports many aspects of physical learning—such as accessing resources, submitting assignments, and facilitating communication—the core of physical learning lies in the in-person engagement it offers. Physical learning is viewed as having enhanced effectiveness, increased accessibility, fewer technical difficulties, and a lower likelihood of academic dishonesty and deception compared to its online equivalent. Based on the research by Zhu et al. (2023), noticeable differences in learning outcomes stem from students' motivational attitudes in both online and physical learning environments. The study indicates that students hesitate to participate in online learning, whereas they demonstrate enthusiasm in actively partaking in offline educational tasks.

Learning outcomes are crucial indicators for assessing the effectiveness of educational processes and the achievement of teaching objectives even with varying levels of student engagement, measurable results consistently emerge, reflecting the success of different instructional methods (Trigwell and Prosser, 1991). In research conducted by Singh et al. (2021), noticeable differences were identified in student learning outcomes between physical and online instructional methods. The results highlighted the superior effectiveness of face-to-face education over its online counterpart. Jiao et al. (2022) found that face-to-face learning environments often lead to better educational efficacy, higher productivity, and a more conducive atmosphere for learning compared to online settings.

This research aims to evaluate class course units delivered through online and physical instructional methods. This study explores the differences in learning outcomes between online and physical instructional methods, focusing on data gathered from first-year students in a management course. Utilizing pre-test and post-test evaluations, the study intends to gauge the effect of these teaching modalities on student achievements. The study is based on the systematic collection and comparison of data from a 2022 pre-test on online learning and the physical pedagogies implemented in 2023. The investigative spotlight is cast upon a pivotal foundational course provided by the Department of Business Administration within the School of Management. This principal course constitutes a vital segment of the curriculum for incoming students, integrating fundamental tenets of management theory and its tangible execution.

By analyzing and comparing data from these distinct educational approaches, our study aims to identify key differences and inconsistencies. This thorough examination provides critical insights that can be used to enhance pedagogical methods. Leveraging these insights, educators can refine their instructional strategies to significantly improve student learning outcomes.

1.1 Research Question and Objective

The Research Questions of this research encompass the following:

R1: What is the comparative educational efficacy of traditional physical learning versus online learning environments?

R2: How do learners' achievements in the IPA quadrant differ between traditional and online courses, and how can this inform teaching improvements?

The objectives of this research encompass the following:

O1:Evaluate the level of educational efficacy in both traditional physical and online learning.

O2: Analyze variations in the distribution of learners' educational achievements in the IPA quadrant when comparing traditional and online courses.

2. Literature Review

2.1 Student Self-Assessment

Self-assessment in students is an instructional strategy within the educational realm that encourages learners to gauge their academic advancement and output actively. As a pivotal element of ongoing evaluation, self-assessment accentuates reflective thinking, deepening students' grasp of their learning trajectories and accomplishments (“Self-Reported Learning Outcomes at UMass Amherst”, 2017). Even though students' self-evaluations often reflect perceptions rather than verifiable abilities, higher educational institutions employ these in tandem with objective evaluations to scrutinize student learning. Evidence suggests that students' subjective evaluations sometimes coincide with objective measures. Though not exact replicas, such self-reported metrics aid in understanding student perceptions across diverse learning objectives.

In earlier research, Kikas and Jõgi (2016) explored the creation and utility of two tools meant to measure the learning tactics of middle schools and their potential learning outcomes. Their findings underscored the significance of meticulously selecting assessment techniques for middle school settings. Laine et al. (2019) researched the effects of an entrepreneurship education structured around business plans, probing its repercussions on students' self-assessed learning outcomes concerning entrepreneurial competencies, inclinations, and capabilities. Their investigation discerned four primary self-recognized learning outcomes: pivotal professional competencies, organizational skills, entrepreneurial confidence, and a bias toward growth.

In other research, Ifenthaler, Schumacher, and Kuzilek (2023) leveraged learning analytics to delve into the nexus between students' engagement in self-assessments, their subsequent performance in the final examination, and their self-articulated self-evaluation methods. Their discoveries showed a predominant tendency among students to employ self-assessments ahead of pivotal tests. They also identified two distinct clusters based on the intensity of engagement with self-assessments, with heightened attention resonating positively with superior final exam results.

2.2 Learning Performances

Learning outcomes are essential indicators that define the expected knowledge, skills, and abilities students should acquire after completing an educational activity (Alshammary and Alhalafawy, 2023). These outcomes act as the educational process's roadmap, giving educators and students a clear goal to target. Evaluating these learning outcomes can include many indicators such as satisfaction levels, task performance, self-rated knowledge acquisition, observed achievements, in-class assessments, active involvement, self-belief in learning capacity (self-efficacy), immersion in learning, and the overall educational experience (Oktriani, Hufad, and Utami 2023). Hill et al. (2011) combine various assessment criteria, covering aspects like learning results, self-assessment, achieved outcomes, Satisfaction, in-class evaluations, participation, self-confidence, technological ease, and student predispositions and views, which aligns with our approach to comparing these two modalities.

Furthermore, Pondee, Panjaburee, and Srisawasdi (2021) propose a multi-layered methodology for assessing learning efficiency, encompassing response, knowledge gain, behavior, and accomplishments. This approach is particularly relevant to our study as it provides a structured way to evaluate the differences in learning outcomes between online and physical learning. Additionally, the role of student attitudes, as highlighted by (Hellmich, Löper, and Görel, 2019) is critical in understanding the efficacy of these learning environments, making it a key component of the analysis.

2.3 Learning Satisfaction

Learning satisfaction (Jiang et al. 2021) is a critical component of the educational experience, encompassing the emotional and attitudinal responses of students to their learning environments. It is driven by the degree to which students feel their learning needs—both physiological and emotional—are being met. While this connection between student satisfaction and academic outcomes is well-documented, the extent and nature of this relationship vary depending on the learning context. For instance, Rajabalee and Santally (2021) found a clear link between student satisfaction, participation in online courses, and subsequent academic performance, suggesting that engagement in online settings can significantly influence how students perceive their educational experience. However, Zhang and Lin (2020) provide a more nuanced view, arguing that learning satisfaction is a holistic construct that reflects not only the fulfillment of expectations but also the emotional journey of students through their educational experiences. This broader perspective emphasizes the importance of aligning educational settings with student expectations, an area where both online and physical learning environments can struggle or succeed depending on various factors.

Building on background, Eagleton (2015) the multifaceted influences on learning satisfaction, including student traits, instructor effectiveness, course content, and the overall educational environment. This complexity suggests that while student satisfaction can be a useful metric, it is also shaped by a wide array of variables that may interact differently across online and physical learning contexts. While, Topala and Tomozii (2014) supports the need for validated tools to measure student satisfaction, indicating that the subjective nature of satisfaction can be systematically assessed. Cheng, Mo, and Duan (2023) underscore the role of motivation in e-learning, particularly during the COVID-19 pandemic, pointing to the challenges faced in maintaining satisfaction in online environments. These studies collectively highlight the importance of understanding the specific factors that drive satisfaction in different learning settings.

2.4 Physical and Online Learning

Empirical evidence from prior studies consistently indicates a stronger association between face-to-face instruction and enhanced academic outcomes compared to online learning. Specifically, Tratnik et al. (Tratnik, Urh, and Jereb 2019) demonstrated that business English students achieved higher learning outcomes in traditional classroom settings than their peers in online environments. Similarly, Bir (2019) found a statistically significant improvement in academic performance among engineering students in face-to-face courses compared to online versions. Additionally, Faux and Black-Hughes [48] highlighted better performance metrics and greater student satisfaction within traditional instructional settings, particularly in a social work history curriculum. These studies collectively suggest that traditional, in-person education may be more effective in promoting academic achievement and satisfaction.

However, what these studies lack is an exploration of the underlying reasons why face-to-face instruction often yields better outcomes. They also do not fully account for the nuances of how different disciplines or student demographics might interact with these instructional modes. Moreover, while these studies provide valuable insights into the advantages of physical learning, they do not extensively examine the potential benefits or unique challenges of online learning environments, especially in the context of a rapidly changing educational landscape influenced by the COVID-19 pandemic. Moreover, several studies (Park and Choi, 2009; D. Yang, Baldwin, and Snelson, 2017) have ubiquitously corroborated high retention indices for on-site pedagogical environments in contrast to digital course offerings.

The COVID-19 crisis has significantly disrupted conventional classroom instruction, leading to a global shift towards online education (Lavonen and Salmela-Aro, 2022; Iglesias-Pradas et al., 2021; Hsiao, 2021). The interplay between COVID-19 and virtual education has markedly transformed the existing educational terrain, establishing online teaching as the only viable avenue for disseminating knowledge. Past research has scrutinized students' involvement in digital learning environments. Gray and Diloreto (2016) explored the relationship between course layout, student interaction, engagement, and instructor involvement, assessing their influence on student contentment and perceived knowledge acquisition. Czerkawski and Lyman (2016) proposed a pedagogical design model complemented by tactics to augment student participation in virtual education. Abou-Khalil et al. (2021) delved into efficient engagement methodologies as discerned by tertiary education students in online classrooms within resource-limited environments. Ristić et al. (2023) assessed student performance within a digital learning schema, highlighting that a flexible e-learning platform can bolster student educational achievements.

Despite these contributions, a gap remains in understanding how online and physical learning environments compare in terms of their impact on student learning outcomes, particularly in a post-pandemic context. This study aims to fill this gap by systematically comparing the effectiveness of online and physical learning modalities in a management course for first-year students. By doing so, it seeks to provide a more comprehensive understanding of how different instructional methods can be optimized to improve educational practices in diverse learning environments.

2.5 Theory and Hypotheses

The proposed conceptual framework for evaluating student satisfaction with learning performance integrates various factors, including both online and physical learning course units. This framework is informed by prior research that has explored the differences in student satisfaction and learning outcomes between these two instructional methods. Even though prior studies (Kamalia, Sakti, and Kurniawan, 2022; Yang et al., 2022; Valentino et al., 2021) have examined and contrasted the satisfaction levels in learning performance between online and physical learning. The study utilized data collected from two different pre-test and post-test inquiries of online and physical education students. Based on the compilation of prior research outlined in the preceding sections, the author put forward a conceptual framework encompassing satisfaction of learning performance.

These studies collectively highlight the complex interplay between the mode of instruction and student satisfaction, underscoring the need for a nuanced approach to evaluating learning performance. Based on these insights, the current study proposes a conceptual framework that aims to systematically assess student satisfaction in both online and physical learning environments. The study utilized data collected from pre-test and post-test evaluations conducted with students in both online and physical learning settings. This approach allows for a direct comparison of how different instructional methods impact learning satisfaction over time. Figure 1 shows Model of Conceptual Framework. Following the examination of existing literature, this study has formulated the hypotheses for design as stated below:

H1: The degree of improvement in understanding Management Basis influences students' Satisfaction with learning performance in online learning.

H2: The degree of improvement in understanding Management Operations influences students' Satisfaction with learning performance in online learning.

H3: The degree of improvement in understanding Control Tools influences students' Satisfaction with learning performance in online learning.

H4: The degree of improvement in understanding Management Basis influences students' Satisfaction with learning performance in physical learning.

H5: The degree of improvement in understanding Management Operations influences students' Satisfaction with learning performance in physical learning.

H6: The degree of improvement in understanding Control Tools influences students' Satisfaction with learning performance in physical learning.

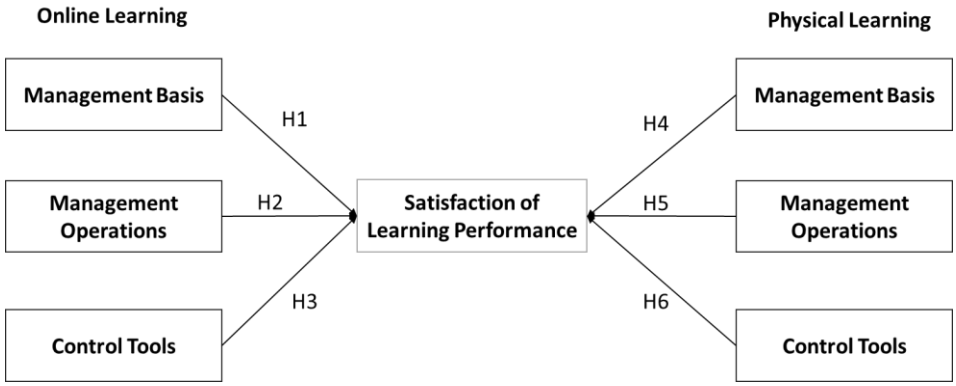

Figure 1: Model of Conceptual Framework

This conceptual framework serves as the basis for evaluating the effectiveness of different teaching methods on student satisfaction and provides a structured approach to understanding the factors that contribute to successful learning outcomes in both online and physical settings.

3. Materials and Methods

3.1 Sample and Data Collection

Using a longitudinal design, this research collected data from first-year students in the management curriculum at a private Taiwanese university. The study contrasted the pedagogical outcomes of virtual and traditional classroom settings. "Management" is a core three-credit course within the Business Administration Department covering broad management facets. Due to COVID-19, data was acquired from the same management education course and different first-year students at the beginning (February) and end of the semester (June) in 2022, primarily via email and line. yielding 65 responses. In 2023, with evolving pandemic dynamics, traditional feedback mechanisms were adopted, collecting data in classroom setting resulting in 63 responses from the first-year cohort, respectively. The questionnaire was created in Chinese. Subsequently, the questionnaire coding and translation process was carried out. The questionnaires were collected with the consent of the students, and all students in the classes participated.

3.2 Questionnaire Design and Variable Measurement

The initial development and design of the self-made questionnaire underwent multiple stages, anchored in theoretical principles and teaching materials, a review of related literature, and relevant research data assimilation. The collective information influenced the questionnaire's architecture and content. This design process was rooted in established academic principles, complemented by an in-depth literary survey to gain critical insights. Essential research findings were also integrated into the development phase. In January 2022, three information management and education experts rigorously assessed the questionnaire for validity. Based on their feedback, content alterations were made. The experts then affirmed its content accuracy. Unnecessary elements were discarded, particularly from the curriculum scale.

The descriptions for the subsequent 14 items underwent refinements, and an additional question was introduced to measure learning satisfaction. The research utilized a 7-point Likert scale to capture participants' levels of agreement. This format, ranging from 'Strongly Disagree' to 'Strongly Agree,' facilitates straightforward data collection. The 7-point structure was chosen to obtain nuanced feedback and enhance the clarity of responses. This method aligns with customary research norms, balancing detail and user-friendliness. The study utilized statistical software package, SPSS 23.0 for analyzing the data. The reliability and validity of the questionnaire are discussed in the next section. Construct validity ensures a research scale accurately measures abstract concepts, involving convergent and discriminant validity. Convergent validity links questions to specific factors, while discriminant validity prevents questions from belonging to multiple factors. This study confirms all questions exhibit both validities, confirming the research scale's construct validity, shown in further sections.

3.3 Class Course

This study advanced management education using a framework grounded in theoretical management guidelines and an innovative approach to aid learners in understanding core concepts. During the first fourteen weeks, emphasis is placed on deepening subject knowledge and analytical skills. The curriculum uses Professor Lin Jian Huang's "Introduction to Management, 6th Edition" from January 2022 for theoretical lessons. The survey, with its fourteen questions, aligns with topics such as organizational structure, corporate ethics, decision-making, HR management, effective leadership, communication strategies, and technology's role in oversight. Details of these classroom-focused questions can be found in Table 1, with 14 items specifically crafted to assess course satisfaction.

Table 1: Self-evaluation form before and after learning the management course

No.	Variable	Question
1	Management Basis	I understand the difference between organization and management.
2		I understand the impact of the management environment on the enterprise.
3		I understand the meaning of enterprise ethics and social responsibility.
4		I understand the importance of decision-making.
5		I understand the meaning of planning.
6		I understand the meaning of organizational design.
7		I understand the meaning of organizational change and learning.
8	Management Operations	I understand the meaning of human resources.
9		I understand the meaning of incentive theory.
10		I understand the meaning of leadership.
11		I understand the difference between a group and a team.
12		I understand the importance of communication in conflict management.
13	Control Tools	I understand the meaning of the basis of control.
14		I understand the tools of control.
15	Overall Satisfaction	The course design contributes to my Satisfaction with my learning performance (Posttest only).

4. Results

4.1 Validity and Reliability Analysis

The results from the factor analysis of the Management Course Satisfaction Scale show a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy at .833, indicating strong suitability. Additionally, Bartlett's test of sphericity yielded a significance level of .000, well below the .05 threshold, further supporting the scale's appropriateness for factor analysis. It's worth noting that a higher KMO value, as explained by Kaiser (1974), indicates better correlation between variables for factor analysis.

The scale's initial factor, labeled “Management Course Dimension,” covers questions 1 to 7, addressing topics like organizational differences and decision-making. The second factor (questions 8 to 12) delves into areas such as leadership and communication. The third factor includes questions 13 and 14, focusing on control aspects. The factor analysis results of this study demonstrate that the eigenvalues of each facet surpass 1, all factor

loadings exceed 0.5, and the proportion of variance elucidated by each facet exceeds 50%, all aligning with the criteria scholars' advocate.

Construct validity ensures a research scale accurately measures abstract concepts, involving convergent and discriminant validity. Convergent validity links questions to specific factors, while discriminant validity prevents questions from belonging to multiple factors. This study confirms all questions exhibit both validities, confirming the research scale's construct validity. See Table 2 for the factor facet distribution summary. Following the results of the factor analysis, the study divides the course unit into three clear sections: Management Basis (H1, H4), Management Operations (H2, H5), and Control Tools (H3, H6).

Table 2: Management Course Satisfaction Scale Factor Analysis(n=128)

No.	Management Operations	Management Basis	Control Tools
12	.828		
10	.824		
9	.816		
11	.775		
8	.634		
4		.606	
1		.829	
5		.825	
6		.781	
7		.632	
2		.597	
3		.564	
14			.879
13			.585
Eigenvalues	3.780	2.949	1.991
Explained Variance	37.333	22.491	7.726
Cumulative Explained Variance	37.333	59.824	67.550

The assessment applies item analysis to measure test items by analyzing participants' pre- and post-learning improvement levels. Which means that students were asked to assess themselves before the beginning (pre-learning) of the course and then at the end of the course (post-learning). The approach based on internal consistency is used to divide the cumulative scale scores into two clear categories: the top 27% as the higher-ranking and the bottom 27% as the lower-ranking respondents. This division aids in contrasting the average scores for each test item.

A significance level of $p<.05$ is set for each item to determine its discriminatory strength. If the critical ratio exceeds 3, it indicates the item's discriminatory solid capacity. This method was used to evaluate the management course scale's efficacy. The results showed that all 14 items achieved a significance level of $p<.05$, emphasizing the validity of these questions. The analysis indicates that all 14 questions differentiate between the higher and lower-ranking groups. Table 3 offers a detailed analysis of the scale items' results. The adopted strategy provides insights into each question's discriminatory capability and affirms the overall efficacy of the measurement scale in evaluating the management course's impact. The thorough results highlight the solidness of the item analysis method in assessing the questions' discriminatory capabilities and reinforce the assessment's reliability.

Moreover, to determine the reliability of the measurement scale, Cronbach's α internal consistency coefficient is utilized. The results show an overall scale Cronbach's α coefficient of .898, with individual subdomains ranging between .801 and .909. Generally, a reliability coefficient above .70 indicates good measurement consistency, while coefficients below .35 are deemed insufficient (Nunnally, 1978).

Table 3: Validity and reliability analysis (n=128).

NO	F	Critical Value t	MD	SE	Cronbach's α if the item is deleted
1	3.50	-8.41***	-1.55	0.18	0.909
2	1.22	-10.12***	-1.95	0.19	0.903
3	2.66	-8.14***	-1.65	0.2	0.907
4	12.87	-11.69***	-2.19	0.19	0.801
5	12.73	-10.37***	-2.22	0.21	0.808
6	10	-9.91***	-2	0.21	0.904
7	13.84	-8.93***	-1.93	0.22	0.906
8	16.57	-11.48***	-2.23	0.19	0.901
9	3.32	-10.98**	-2.16	0.19	0.804
10	43.60	-11.8***	-2.85	0.19	0.803
11	6.57	-7.68***	-1.7	0.22	0.906
12	6.62	-5.9***	-1.38	0.23	0.811
13	21.47	-7.8***	-1.82	0.23	0.904
14	30.67	-3.1*	-4.82	0.15	0.816

Note: ***p＜.001, **p<0.01, *p<0.05

4.2 Descriptive Analysis

Our study encompassed a representative sample of 128 participants from the collected data via student questionnaires. The course was delivered online in 2022 (February-June) and transitioned to in-person instruction in 2023 (February-June). The same instructors taught the subject course during both semesters. These participants were actively engaged in the management course during the second semester of the academic year 2021-2022. It is pertinent to highlight that within the sample, two specific subsets or classes emerged as noteworthy due to their gender composition. Notably, one class had a female majority, with 50 female students representing 76.9% of its composition. This observation may have implications for further gender-based analyses in academic contexts.

Similarly, the second class consisted of 40 female students, making up 63.5% of the total participants in that class. Notably, the research was expanded to include a distinct subset: 90 female first-year students from the Department of Business Administration. The subset accounted for 70.3% of the research participants, emphasizing its pivotal role and influence within the overarching study. The observed distribution in this sample is especially noteworthy as it reflects the demographic structure of the larger reference group. The unity between the model and the larger student body is evident when consulting Table 4, which graphically delineates the parity between the research participants' composition and the more extensive student group. The sample distribution indicates that most business management students at the case university are female. This proportion in the study aligns with that of the parent system.

Table 4: Respondent data descriptive statistics

Modes	Gender	N	Pec. (%)
Online Learning	Female	50	76.9
	Male	15	23.1
	Total	65	100
Physical Learning	Female	40	63.5
	Male	23	36.5
	Total	63	100
Total	Female	90	70.3
	Male	38	29.7

Modes	Gender	N	Pec. (%)
	Total	128	100
Business Administration Department	Female	494	71.6
	Male	196	28.4
	Total	690	100

4.3 Important Performance Analysis (IPA)

The research comprised six sequential steps for data collection and IPA, executed using IBM SPSS Statistics 23, which are delineated below:

- Verify the credibility and consistency of the questionnaire.
- Calculate the average of self-evaluated ratings given by participants before and after the instructional phase for each item.
- Ascertain the differences between the post-instructional and pre-instructional mean scores for every item.
- Represent the scores before instruction on the x-axis and those after instruction on the y-axis to formulate the coordinates for a scatter plot (x, y).
- Derive the average score before instruction (and after instruction) for all items and set it as the bifurcation line on the x-axis (y-axis); then, use this coordinate duo (x, y) as the focal point to demarcate four sectors.
- Compare each set of pre- and post-instruction scores for the 14 items to the central reference and allocate them into one of the four sectors.

There was a noticeable significance when comparing online and physical learning ($p<0.001$, $t=10.29$). Additionally, utilizing the "paired sample test" to evaluate various learning methods revealed marked differences in students' self-evaluation scores for online learning ($p<0.001$, $t=17.05$) and physical learning ($p<0.001$, $t=19.10$) before and after instruction. The average enhancement scores stood at 1.76 for online learning and 2.59 for physical education. This analysis suggests that students' self-assessed scores and overall improvement after the course are notably higher in physical classes than in online ones, as illustrated in Table 5.

Table 5: Paired sample test

Modes	Pair	Pairwise Difference			t	DF
		Mean	SD	SE		
Online Learning	After Class - Before Class	1.76	0.58	0.05	17.05***	64
Physical learning	After Class - Before Class	2.59	0.62	0.08	19.10***	62

Note: ***p＜.001

Mentioning to Table 6, in the context of online learning, the IPA method was employed. Here, scores after instruction were charted on the x-axis and those before instruction on the y-axis. Creating a scatter plot based on the average pre- and post-instruction scores defined a reference point at the connection of these averages (3.79, 5.55). Following these data, the 14 items were divided into four sectors. Quadrant I housed items 1, 2, 3, 4, 5, 8, 10, 11 and 12.

Table 6: Descriptive statistics- online learning (n=65)

No	Before learning		After learning		Improvement		Quadrant
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
01	3.75	0.85	5.92	0.76	2.17	0.80	I
02	3.77	1.00	5.92	0.76	2.15	0.97	I
03	4.28	0.80	6.20	0.67	1.92	0.79	I
04	3.80	1.21	5.86	0.81	2.06	1.16	I
05	3.88	1.15	5.62	0.70	1.74	0.85	I

No	Before learning		After learning		Improvement		Quadrant
	Mean	S.D.	Mean	S.D.	Mean	S.D.	
06	3.20	0.96	4.82	0.56	1.62	0.84	III
07	3.40	1.17	4.97	0.87	1.57	0.77	III
08	3.97	1.12	6.08	0.85	2.11	1.14	I
09	3.67	1.31	5.95	0.94	2.28	1.15	II
10	4.50	1.20	6.20	0.79	2.05	1.20	I
11	3.96	1.27	6.05	0.86	2.10	1.10	I
12	3.91	1.16	6.14	0.86	2.23	1.07	I
13	3.55	0.83	4.20	1.06	0.65	0.68	III
14	3.40	1.06	3.80	1.00	0.40	0.46	III
RNG	1.30	0.51	2.40	0.50	1.88	0.74	
AVG	3.79	1.08	5.55	0.82	1.76	0.93	

Meanwhile, Quadrant III included items 6, 7, 13 and 14. This distribution can be visualized in Figure 2. Notably, Quadrant IV had no items, implying that no items had high initial comprehension but limited growth potential. On the other hand, Quadrant II contained only one item, namely item 9, indicating low foundational knowledge but showed notable growth. For the four items in Quadrant III, initial understanding and subsequent progress were limited, pointing toward the need for a more focused instructional approach.

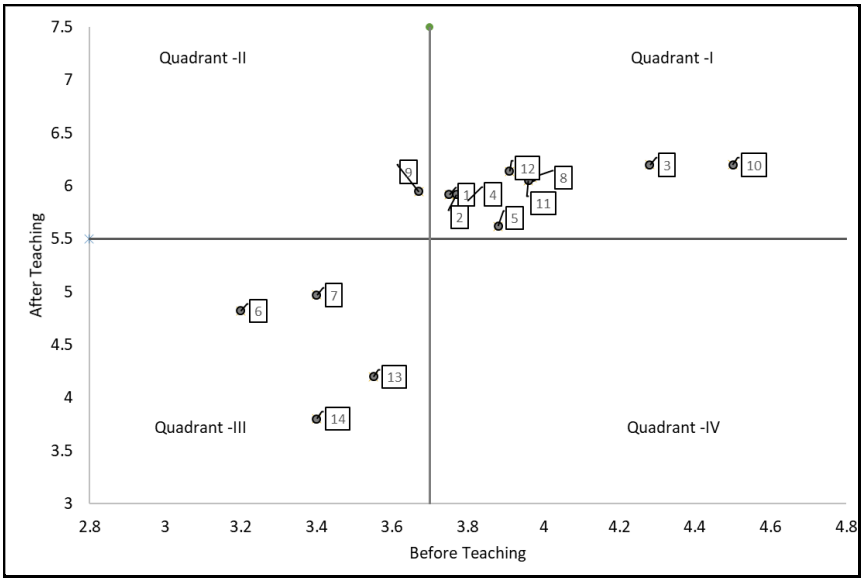

Figure 2: IPA for Online Learning

Additionally, the results of physical learning depicted in Table 7, the average scores before and after teaching (3.38, 5.97) were used to set a reference point. Items 3, 4, 8, 10, 11, and 12 found their places in Quadrant I. Items 2 and 5 fell into Quadrant II. Items 1, 6, 7, 13, and 14 were allocated to Quadrant III. Concluding the categorization, item 9 was positioned in Quadrant IV, as visualized in Figure 3. The positioning of item 9 showed strong foundational knowledge but needed more growth prospects. Conversely, the two items in Quadrant II represent subjects with initially lower comprehension but significant post-instructional improvement. In Quadrant III, the five items present suggestions at low baseline knowledge corresponding with minimal subsequent growth, indicating the importance of increasing teaching strategies for these items.

When examining Quadrant III, a noticeable difference emerges: online instruction has four items, while physical instruction contains five. The observation underscores educators' need to dedicate more resources and effort to enhance the delivery of these topics. Notably, items 6, 7, 13, and 14 are common to online and physical modes. Enhancements in the teaching approach for these items would benefit both instructional methods. Within Quadrant II, which signifies subjects with low foundational understanding but marked improvement post-

instruction, online learning displayed one item, whereas physical learning highlighted two items. The analysis indicates a more significant improvement in subjects with initial low comprehension in physical classes compared to online settings.

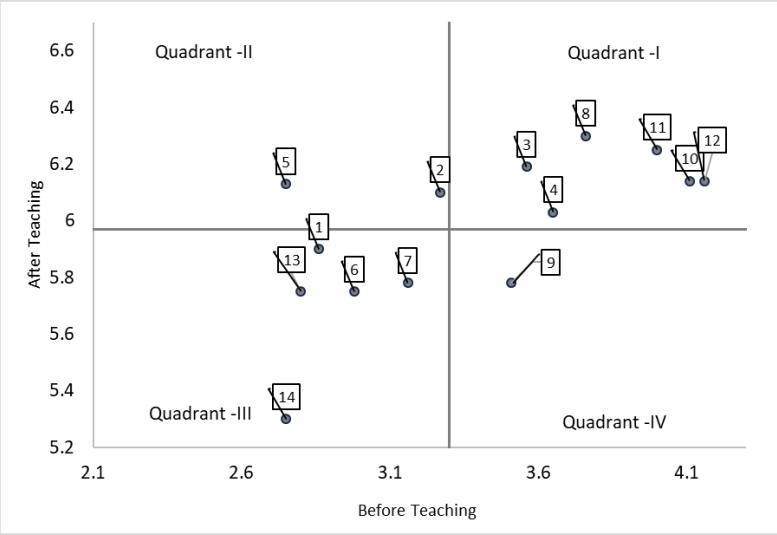

Figure 3: IPA for Physical Learning

Table 7: Descriptive statistics-physical learning (n=63)

No.	Before Learning		After Learning		Improvement		Quadrant
	Mean	SD	Mean	SD	Mean	SD	
1	2.86	1.01	5.90	0.95	3.05	1.08	III
2	3.27	1.07	6.10	0.86	2.83	1.11	II
3	3.56	1.00	6.19	0.86	2.63	1.15	I
4	3.65	1.08	6.03	0.86	2.38	1.08	I
5	2.75	0.97	6.13	0.89	3.38	1.28	II
6	2.98	0.98	5.75	1.00	2.76	1.23	III
7	3.16	1.05	5.78	0.96	2.62	1.26	III
8	3.76	1.00	6.30	0.80	2.54	1.12	I
9	3.51	1.24	5.78	1.10	2.27	1.26	IV
10	4.11	1.28	6.14	0.91	2.03	1.15	I
11	4.00	1.37	6.25	0.88	2.25	1.14	I
12	4.16	1.15	6.14	0.84	1.98	1.04	I
13	2.80	1.33	5.75	1.02	2.95	1.33	III
14	2.75	1.02	5.30	0.81	2.55	0.71	III
RNG	**1.41**	**0.40**	**1.00**	**0.30**	**1.40**	**0.62**	
AVG	**3.38**	**1.11**	**5.97**	**0.91**	**2.59**	**1.14**	

Quadrant IV, distinguished by subjects with robust initial comprehension and marginal growth prospects, saw item 9 for physical learning, while online learning didn't manifest any. Meanwhile, Quadrant I, indicative of subjects with solid foundational knowledge and significant subsequent growth, encompasses nine items for online learning and six for physical learning. Notably, items 3, 4, 8, 10, 11, and 12 were present in both instructional formats, majorly addressing aspects tied to management operations (items 8-12).

Based on the self-reported data gathered before and after the research, the findings in Table 6 and Table 7 and the corresponding Figure 4 indicate that average post-learning scores for both online and physical learning notably outpace the scores before learning. For online learning, the scores saw an uptick from 3.79 to 5.55. Conversely, for physical learning, scores climbed from 3.38 to 5.97. While the starting average score for online

teaching is marginally higher than its physical counterpart, the post-instruction average score in the physical setting surpasses online learning. Moreover, the advancement in student performance in physical learning (2.59) is more significant than online instruction (1.79). The analyses suggest that, regardless of the initial knowledge variances, all 14 items evaluated in this research showed marked improvement across both teaching modalities.

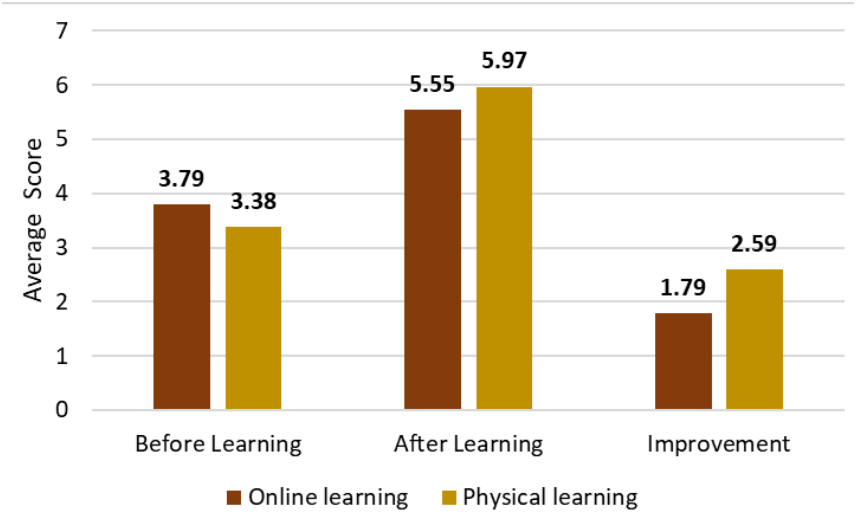

Figure 4: Mean score comparison in online and physical learning

Additionally, when considering the overall Satisfaction with the learning outcomes, learners provide feedback post-learning. As per the results from Table 8, the average satisfaction score for online learning stands at 4.86, less than the score for physical learning at 6.41. The efficacy of physical learning surpasses that of online learning. Moreover, female students are more satisfied than male students in online and traditional classroom settings.

Table 8: Overall Satisfaction with Learning Performance

Item	Gender	N	Mean	SD
Online learning	Male	15	4.67	0.82
	Female	50	4.92	0.85
	Total	65	4.86	0.84
Physical learning	Male	23	6.17	0.89
	Female	40	6.55	0.68
	Total	63	6.41	0.78
Total	Male	38	5.58	1.13
	Female	90	5.67	1.11
	Total	128	5.64	1.12

4.4 Regression Analysis

Table 9 offers a detailed breakdown of the analytical findings for online learning. It's worth noting that the variables A1 (Management Basis) and A2 (Management Operations) have p-values below 0.05, signifying their significant influence in the study's context. The derived equation for the overall Satisfaction with learning performance is represented as Satisfaction with learning performance = 0.315 * A1 + 0.201 * A2. The analysis reveals a positive association between overall satisfaction and the variables A1 (Management Basis) and A2 (Management Operations) in online learning among first-year students. However, the variable A3 (Management Tools) does not show a significant effect.

Table 9: Multiple regression analysis for online learning (n=65)

Learning improvement	Unstandardized Coefficient		Standardized Coefficient	T	Sig.	VIF	Rank
	B	SE	β				
(Constant)	1.322	.330		4.006	.000		
A1	.583	.215	.315	2.717	.009*	3.10	1
A2	.408	.154	.201	3.043	.003*	3.51	2
A3	.404	.234	.257	1.728	.089	1.64	

Note: (a) $p < 0.05$, F=6.484, Adjusted R square = .307 (b) Dependent variable: the overall Satisfaction with learning performance

The results differ when the same model is applied to analyze physical learning data. The following equation emerges: the overall Satisfaction with learning performance = 0.199 * A1 + 0.168 * A2 + 0.158 * A3. The result displays that for first-year students, there's a favorable connection between overall Satisfaction and all three variables. A1 (Management Basis) has the most substantial influence, succeeded by A2 (Management Operations) and then A3 (Control Tools) in a decreasing order. A comprehensive analysis is laid out in Table 10.

Table 10: Multiple regression analysis for physical learning(n=63)

Learning improvement	Unstandardized Coefficient		Standardized Coefficient	T	Sig.	VIF	Rank
	B	SE	β				
(Constant)	.354	.810		.437	.044		
A1	.304	.255	.199	1.191	.039*	2.72	1
A2	.290	.221	.168	.407	.045*	2.52	2
A3	.238	.189	.158	1.258	.013*	1.60	3

Note: (a)***p＜.001, *p<0.05, F=3.073, Adjusted R square = .648 (b) Dependent variable: the overall Satisfaction with learning performance

4.5 Learning Mode Effectiveness

The analysis in Table 11 revealed significant differences in improvements and overall satisfaction among different learning approaches. Physical learning outperformed online courses, with notable differences in A3 (control tools, p=0.01) and overall satisfaction (p=0.02). Further examinations emphasized the superiority of traditional classroom courses in terms of improvement and satisfaction. E-learning courses exhibited higher standard deviations, indicating a wider range of progression and satisfaction ratings in online education.

Table 11: A comparison of learning mode effectiveness

Learning improvement	Physical learning(n=63)		Online Learning(n=65)		T	p
	Mean	SD	Mean	SD		
A 1	2.81	0.83	1.89	0.84	6.69	0.56
A 2	2.22	0.92	2.14	0.95	6.69	0.58
A 3	1.91	0.86	1.39	0.88	0.43	0.01*
Overall Satisfaction	6.41	0.78	4.89	0.85	5.68	0.02*

Note: ***p＜.001, *p<0.05

5. Discussion

This research aimed to assess the efficacy of educational methods in traditional physical and online learning environments, evaluate shifts in student performance distribution within the IPA quadrant for both traditional and online courses, delve into variations in student engagement and educational impact within specific course

units, and discern gender differences in overall learning efficacy in both learning contexts. The pedagogies for online teaching were restricted to the online teaching platforms, using PowerPoint slides, online resource materials as the main source of method of instruction and online assignment, quizzes, and discussions for assessing the student performance, while physical setting included the use of the above in addition to the in-person learning and discussions, field trips and project and task-based learning.

Through our analyses, we gained deeper insights into the nuances of the management course. The item analysis facilitated a meticulous assessment of each test item, suggesting that all 14 questions adeptly distinguish among students with varying skill levels, as corroborated by the significant level of $p < 0.05$. The finding emphasizes the credibility of these questions in differentiating between participants' proficiencies.

Employing regression analysis, the study probed the relationships between the independent variables ("Management Basis," "Management Operation," and "Control Tools") and the dependent variable ("Satisfaction of Learning Performance"). The model presented an adjusted R2 value of 0.679 for physical learning, signifying that 67.9% of the behavioral intention variance is accounted for. Notably, unlike online sessions, students showcased enhanced progress in their self-assessment scores after physical learning. Furthermore, through regression analysis, it was determined that the enhancement of A1 (Management Basis) and A2 (Management Operations) has a greater impact on satisfaction in online learning compared to physical learning. This disparity could be attributed to online teachers dedicating more attention to their students, offering real-time quizzes, and providing various digital resources tailored to autonomous learning modes, all of which contribute to enhancing students' learning performance (Haleem et al., 2022; Tong et al., 2022).

In our analysis, hypotheses were categorized based on the learning mode: online or physical. Each category contained three core hypotheses. The primary hypotheses for online learning investigated the influence of Management Basis comprehension on students' overall learning satisfaction. Results revealed that both Management Basis (H1) and Management Operations (H2) considerably influence student satisfaction, whereas Control Tools (H3) had no notable impact. Conversely, for physical learning, the Management Basis (H4), Management Operations (H5), and Control Tools (H6) all positively affected student satisfaction, suggesting that the complexities of control tools are better comprehended via traditional teaching methods (Hung et al., 2009; Mrazek et al., 2019).

Table 12 and Figure 5 delineate the associations between the learning modalities (online vs. physical) and their respective hypotheses on their influence on students' learning satisfaction. The data presents a breakdown of each theory and its results, clarifying the supported and unsupported assumptions. The study offers an analytical perspective on the differential impacts of instructional modes on student satisfaction levels.

Table 12: Result of Hypotheses

Modes	Hypotheses	Results
Online Learning	H1- The degree of improvement in understanding of "Management Basis" influences students' overall Satisfaction of learning performance.	Supported
	H2- The degree of improvement in understanding "Management Operations" influences students' overall Satisfaction with learning performance.	Supported
	H3- The degree of improvement in understanding "Control Tools" influences students' overall Satisfaction with learning performance.	Not Supported
Physical Learning	H4- The degree of improvement in understanding of "Management Basis" influences students' overall Satisfaction of learning performance.	Supported
	H5- The degree of improvement in understanding "Management Operations" influences students' overall Satisfaction with learning performance.	Supported
	H6- The degree of improvement in understanding "Control Tools" influences students' overall Satisfaction with learning performance.	Supported

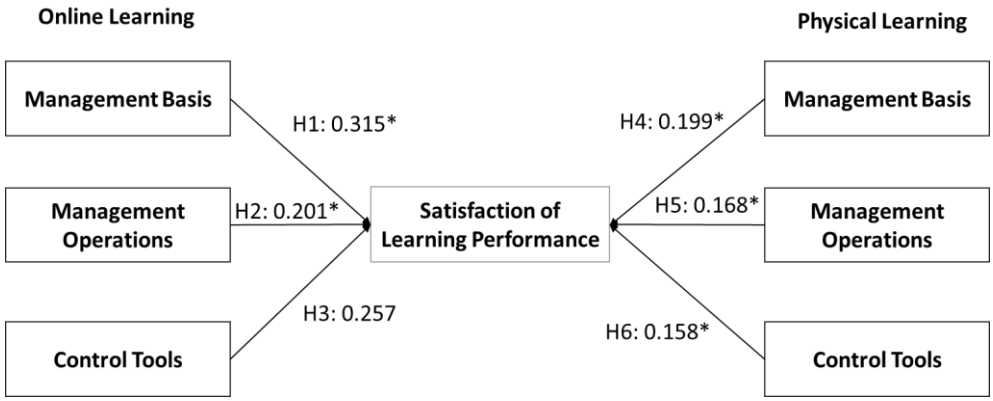

Figure 5: Result Score of Hypotheses

Management control tools and technologies often require extra explanation and physical learning implementation by instructors unlike Management Basis and Management Operations, which are based on foundational and basic theories and can be learned more easily through online methods. Online teachers often pay more attention to their students and offer real-time quizzes or various digital resources based on autonomous learning modes to enhance students' learning satisfaction. Thus, incorporation of digital teaching methods to enhance learning efficacy has the potential to increase overall learner satisfaction.

The findings of the study highlight the performance improvement post-learning effectiveness associated with physical learning as compared with online teaching. The improvement in the physical teaching, thus, correlates with the student satisfaction, including aspects such as variables used in the study, management basis, management operations, control tools utilization. Whereas, in terms of online teaching, the learning satisfaction is nuanced, where only management basis and management operations have positive correlation in the results Including online pedagogy is essential to enhance the learning efficacy due to its potential for increased student satisfaction.

The study develops from the previous research by evaluating the learning performances in both online and physical learning environments. The study has its implications for the educators and the overall educational landscape. The results of the study can be leveraged as guiding compass for educators in terms of refining their teaching methodologies, in order to create effective learning experiences and enhancing the course design. Data driven insights help educators to utilize specific areas where students might find it difficult or vice versa, enabling educators to precisely implement focused interventions and support mechanisms in time complex situations. The study, thus, not only has academic contributions but also offers a tangible framework to elevate educational practices leveraging strategic insights and personalized interventions.

6. Conclusions and Future Works

The study aimed to analyze the student performance satisfaction in both online and teaching methods of learning. The study explored the direct implications for continued student engagement in a foundational management course tailored for first-year students in Department of Business Administration. The research presents distinct findings based on educational efficacy comparison, disparities between physical and online learning and correlation with the learning satisfaction. It was observed that improvements in scores for physical learning were notably higher than for online learning. Specifically, online learning scores rose from 3.79 to 5.55, while physical learning scores jumped from 3.38 to 5.97 ($p<0.001$, $t=10.29$). There was a marked difference in Satisfaction and improvements between physical and digital learning, with physical modes faring better. Independent t-tests revealed no significant differences in the areas of "Management Basis" ($p=0.57$) and "Management Operations" ($p=0.68$). Yet, "Control Tools" ($p=0.01$) and overall Satisfaction ($p=0.02$) showed significant variances.

For physical learning, theoretical units like “Management Basis” ($p=.039$, $\beta=0.199$), “Management Operations” ($p=.045$, $\beta=0.168$), and "Control Tools” ($p=.013$, $\beta=0.158$) all positively correlated with overall learning satisfaction. For online methods, only “Management Basis” ($p=.009$, $\beta=0.315$) and “Management Operations” ($p=.003$, $\beta=0.201$) displayed positive relationships with Satisfaction, while "Control Tools" lacked a significant link. Because of the positive impact of improvements in A1 and A2 on satisfaction, online learning proves to be more effective than physical learning. This research sheds light on the intricate relationship between teaching

methods, learning outcomes, and student satisfaction. The insights gleaned can influence curriculum design and teaching approaches. By utilizing data analytics, the study foresees improvements in first-year student outcomes, aiming to refine teaching methodologies, boost student achievements, and devise a superior curriculum evaluation system to enhance the educational quality offered.

In future studies, combining student performance data from both mid-term tests and final exams can offer a comprehensive view of student progress. Analyzing the joint data can provide insights into student understanding, mastery, and challenge areas throughout their learning journey. Such insights can guide teachers in refining teaching methods and providing additional support. By evaluating both mid-term and final results, the long-term effectiveness of teaching strategies can be better understood and improved.

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A Systematic Review on the Efficacy of Flow Experience on Continuance Intention in e-Learning: The Need for Overarching Evidence Synthesis

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Abstract: The application of the concept of flow in the context of the e-learning environment has widespread benefits. Creating a sense of flow can result in a positive learner experience and continuance in the e-learning environment. However, in the past two decades, applying the flow concept in analysing continuance intention in an e-learning context has been vague and complicated due to the broad nature and learners' behaviour. This includes the lack of certainty in operationalising the flow framework, theories, multitude of methods, or delivery settings. More specifically, uncertainty persists regarding the association between flow experience and continuance in e-learning. Hence, we intend to systematically review, synthesise and appraise the literature on the operationalisation of flow experience, methods used to study the flow concept, and the relationship between flow experience and continuance intention. We reported this systematic review according to the guidance of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses). Electronic database searches on Scopus, Web of Science, JSTOR, and manual searches yielded 913 potential papers. Overall, n=20 peer-reviewed articles published between 2000 and 2021 satisfying the eligibility criteria were included. The synthesis identified that all the studies applied quantitative research design to examine the relationship between flow experience and continuance intention. While evidence also accumulated that no included studies have conceptualised flow experience considering all the nine dimensions, the lack of certainty in operationalising the flow framework applied in e-learning invites the attention of the researchers to validate the dimensions. Finally, most studies in the review exhibited a significant relationship between flow experience and continuance intention. The study provides a comprehensive synthesis and an in-depth analysis of the body of knowledge produced in the area of flow experience and continuance in the e-learning context, as it helps in providing implications for online marketers, learners, and academic institutions. The approach incorporated for synthesising evidence in this study lays a rigorous benchmark for conducting systematic reviews. This research study will be an asset for researchers and methodologists undertaking systematic reviews in e-learning.

Keywords: Flow experience, Flow theory, Continuance intention, e-Learning, Systematic review and continuance

1. Introduction

Transformation in information systems (IS) has enabled various institutions to deliver services and products effectively. Integration of IS into education facilitated better learning and contributed in overcoming traditional learning barriers such as lack of time and physical space (Panigrahi, Srivastava and Sharma, 2018). Given the consequential merits and convenience it bestows to students, instructors, and universities, e-learning has become an approachable and popular teaching alternative for most universities worldwide (Choi, Kim and Kim, 2007). Stationed in the hub of digital technology networks, educational institutions contribute decisively by disseminating knowledge that contributes to the lifelong learning of the learners (Sharma and Singh, 2023). Not astoundingly, e-learning has been experiencing tremendous growth at warp speed since its emergence in the mid-1990s (Muljana and Luo, 2019). The global e-learning market is expected to reach USD 370 billion by 2026

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at a CAGR of 8.56% from 2021 to 2026 (Reports, 2021). An enthralling number of individuals are embracing e-learning, evidenced to be a matter of fact, as e-learning is considered the primary medium for engaging students (Regmi and Jones, 2020). Also, leveraging technology in the education sector has been a fundamental goal of the government, academia, e-learning service providers, and educational institutions for better inclusivity; hence, enormous funds are being released to implement the e-learning avenues (Pushpanadham,2019).E-learning is defined as the "use of the internet to access learning materials; to interact with the content, instructor, and other learners; and to obtain support during the learning process, in order to acquire knowledge, to construct personal meaning, and to grow from the learning experience" (Muljana and Luo,2019; Regmi and Jones, 2020). Despite its advantages, such as equal access, cost-effectiveness, self-directed learning, and improved quality of education (Panigrahi, Srivastava and Sharma, 2018), literature demonstrates the high drop out among e-learners (Franque, et al.,2020). Learners are likely to drop from the learning process when the facilitator fails to enhance user experience and develop learning activities that drive completion of the committed subject. Different theories exist in the literature to analyse the adoption and continuance of behavior, and they serve as valuable lenses to draw more profound insights into phenomena (Davis, Bagozzi and Warshaw, 1989; Venkatesh, Thong and Xu, 2012). Some of the commonly used theories are the theory of planned behaviour, technology acceptance model, expectation confirmation model, and unified theory of acceptance and use of technology model, which serves as a causal link between attitude, intention and actual behaviour. Despite the wider applicability, these models disregard the intrinsic motivation viewpoint. Further, mere adoption is insufficient, considering the cost of acquiring a new learner rather than retaining the existing one (Guo, et al., 2015). Continuous use is necessary for recouping the investment in e-learning (Franque, et al.,2020).

1.1 Problem Statement

Retaining a learner in the e-learning platform has been challenging for service providers and academic institutions. Prior research works have posited that the success of e-learning majorly relies upon the learner's intention to continue with the e-learning platform (Guo, et al., 2015). Continuance intention refers to the intention of the learner to use e-learning after the initial usage (Franque, et al.,2020). Flow experience, which captures the subjective enjoyment of an individual while interacting with the technology, is the key factor in influencing outcomes, such as the learner's e-learning continuance. The flow theory proposed by Csikszentmihalyi has been widely applied in information systems-based studies mainly to assess online service users' 'optimal experience' (Akbari, et al.,2020; Khan et al.,2017). Csikszentmihalyi (1975) defines "flow" as "the state in which people are so involved in an activity that nothing else seems to matter." A state of flow is experienced when an individual participates in an activity, and it is so satisfying that the individual wants to repeat the activity continuously. Prior studies have empirically confirmed flow as the crucial antecedent of behavioral outcomes, such as technology adoption, enhanced exploratory behavior, satisfaction, effective learning, and continuous intention (Guo et al., 2015). Although seminal works have posited continuance intention and satisfaction as the positive outcome of flow. There is still no consensus that flow is the determinant of the continuance intention in e-learning (Buil, Catalán and Martínez, 2018; Cheng, 2014; Guo, et al., 2015; Hong, et al., 2019; Kim and Thapa, 2018; Rodríguez-Ardura and Meseguer-Artola, 2015; Zhang, et al.,2020). Additionally, researchers have examined the influence of the key factors on continuance, combining various theoretical underpinnings from various disciplines due to the complexity of human behavior (Lee, 2009; Zhang and Li,2019). Furthermore, studies have emphasised that flow experience lacks specific conceptualisation due to the multiple ways of operationalisation and measurement (Akbari, et al.,2020; Guo, et al.,2015; Hsu, Chang and Chen, 2012; Kim, Yoo and Yang, 2020; Wang and Lee,2020; Zhang, et al.,2020). As the demand for e-learning expands, education institutions experience elevating pressure to understand the mechanisms underlying the flow experience features of e-learning. The reason lies in the need to grab the advantage of novel education systems in providing students with the opportunity to promote e-learner continuance. As a result, lack of consensus on the relationship between flow experience and continuance intention, the further adaption of scales and theories from multiple disciplines and disparities in the conceptualisation of the flow mandated researchers to carry out a systematic literature review to provide a substantial overview of related literature.

2. Literature Overview

The prominence of flow experience on continuance intention in an e-learning settings:

Flow is a widely adopted measure by researchers to examine optimal experiences in varied scenarios (Csikszentmihalyi, 1975). It is a psychological state that results in a positive outcome. It is an intrinsically fulfilling state, described by complete submersion in a task and the feeling of everything falling into place, even in

demanding conditions (Csikszentmihalyi, 2002). Individuals experience flow when they participate in the activity for their own good, and the movement is so fulfilling that individual tend to repeat the behavior (Panigrahi et al.,2018; Wang and Lee,2020). Different levels of consciousness usually complement the state of flow in individuals, where they experience complete concentration, loss of self-consciousness, feelings of control and time distortion. The concept of flow is widely applied and empirically tested by researchers in marketing, psychology, sports, and education (Finneran and Zhang, 2003; Jackman, et al.,2020; Swann, et al., 2012). For instance, Bakker (2008) studied the effect of flow in the work setting and showed that it is positively associated with well-being, job satisfaction and enhanced productivity. Further, flow in sports is featured by deep engagement in the activities and optimal challenges, resulting in efficient physical and psychological performance (Jackson and Csikszentmihalyi, 1999). In the e-learning context, evidence suggests that learners experiencing flow likely persist in their activities and attain positive learning outcomes (Lakhal, Khechine and Mukamurera, 2021). Various researchers study flow as a unidimensional (Novak, et al., 2000) and multi-dimensional construct. Csikszentmihalyi (2002) conceptualized flow as a multifaceted construct comprising nine dimensions: a sense of control, autotelic experience, challenge-skills balance, loss of self-consciousness, immediate feedback, action awareness merging, clear goals, time distortion and concentration of the task at hand. Additionally, Bölen, Calisir and Özen (2020) in their review, pointed out that flow experience in IS settings lacks conceptual clarity due to numerous measures and applications. In the same vein, Guo, et al. (2015) emphasize that no efforts have been made to systematically examine the dimensions commonly used in measuring the overall flow experience.

Existing literature evidence reports that higher educational institutions form a promising setting to apply the flow concept as students majorly spend time in this environment, leading to boredom and disengagement (Goh and Yang, 2021; Hariguna and Akmal, 2019; Lakhal, et al., 2021). Flow encourages individuals to engage in challenging tasks that drive their curiosity, creativity, and personal growth. Prior studies in education exhibit optimal experience as the key determinant of satisfaction, learning outcome, and persistence (Bao and Huang, 2018; Khan et al., 2017). The application of the concept of flow is very apt in the context of the e-learning environment. E-learning platforms demand the learners to be self-regulated as they lack interpersonal communication compared to offline courses and warrant the learners to sort any issue independently. Lack of interaction results in feelings of isolation and loneliness, and learners tend to disengage or drop out from e-learning platforms (Al-Adwan, et al., 2021; Jung and Lee, 2018; Tri Prasetyo, et al., 2021; Yuan, et al., 2021). The efficacy of online platforms is plagued due to high attrition rates and lower continuance intention; however, massive technological development has significant potential to enhance the flow experience of the learners through various learning activities and tools. Therefore, Akbari et al. (2020) affirmed that flow theory had been applied in information technology to evaluate user behavior. Prior studies have reported the significance of flow experience as an indicator of technology acceptance, better exploratory behavior, technology use, and Continuance (Akbari, et al.,2020; Choi, et al., 2007; Guo, et al.,2015; Hsu, et al.,2012; Wang and Lee,2020). Karimi (2016) demonstrated that a greater adoption level of information systems could be achieved when systems are designed to capture the attention, arouse curiosity and enjoyment among the users. Persistence intention relies on the flow or immersion experienced during the use of technology (Panigrahi, et al.,2018). Furthermore, Kim, et al. (2020) reported flow as the critical construct to understand and enhance the online engagement of the customer. Ability to understand flow results in sustainable competitiveness and retention of the customer. The review of scholarly publications on the association between flow experience and continuance intention is beneficial for educators and course developers to develop strategies that drive the sustainability of e-learning systems. Furthermore, the review of flow dimensions contributes to a deeper understanding of flow in the realm of e-learning and aids in the advancement of standardised measurement scales. Hence, this study set out to determine the commonly used dimensions to measure flow experience (Choi, et al.,2007; Wei and Li,2021); and its influence on continuance intention among online learners (Guo, et al.,2015; Khan et al., 2017; Kim, et al., 2020; Wei and Li,2021; Zhang, et al.,2020).

The rationale of the study

The literature overview underscores that there is a steady expansion and acute need in gauging the conclusive outcome of relationship between flow experience and continuance intention paving ways to suggest measures on mitigating the attrition rate of users of e-learning. This review focusses on addressing the gap on conceptualisation of flow experience impacting on continuance intentions of e-learning users.

3. Research Methodology

The current study adopted a systematic literature review (SLR) method to identify and synthesize the relationship between flow experience and continuance intention in e-learning. Systematic review is known to be an efficacious form of research, which is associated with the scientific technique being "designed to locate, appraise and synthesize the best available evidence" in association with the research purpose, that enables to provide "informative and evidence-based" research (Regmi and Jones, 2020; Snyder, 2019; Xiao and Watson, 2017). The application of systematic review in business research has received attention in recent times. Existing literature evidence asserts that systematic review is a reliable and scientific way of conducting a literature review and serves as a foundation for future research (Dangelico and Vocalelli, 2017). The SLR for the current study is conducted by searching databases – like Scopus, Web of Science, and JSTOR. Primary search terms were e-learning, flow experience, and continuance intention using Thesaurus terms. This systematic review was conducted adhering to the guidelines of the Preferred *Reporting* Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher, et al., 2015; Shamseer, et al., 2015). A three-stage approach was employed, which comprised of the following stages: designing the review, performing the review by analyzing studies, and finally, writing the review results to provide the answer to the following questions.

RQ 1) *How does flow experience influence the continuance intention of the learner?*

RQ 1.1) *What are the outlines of current studies on flow experience and continuance intention in e-learning in terms of theoretical lenses and research approaches?*

RQ 1.2) *How the various studies conceptualized flow experience to understand the impact on continuance intention in e-learning.*

3.1 Data Collection

The study utilized peer-reviewed literature identified using three scientific databases: Scopus, Web of Science, and JSTOR. These provide an overview of the articles indexed from 20000 plus journals from a wide range of disciplines. A keyword search was performed on databases to recognize relevant articles using a number of words or phrases and Boolean operators. The final search strategy was "e-learning" **OR** "online learning" **OR** "electronic learning" **OR "**mobile learning" **OR** "MOOCs" **AND** "continuance" **OR** "continuing intention" **OR** "technology continuance" **OR** "continuance in e-learning" **AND** "Flow experience" **OR** "flow theory." The search query was similar under each concept but modified for use in other databases. The search field was restricted to title, abstract, and keywords (for detail search strategy refer the appendix table no: 3).

3.2 Inclusion and Exclusion Criteria

After recognizing keywords, the inclusion/exclusion criteria were defined to set the literature search limits compatible with the research scope. Research articles from the keyword search strategy were scrutinized based on the inclusion and exclusion criteria defined for the study using the PICOTS framework in Table no 1. The year 2000 was considered as the foundation as studies on e-learning conducted prior to 2000 are too obsolete, and the concept of flow was observed by researchers after the 2000s (Bölen, Calisir and Özen,2020).

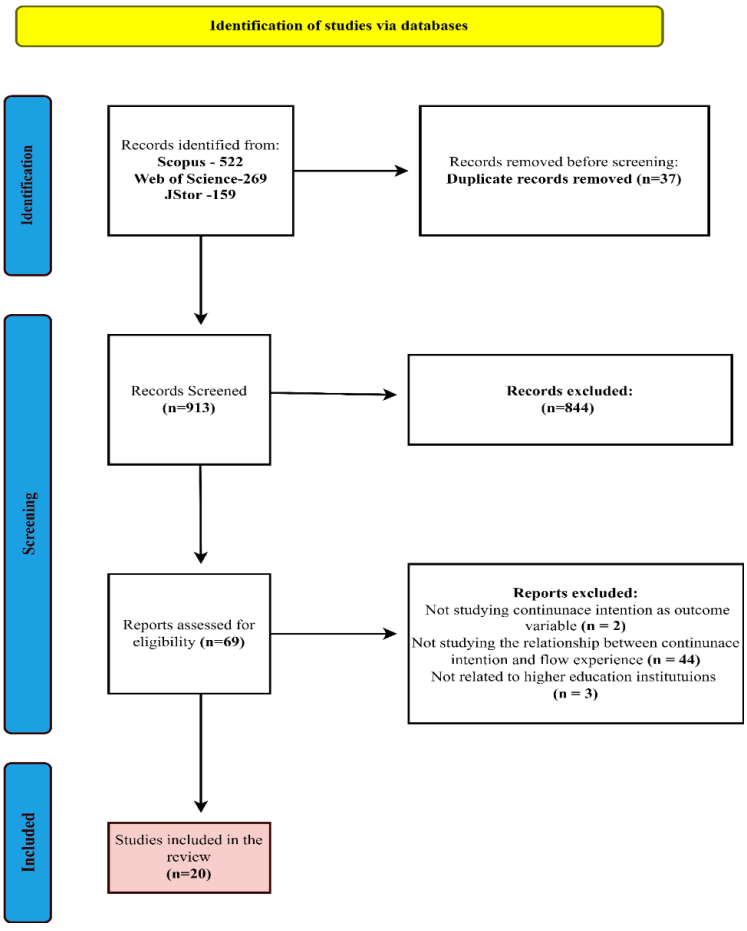
Table 1: Inclusion and Exclusion Criteria Based on PICOTS Framework

PICOTS Component	Inclusion Criteria	Exclusion Criteria
P- Population	Learners using e-learning platforms in higher education institutions. Higher education institutions include universities, colleges, professional schools in specialised fields, technical institutes and specialised institutes. E-learning included learning through virtual classrooms, online courses, hybrid learning, mobile learning, and virtual learning.	Learners using e-learning platforms in corporate organisations, school level education.
I- Intervention	Investigating the effect of flow experience	Not investigating the effect of flow experience
C-Comparator	None	

PICOTS Component	Inclusion Criteria	Exclusion Criteria
O - Outcome	Continuance intention as a dependent variable in e-learning context	Not continuance intention as an outcome variable of interest in e-learning context
T - Timeframe	Articles published between the period of 2000 to 2021 and those obtainable in full text written in English language	The articles that were not published between the period of 2000 to 2021 and those not available in full text after requesting the authors
S - Study Design	Quantitative and qualitative research studies	All the lectures, books, review articles and non-scholarly work published in the selected databases.

3.3 Search Results

The initial search strategy in all three databases resulted in 950 articles. Thirty-seven duplicates were eliminated, and articles came down to 913 articles. Further results were narrowed down with the application of the inclusion and exclusion criteria, 266 articles were not studying continuance intention as the outcome variable, 278 articles were not related to e-learning, 117 were not related to higher educational institutions, 175 were not examining the relationship between flow experience and continuance intention, 8 articles were not available even after full-text request and concluded with 69 articles for the full screening (ref figure no. 1).



Flow diagram demonstrating the search and selection process (Page et al., 2021).

Figure 1: Prisma Flow chart (version 2020)

3.4 Data Synthesis

Three authors (PR) (S) (LM) independently analyzed 69 articles, further leading to the elimination of the 49 irrelevant articles not adhering to the inclusion-exclusion guidelines. Finally, 20 articles were considered for the review, and most of them were quantitative in nature. In order to address the research questions of the study, the data of the articles considered for the review were synthesised following the coding scheme offered in the prior reviews of IS (Bandara, Miskon and Fielt, 2011). Three authors separately read the eligible articles and summarised the required elements of every article in the Microsoft Excel form that encapsulated details on "bibliographic information (title, year, author), country, research approach, sample size, theoretical underpinnings along with flow theory", flow dimensions and the relationship between flow experience and continuance intention, limitations and future scope". To achieve consistency, the authors compared their Excel sheets and discussed the differences in the weekly meetings during the coding process. The data was extracted to a single Excel file upon reaching a consensus by three authors and further verified by the fourth author as a critical reviewer. *Annexure Table 4* exhibits the detailed information of the articles finally considered for the review.

3.5 Quality Appraisal

The quality of the included study was assessed using the "QualSyst" tool proposed by Kmet, Lee and Cook, (2004). The tool comprised a set of 14 items for a quantitative study and 10 items for a qualitative study, a score between 0-2 was given for each question, with a final score determined by summing the overall score across the items and dividing them by the total possible sum (e.g., 28 for quantitative and 20 for qualitative studies) (Kmet, et al., 2004; Lee, et al., 2008; Maharaj and Harding, 2016; Regmi and Jones, 2020). All the articles considered for the review were quantitative; 75% was set as the threshold limit for considering the articles for the review based on the quality appraisal. A detailed overview of the quality appraisal of each study is provided in *Annexure Table 5*

4. Results

The following section provides the overview of the studies considered for the review as listed in *Annexure Table 4.* Overall, 20 articles were included in the review of which all the studies selected were quantitative in nature. The results section reports descriptive information about the publication period, geographical distribution, and key theoretical perspectives. Next, the study characterizes the commonly used dimensions to measure flow experience and the relationship between flow experience and continuance intention grounded on the prime focus of the selected articles.

4.1 Descriptive Findings

Publication period

Figure No: 2 exhibits the distribution of the selected articles per year for the review. As shown, the publication on flow experience studies in the e-learning context is very limited initially. The first publication was in 2009, with no publications in 2011 and 2013. Most studies were published in the year 2012, 2015,2016 and 2019. From 2020 it can be observed that the research on flow in e-learning is gaining momentum, the reason being the outbreak of the pandemic and gaining importance of online education for engaging learners.

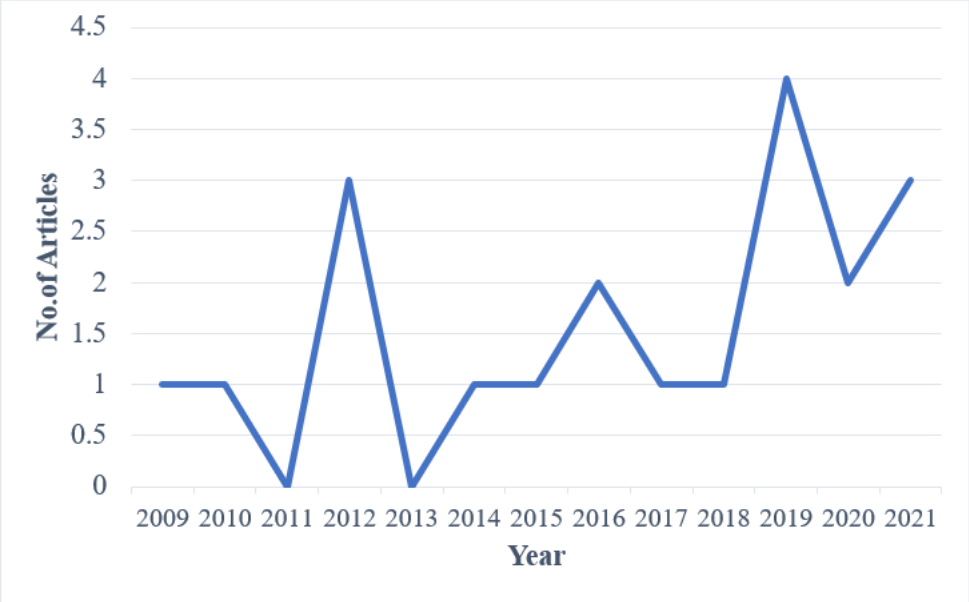


Figure 2: Publication trend of the included studies

Geographic distribution:

Figure No: 3 displays the overview of the geographical distribution of the selected studies for the review. It can be observed that most studies on flow experience in an e-learning context emerge from China (N = 7) and Taiwan (N = 7), followed by South Korea (N = 3) and then Europe (N = 2). In comparison, only one study emerged from Malaysia.

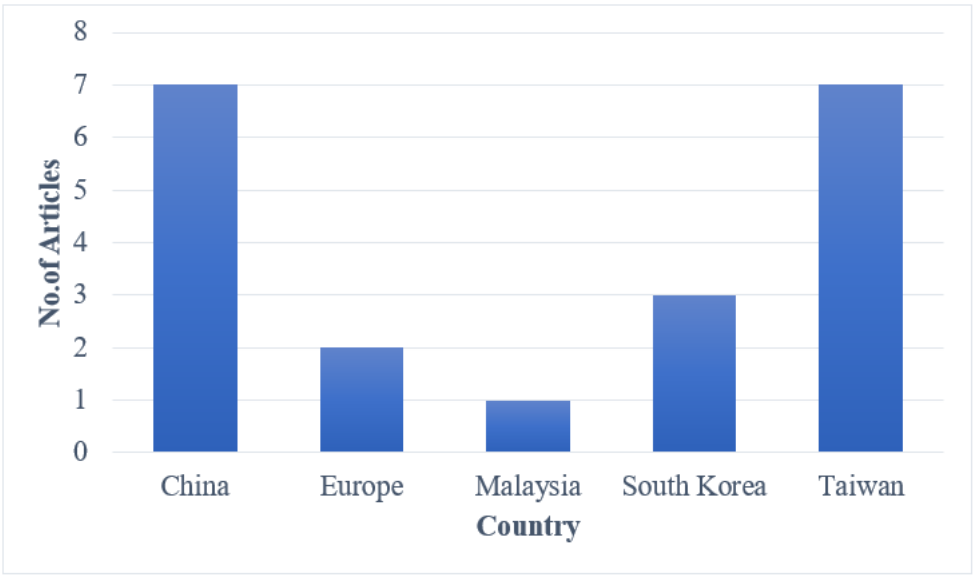


Figure 3: Geographical Distribution of the included studies.

The application of the theoretical framework assists in proposing the key theoretical and practical implications for the study. Table no: 2 shows the theoretical frameworks employed by the researchers to examine the relationship between flow experience and continuance intention in the e-learning context. Psychological, behavioral, and social sciences researchers adopt theoretical frameworks and models. The frequently used theories, with 15,7 and 5 articles each, were Flow theory, Expectation confirmation theory, and Technology Acceptance Model, respectively, in the review. Stimulus Organism and Response Framework, IS success model and Theory of Planned behavior are some more frameworks applied by the researchers. Flow theory was combined and studied with other theories by the researchers. Further, Rodríguez-Ardura and Meseguer-Artola

were the core contributors to the examine the impact of flow experience on continuance intention in the e-learning context.

Table 2: Overview of the included research articles

Sl. No	Citation	Theoretical Lenses	Flow Dimensions	Paths
1	(Lee, 2009)	Expectation–Confirmation Model (ECM), Technology Acceptance Model (TAM), Theory of Planned Behavior (TPB), and Flow Theory	Perceived Enjoyment, Concentration, and Perceived control	Concentration and perceived behavioral control exhibited a weak relationship, and Perceived Enjoyment did not influence Continuance Intention.
2	(Joo, Joung and Sim, 2010)	Flow theory.	Concentration	Significant
3	(Lee and Choi, 2012)	Flow theory.	Concentration	Insignificant
4	(Joo, Joung and Kim, 2012)	Flow theory.	Concentration and Enjoyment	Significant
5	(Chang, et al., 2012)	TAM Theory, the theory of self-determination and Motivation Theory	Perceived playfulness (concentration, curiosity, enjoyment)	Significant
6	(Cheng, 2014)	Expectation confirmation model (ECM), Flow theory, and Updated DeLone and McLean Information System (IS) Success Model	Cognitive concentration, Perceived Enjoyment, and Temporal dissociation	Significant
7	(Guo, et al., 2015)	Theory of telepresence and the Value-satisfaction-Continuance Intention (V-SAT-CI) model, Flow theory.	Concentration on the task at hand, loss of self-consciousness, sense of control, and time distortion	Significant
8	(Rodríguez-Ardura and Meseguer-Artola, 2015)	SOR (stimulus-organism-response) framework, Flow theory	Feeling of immersion	Significant
9	(Rodríguez-Ardura and Meseguer-Artola, 2016)	TAM theory, flow theory	Holistic state of immersion	Significant
10	(Rodríguez-Ardura and Meseguer-Artola, 2017)	Flow theory.	Holistic state of immersion	Significant
11	(Mohamad and Rahim, 2018)	TAM theory, Flow theory, and Social Cognitive Theory.	Enjoyment (holistic experience)	Significant
12	(Wang, Lin and Huang, 2019)	Expectation-Confirmation Theory and Flow Theory.	Enjoyment	Significant

13	(Hong, et al., 2019)	Inquiry learning model, Cognitive-Affective Theory of Learning, Theory of intelligence, Cognitive load theory, Flow theory, and Cognitive evaluation theory.	Focus of awareness, Lack of self-consciousness, Responsiveness to clear goals, Unambiguous feedback, and Sense of Control	Significant
14	(Zhao, Wang and Sun, 2019)	Flow theory, SOR paradigm	Time distortion and enjoyment	Significant
15	(Zhang and Li, 2019)	Expectation-Confirmation Model and Flow Theory.	Time distortion and Focused attention	Significant
16	(Zhang, et al., 2020)	Expectation Confirmation Model (ECM) and Flow theory.	Time distortion and Focused attention	Insignificant
17	(Cheng, 2020)	ECM, Flow theory, and HOT fit framework based on the information system success model.	Cognitive concentration, perceived control, perceived enjoyment, temporal dissociation	Significant
18	(Wang and Lin, 2021)	ECT and Flow theory	Skill challenge balance and enjoyment through immersion	Significant
19	(Goh and Yang, 2021)	Flow theory and TAM	Flow second-order reflective consists of concentration, enjoyment, telepresence, and control dimension.	Significant
20	(Wang, et al., 2021)	Technology Acceptance Model	Enjoyment, Concentration, and Control	Significant

Table no:2 presents variances in the conceptualization of flow experience. Debate persists on critical dimensions for examining the flow experience construct. Few researchers conceptualized flow experience as a unidimensional construct (Joo, et al., 2010; Lee and Choi, 2012; Mohamad and Rahim, 2018; Rodríguez-Ardura and Meseguer-Artola, 2016; Rodríguez-Ardura and Meseguer-Artola, 2017; Wang, et al., 2019) and few measured using multiple dimensions (Chang, et al., 2012; Cheng, 2014; Cheng, 2020; Goh and Yang, 2021; Guo, et al., 2015; Hong, et al., 2019; Joo, et al., 2012; Lee, 2009; Wang and Lin, 2021 and Wang, et al., 2021; Zhao, et al., 2019; Zhang and Li, 2019; Zhang, et al., 2020;). Therefore, each article considered for the review was examined to determine the commonly used dimensions to measure flow experience construct. The results of the study demonstrate that the majority of the articles considered for the review measured flow as a multifaceted construct. Interestingly it was observed that no study in the review employed all the nine dimensions proposed by (Csikszentmihalyi, 1990 and 2002). Out of 20 articles, 13 studied flow as a multi-dimensional construct, and the remaining 7 considered flow as a unidimensional construct. However, it was observed, in studies measuring flow as a unidimensional construct, each item of the construct signified one dimension of the flow.

It is quite evident that researchers have commonly adopted Concentration/feeling of immersion (Chang, et al., 2012; Cheng, 2014; Cheng, 2020; Goh and Yang, 2021; Joo, et al., 2010; Joo, et al., 2012; Lee, 2009Lee and Choi, 2012; Rodríguez-Ardura and Meseguer-Artola, 2015; 2016; 2017; Wang, et al., 2021), Perceived enjoyment (Chang, et al., 2012; Cheng, 2014; Goh and Yang, 2021; Joo, et al., 2012; Lee, 2009; Mohamad and Rahim, 2018; Wang, et al., 2019; Zhao, et al., 2019; Wang and Lin, 2021 and Wang, et al., 2021) and Time distortion (Zhang and Li, 2019 and Zhang, et al., 2020; Zhao, et al., 2019;) as key dimensions of flow. It was also noted that "focused attention" and "concentration" were often used synonymously in the literature. The operational definition of these constructs was analogous. Very few studies adopted context-specific dimensions such as the focus of awareness, unambiguous feedback, challenge skill balance, lack of self-consciousness, responsiveness to clear goals, and sense of control (Cheng, 2020; Guo, et al., 2015; Hong, et al., 2019; Lee, 2009; Wang and Lin, 2021; Wang, et al., 2021) to measure flow.

Though e-learning platforms are vulnerable to higher attrition rates and lower continuance intention, technology-mediated learning has the ability to provide learning activities to stimulate optimal flow experience

during the learning process. Understanding flow experience is vital for providing quality education and promote persistent intention to use e-learning, which solves the inherent problem of the e-learning platforms. However, prior studies examining the association between flow experience and continuance intention have failed to confirm the relationship due to the inconsistencies in the study outcome (Buil, et al., 2018; Cheng, 2014; Guo, et al., 2015; Hong, et al., 2019; Kim and Thapa, 2018; Rodríguez-Ardura and Meseguer-Artola, 2016; Zhang, et al.,2020). Therefore, the key objective of the review was to examine the existing literature evaluating the impact of the flow experience and continuance intention to use e-learning systems.

As presented in Table No: 3, out of 20 articles, 17 studies reported a significant relationship between flow experience and continuance intention to use e-learning platforms (Chang, et al., 2012; Cheng, 2014; Cheng, 2020; Hong, et al., 2019; Joo, et al., 2010; Joo, et al., 2012; Goh and Yang, 2021; Guo, et al., 2015; Mohamad and Rahim, 2018; Rodríguez-Ardura and Meseguer-Artola, 2015, 2016, 2017; Wang, et al., 2019; Wang and Lin, 2021 and Wang, et al., 2021; Zhao, et al., 2019; Zhang and Li, 2019;). Further studies by Lee and Choi (2012) and Zhang, et al. (2020) reported an insignificant relationship between flow experience and continuance intention. Lee (2009) adopted a multifaceted conceptualization of flow comprising concentration, perceived behavioral control, and perceived enjoyment. Concentration and perceived behavioral control exhibited a weak relationship with continuance intention, while perceived enjoyment insignificantly influenced continuance intention. Overall, most of the studies found a significant relationship between flow experience and continuance intention.

5. Discussion

The main purpose of the study was to systematically review, examine and synthesize the impact of flow experience on continuance intention in e-learning.

5.1 RQ 1) How Does Flow Experience Influence the Continuance Intention of the Learner?

Creating a sense of immersion or concentration can result in a positive learner experience and continuance in the e-learning environment. Furthermore, the existing studies report (Akbari, et al.,2020; Choi et al., 2007; Guo, et al.,2015; Hsu, et al.,2012; Jackman, et al.,2020; Wang and Lee,2020), in order to achieve educational goals, for productive outcomes and persistence, the learners need to get into a flow zone. Therefore, considering the number of studies and inconsistencies in the study results, the current review aimed to collectively analyze the relationship between flow experience and continuance intention to use e-learning platforms. 85% of the studies considered for the review (Cheng, 2020; Hong, et al., 2019; Goh and Yang, 2021; Wang, et al., 2019; Wang and Lin, 2021; Wang, et al., 2022; ; Zhang and Li, 2019 Zhao, et al., 2019) reported a significant relationship between flow experience and continuance intention to use e-learning platforms. Further studies by (Lee and Choi, 2012 and Zhang, et al., 2020) reported an insignificant relationship between flow experience and continuance intention. Lee (2009) adopted a multi-dimensional conceptualization of flow comprising concentration, perceived behavioral control, and perceived enjoyment. Concentration and perceived behavioral control exhibited a weak relationship, and perceived enjoyment insignificantly influenced continuance intention. Though, the majority of the studies in the review exhibited a significant relationship between flow experience and continuance intention. Most of the studies are cross-sectional and quantitative. The increase in the intensity and incidence of flow on learners can significantly impact the conative outcomes such as adoption intention, continuance intention, and usage intention in the long term, which is not captured in previously adopted research designs. Therefore, further research should avoid merely focusing on examining the associations and concentrate on understanding the long-term and short-term impact on the continuance intention employing advanced research designs. For instance, future research could assess the potential consequences of flow on the actual continuance behavior of the learner.

RQ 1.1) What are the outlines of current studies on flow experience and continuance intention in e-learning in terms of theoretical lenses and research approaches?

The review results exhibit that researchers have widely applied flow theory in e-learning settings. The first article exploring the correlation between flow experience and continuance intention was published in 2009. Since then, numerous articles substantiated the attention directed by the researchers in explaining how flow experience influences user's continuance intention. The rise in the number of publications is mainly justified due to the extension and application of technology in the education sector. Integration of education and technology has emerged to be a powerful tool that provides flexibility to an individual to enhance knowledge and skills irrespective of geographical boundaries and time frame (Agariya and Singh, 2012; Ehlers, 2009). The implementation of an e-learning system is happening at the world level due to its prominence and growing

importance in the present economy (Rahman, Rosman and Sahabudin, 2020). The availability of tools has simplified e-learning course creation, and therefore it is resulted to be popular and widely accepted ever since 2011. Students opt for such platforms for the upgradation of knowledge and skills in their subject domain. Some corporates leverage the advantage of e-learning and motivate the workforce to enroll in online courses to enhance their skills to meet their client's expectations (Liu and Pu, 2020; Ray, Bala and Dwivedi, 2019). A closer look on the reviewed studies manifested that all the studies applied quantitative research design for examining the relationship between flow experience and continuance intention; predominately survey method was adopted for the data collection. The review highlights the dearth of research employing qualitative and mixed approaches; therefore, it calls for further research adopting these research designs for an in-depth view of the concept. The majority of the review articles emerged from Asia (i.e., China, Taiwan, South Korea, and Malaysia), followed by Europe. However, no studies assessing the relationship between flow experience and continuance intention emerged from African, North American, South American, and Australian regions. Further research is required to collect data from other countries for the generalisability of the study findings.

Studies on e-learning have employed a variety of theories, such as the Expectation Confirmation Model (Bhattacherjee, 2001), Expectation Confirmation Theory (Oliver,1980), Technology Acceptance Model (Davis, et al.,1989), Unified Theory of Acceptance and Use of Technology (Venkatesh, et al.,2003;2012), Information Systems Success Model (DeLone and McLean, 1992; 2003) to mention a few. The findings of the review present that Flow Theory, ECT, and TAM are the most frequently used theories. These results are not unanticipated as behavioral theories are commonly applied by researchers to understand human behavior in information systems research (Chen, et al., 2022; Dhiman, Singh and Sarmah, 2022; Lee, 2021; Yang, et al., 2017; and Zhang and Yu, 2022). Most researchers integrated more than one theory in the context of e-learning. It can also be observed that researchers theoretically extended the scope of their conceptual framework by integrating the constructs from flow theory and other renowned behavioral theories (Cheng, 2014; Cheng, 2020; Lee, 2009; Mohamad and Rahim, 2018; Wang, et al., 2019; Wang and Lin, 2021; Zhang and Li, 2019; Zhang, et al., 2020;). Therefore, it can be understood that combining more than one theory is extensively practiced by scholars to enhance the theoretical models and provide a more comprehensive explanation of occurrences. Besides, a study by Hong, et al. (2019) combined Flow theory with multiple learning theories such as the Inquiry learning model, Cognitive-affective Theory of Learning, Theory of intelligence, Cognitive load theory, and Cognitive evaluation theory. Overall, the results of the review indicated that flow theory was commonly combined with behavioral theories for providing the overview on outcome of human behavior within the e-learning life cycle. The study by Wilkie (1994) reported that human behavior is complex and formed by the interplay of physical, emotional, and mental components. Considering this fact, researchers have employed flow theories along with the established behavioral theories to capture the emotional and cognitive attributes of human behavior.

RQ 1.2) How the various studies conceptualized flow experience to understand the impact on continuance intention in e-learning.

The systematic review revealed, to date, that there are ambiguities in conceptualizing the flow experience construct. Few researchers operationalized flow experience as a unidimensional construct (Joo et al., 2010; Lee and Choi, 2012; Mohamad and Rahim, 2018; Rodríguez-Ardura and Meseguer-Artola, 2015; 2016; 2017; ; Wang, et al., 2019) and few measured using multiple dimensions (Chang, et al., 2012; Cheng, 2014; Cheng, 2020; Goh and Yang, 2021; Guo, et al., 2015; Hong, et al., 2019; Joo, et al., 2012; Lee, 2009; Wang and Lin, 2021;Wang, et al., 2021; Zhang and Li, 2019; Zhang, et al., 2020; Zhao et al., 2019). Csikszentmihalyi (1990) and (2002) proposed a nine dimensions framework to assess the flow experience construct; however, no studies in the review conceptualized flow experience considering all the dimensions. Researchers to understand flow in e-learning have adopted Concentration, Perceived enjoyment, and Time as key dimensions based on the nine dimensions framework. Very few studies adopted context-specific dimensions such as challenge skill balance, the focus of awareness, lack of self-consciousness, responsiveness to clear goals, unambiguous feedback, and sense of control (Cheng, 2020; Guo, et al., 2015; Hong, et al., 2019; Lee, 2009; Wang and Lin, 2021 and Wang, et al., 2021) to measure flow. Considering the evidence, it can be interpreted that flow can be studied as a unidimensional and multi-dimensional construct. However, the lack of certainty in operationalizing the flow framework applied in e-learning captures the attention of the researchers to validate the dimensions. Therefore, further research is recommended to test the validity and advance the understanding in the context.

5.2 Future Directions for Research

The current study exhibited an increase in the application of flow experience in understanding the continuance intention of the e-learner. Based on the review, further directions for the research are recommended. Although

extensive research has been carried out, there's no consensus on the dimensions of flow experience (Akbari, et al., 2020; Jackman, et al.,2020; Kim, et al., 2019; Linares, Gallego and Bueno, 2021; Wei and Li, 2021). The vagaries and disagreement in the operationalization of the flow concept were highlighted in the study by (Abuhamdeh, 2020), The argument is protracted to the current review, as the findings of the review report incongruity in the flow conceptualization. Therefore, researchers should emphasize exploring key dimensions within the e-learning context in future investigations.

Moreover, the majority of the studies are quantitative in nature; therefore, meta-analysis is an effective approach to resolve the inconsistencies in the empirical findings and dimensions of the flow experience. It also opens the opportunity to further adopt qualitative and mixed approach methods to get an overview of the phenomena and propose novel theoretical implications. Furthermore, the intensity of the flow could be genuinely collected through a qualitative approach rather than an objective-based measure. Hence, the advanced research design and longitudinal study would enable the stakeholders to get the holistic overview flow mechanism.

Furthermore, lower persistence levels of e-learners implies that initial adoption does not assure continuance (Henderikx, et al., 2019; Recker, 2016). "Flow theory" was employed by the researchers to exemplify the flow's influence on the learners' continuance intention and engagement. The application of the flow directs the efforts to understand the "point at which learners make the decision to discontinue the e-learning platforms." Hence, future studies should conduct deeper investigations to study the impact of flow experience on temporary discontinuance, switching, and quitting independently.

Besides, available research showed that structural equation modeling was predominately employed as a statistical analysis approach in this context. The researcher also posits that human decision-making phenomena are complex in nature that cannot be solely and accurately analyzed using SEM (Albelbisi, 2020; Liu and Pu 2020; Panigrahi, et al. 2018; Todeschini, et al. 2020). Therefore, additional inquiry is warranted to adopt a multi-analytical approach by compounding analytical (SEM) and Artificial Intelligence techniques for accurate predictions of the cause-effect relationships. Also, the review found that ECT, ECM, IS Success model, and TAM are commonly adopted traditional theories to study the flow and continuance phenomena. However, Bhattacherjee and Barfar (2011) reasoned that the chances of misunderstandings and misapplications of theories are high when traditional theories are individually deployed. Therefore, instead of confining only to traditional theories, future studies should integrate theories from psychology, medical and other domain and explore the direct, mediating, and moderation impacts of the imported constructs for better results and insights.

5.3 Strengths and Limitations

One of the major strengths of this review was approach adopted for reviewing and evaluating the articles for examining the key dimensions of the flow experience. Further, the present study has been one of the first attempt to thoroughly examine the relationship between flow experience and continuance intention in the e-learning context through robust search strategy and comprehensive data extraction. The outcome of the systematic review offers valuable insights for policymakers, instructors and academic institutions. The review offers a clear understanding that learners' continuance intention takes place through optimal flow experience therefore, instructors need to direct more efforts in designing the courses that drive immersion among the learners, making the learning experience enjoyable. Further, course developers can consider flow experience as a means to advance their software designs to enhance the learner engagement. Overall, the review provides insights to practitioners, e-learning marketers, and course developers in creating a significant flow in terms of focused attention and perceived enjoyment. It is implied that learners use e-learning platforms sustainably when the strategic focus is directed toward enhancing the user experience with platforms. When exceptional importance is given to the learner's experience, flow experience results in an outcome such as learner satisfaction, brand loyalty, and persistence.

The review has few limitations that are worth addressing in future research. The review was restricted only to three databases (Scopus, Web of Science, and JSTOR), and no grey literature was searched; therefore, there is a possibility of missing the relevant articles. Further, the articles for the study were restricted to the e-learning applications in higher education institutions; there might be high possibilities of maturity and successful application of the e-learning platforms for organizational training and school-level learning. Hence it is worth acknowledging the need for further studies to conduct a systematic review to analyze the continuance intention of the employees and school students to get an overview of the study outcome. The articles for the review were restricted to the timeline from 2000 -2021, assuming that studies on e-learning conducted prior to 2000 are too obsolete and the concept of flow gained popularity after the 2000s.Further, the studies of the review were

restricted to the English language, and the conclusions could be vulnerable to language and publication bias, while the published articles in a foreign language have limited impact on the study reporting (Schmucker et al., 2017; Jackman et al.,2020).

6. Conclusion

The review contributes to the extant literature by providing an overview of the literature on flow experience and its association with continuance intention in the e-learning scenario. The findings of the review indicate the existence of ambiguity in the conceptualization of flow experience dimensions. In addition, results confirm that the incidence of flow on learners can have a significant impact on continuance intention in the long term; however, existing studies capture that only in the short term. Therefore, further research can validate and compare flow's long-term and short-term impact on the continuance intention employing advanced research designs. The study findings also reveal that flow theory is a promising theoretical underpinning for e-learning research. In addition, the review insights in terms of conceptualizing the constructs of flow experience dimensions revealed broader meaning, leaving scope for future researchers to narrow down the dimensions in specific to their significance level. Overall, the findings of the review facilitate the researchers to make more consequential progress in understanding the significance of the flow on continuance intention in the e-learning context. As a result, it enables the development of robust strategies by e-learning marketers, course designers, and academic institutions to increase the intensity and frequency of the flow state for e-learners, which could rectify the central problem of low persistency levels in e-learning platforms.

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Conflicts of interest

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Appendix 1: Tables 3-5

Table 3: Search Strategy

SS1	"e-learning" OR "online learning" OR "electronic-learning" OR "mobile learning" OR "electronic education "OR "virtual learning" OR "web-based learning" OR "internet-based learning" OR "technology-enhanced learning" OR "massive open online course" OR "MOOCs."
S2	"continuance" OR "continuance intention" OR "continuing intention" OR "technology continuance" OR "continuance in e-learning" OR "continuation intention"
S3	"Flow experience" OR "Flow theory."
SS4	"e-learning" OR "online learning" OR "electronic-learning" OR "mobile learning" OR "electronic education "OR "virtual learning" OR "web-based learning" OR "internet-based learning" OR "technology-enhanced learning" OR "massive open online course" OR "MOOC's" AND "Flow experience" OR "Flow theory."
SS5	"continuance" OR "continuance intention" OR "continuing intention" OR "technology continuance" OR "continuance in e-learning" OR "continuation intention" AND "Flow experience" OR "Flow theory."
Combined SS	"e-learning" OR "online learning" OR "electronic-learning" OR "mobile learning" OR "electronic education "OR "virtual learning" OR "web-based learning" OR "internet-based learning" OR "technology-enhanced learning" OR "massive open online course" OR "MOOC's" AND "continuance" OR "continuance intention" OR "continuing intention" OR "technology continuance" OR "continuance in e-learning" OR "continuation intention" AND "Flow experience" OR "Flow theory."

Table 4: Summary of the Studies Considered for the Review.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
1	(Lee, 2009)	To develop an integrated model based on the technology acceptance model (TAM), expectation–confirmation model (ECM), theory of planned behavior (TPB), and flow theory to analyze the continuance intention to use e-learning.	Taiwan	Online Learners, 363	Quantitative analysis	User satisfaction, Perceived usefulness, Perceived Enjoyment, Concentration, Confirmation, Perceived ease of use, subjective norm, Perceived behavioral control, behavioral attitude, and Continued IT Usage Intention,	Structural equation modeling.	Flow experience was operationalized in terms of perceived control, perceived enjoyment, and concentration. Concentration and PBC were the weakest antecedents of the learner's continuance intention. However, perceived enjoyment insignificantly influenced continuance intention.	Need for a longitudinal study, limitations of common method bias, examine the moderating effect of gender, Apply the proposed study model in different e-learning contexts to enhance the generalisability of the findings.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
2	(Joo, et al., 2010)	To empirically validate the relationship between Flow, internal locus of control, institutional support, and learning persistence.	South Korea	Students, 594	Quantitative	Internal locus of control, Learning flow, Institutional support, and learning persistence	Structural Equation Modelling.	The results of the correlation analysis revealed that flow experience directly influenced learning persistence. Students experiencing higher flow levels exhibited higher persistence intention. Additionally, Flow-mediated the relationship between internal locus of control, institutional support, and learning persistence.	Future studies need to consider other constructs that affect learning outcomes. Studies can utilize various other indices, such as achievement, participation, and satisfaction, as dependant variables, longitudinal study, Measure persistence in terms of actual completion and re-registration rates, and examine the moderating effect of the demographics on persistence.
3	(Joo, et al., 2012)	To empirically validate the cause-and-effect relationship between learning flow, satisfaction, self-regulated learning, and learning persistence of students	South Korea	Students, 594	Quantitative	Self-regulated learning, Learning flow, Satisfaction, and Persistence.	Structural Equation Modelling.	Learning flow exerted direct and as well indirect influence on learning persistence. Indirect influence on flow and learning continuance was intermediate by satisfaction. This implies that high persistence levels among learners are experienced when they are satisfied with the immersion levels.	Need to consider various other constructs, such as self-efficacy, locus of control, and learning objective orientation, as well as learners' extraneous factors, such as interactions among learners, the degree of community activation, and institution support. Self-reporting biases, Measure persistence in terms of actual completion and re-registration rates.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
4	(Chang, et al., 2012)	To offer an extended TAM comprising intrinsic motivation and extrinsic motivation to continue using English mobile learning system (EMLS).	Taiwan	College students, 158	Quantitative analysis	Perceived ease of use, Perceived playfulness, Perceived convenience, Perceived usefulness, and Continuance intention to use.	Structural equation modeling.	Flow experience was operationalized as perceived playfulness. It had a greater influence on the continuance intention to use EMLS.	The need for examining the model on diverse systems and respondents, conducting cross country for analyzing the comparative effects, longitudinal study, and considering other external variables to predict the continuance behavior.
5	(Lee and Choi, 2012)	The aim of the study was to investigate the structural relationships between internal ALOC, Satisfaction, learning strategies, Flow, and student retention in e-learning.	South Korea	Students, 282	Quantitative	Internal ALOC, Learning Strategies, Satisfaction, Flow Experience, and Retention	Structural Equation Modelling.	The results of the current study exhibit the direct relationship between flow experience and learner retention was insignificant; however, flow-mediated the relation between learning strategies and learners' satisfaction.	Sample limited to one online course and one country, need for a longitudinal study to measure the actual retention behavior, Examine the influence of the cultural factors on retention behavior.
6	(Cheng, 2014)	The purpose of this article is to propose a hybrid model based on the , flow theory, and updated DeLone and McLean information system (IS) success model to examine whether quality factors as the antecedents to nurse beliefs affected nurses' intention to continue using the blended electronic learning (e-learning) system.	Taiwan	Students (nurses), 378	Quantitative	Information quality, System quality, Support Service quality, Instructor quality, Perceived Usefulness, Confirmation, Satisfaction, Flow, and Continuance Intention.	Structural Equation Modelling	Flow experienced by the learners directly influenced the continuance intention to use the e-learning system. When mechanisms developed make learners completely immersed in the e-learning system, facilitate continuance intention	The sample is restricted only to Taiwan; further studies need to enrich the model by considering all the dimensions of the flow experience and the demerits of self-reported measures.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
7	(Rodríguez-Ardura and Meseguer-Artola, 2015)	The objective of the study was to develop a hybrid model of user experience in e-learning that captures its consequence in terms of re-usage intention.	China	Students, 2530	Quantitative Analysis	Perceived ease of use, Perceived usefulness, Perceived didactic resources quality, Instructor Attitude, Flow, Presence, Attitude towards use, and continuance intention.	Structural equation modeling.	The results of the study demonstrated a significant indirect effect of flow experience on continuance intention.	Other relevant indicators that predict continuance behavior need to be explored in future studies. Further investigation of the proposed model in the other educational environment to enhance the generalisability of the study findings.
8	(Rodríguez-Ardura and Meseguer-Artola, 2016)	To propose a comprehensive model that examines the influence of behavioral and affective e-learners' responses on actual continuance behavior.	Europe	Students, 2530	Quantitative analysis	Interactivity, Imagery, perceived interactivity, Spatial presence, Co presence, Flow, attitude, behavioral intention, and actual continuance.	Structural equation modeling.	The empirical findings support the significant and positive relationship between flow and continuance behavior.	Other relevant indicators that predict continuance behavior need to be explored in future studies. Further investigation of the proposed model in the other educational environment to enhance the generalisability of the study findings.
9	(Guo, et al., 2015)	To analyze the key antecedents of flow experience and examine mediating links between flow and continuance intention in the e-learning context.	China	Students, 244	quantitative- cross-sectional	Balance between challenge and skills of the task, Clear goals on task, Immediate feedback on task, Telepresence, Flow, Continuance intention, Perceived hedonic value, satisfaction, and Perceived utilitarian value.	Structural equation modeling.	The results of the study indicate flow experience as a significant indicator of continuance intention. Flow fully mediated the relationship between perceived hedonic value and continue intention; however, perceived utilitarian value partially mediated the relation between flow and continuance intention.	Restriction of the sample to undergraduate students of one university, Future studies need to re-examine the model in diverse technological contexts, conduct longitudinal studies and further explore the predictors and consequences of telepresence.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
10	(Rodríguez-Ardura and Meseguer-Artola, 2017)	To empirically validate a conceptual model on Flow's antecedents and the outcomes in e-learning; and to provide evidence on the intermediate effects of Flow in e-learning—which comprises learners' affective, performance-related, and behavioral reactions.	Europe	Students, 2530	Quantitative	Challenge, Focused attention, Control, Presence, Flow, Positive affect, Academic performance, and continuance.	Structural Equation Modelling.	The study findings confirm that flow experience prompted continuance behavior.	Further studies can study achievement, level of participation, and satisfaction as outcome variables and collect samples from the universities that offer blended and pure e-learning programmes.
11	(Mohamad and Rahim, 2018)	To explore the drivers that influence learners to continue to use MOOCs. Additionally, to empirically validate the moderating effect of Internet Self-efficacy in the context of MOOCs.	Malaysia	Students,251	Quantitative Analysis	Usefulness, Enjoyment, MOOCs continuance intention, and Internet self-efficacy.	Structural equation modeling	The flow was studied as an intrinsic motivation factor, representing the learners' subjective feelings of pleasure, joy, affirmative holistic experience, and elation. Enjoyment directly influenced continuance intention, which implies that when MOOC platforms are interesting and interactive, learners are immersed in the learning activity, and it persuades them to stay longer.	Need for further studies to explore the moderating effect of enjoyment and usefulness also measure the percentage of content viewed as the alternative to measure the continuance intention. Influence on the outcome of the study due to self-selection bias.
12	(Zhang and Li, 2019)	The study intended to understand the students' experience of VRLs and explore the potential antecedents of the continuance intention of VRLs in engineering and scientific education.	China.	Students, 238	Quantitative analysis.	Flow experience, Perceived Usefulness, Confirmation, Satisfaction, and Continuance Intention.	Structural equation modeling	Flow experience significantly influenced students' intention to continue using virtual and remote lab learning facilities. The flow experience levels were higher for females than male.	Limited sample size affects the generalisability of the study findings, usage of only quantitative study, and self-selection bias due to self-reporting measures.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
13	(Wang, et al., 2019)	The objective of the study was to adopt flow theory as a base to identify the predictors and outcome of flow experience, simultaneously to analyze the impact of flow experience on continuance intention to use English mobile applications.	Taiwan	Students, 289	Quantitative	Confirmation, Perceived Usefulness, User Satisfaction, flow experience, Perceived skill, Perceived challenge, and IS Continuance intention,	Structural Equation Modelling.	Among the all-predictors, flow experience was the core indicator of continuance intention. The findings of the study argue that when the course designers concentrate on flow experience, it strengthens the intention of continuance.	The sample is restricted to Taiwan, affecting the generalisability of the study findings, using only quantitative study and self-selection bias due to self-reporting measures.
14	(Hong et al., 2019)	To propose the "prediction-observation-quiz-explanation" (POQE) model that predicts the learners' continuance intention based on the cognitive and affective factors.	Taiwan	Students, 375	Quantitative	The incremental belief of intelligence, Intrinsic cognitive load, Green energy learning self-efficacy (GELSE), flow and continuance intention.	Structural Equation modeling.	The findings of the study reveal that flow experience was significantly correlated with the continuance intention of the learner. Flow experience was operationalized as time distortion, attention, and control. A higher level of the Flow experienced by the learners resulted in a higher intensity of continuance intention.	Most studies emphasize quantitative studies; therefore, further studies are required to conduct the qualitative study. Consider gender as moderating variable and examine the proposed model of the study in diverse domains.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
15	(Zhao, Wang and Sun, 2019)	This study aimed to explore the influence of the technological and environmental features of MOOC s systems on continuance intention by applying the stimulus–organism–response (S-O-R) framework.	China	Students, 374	Quantitative analysis	Interactivity, Media richness, Telepresence, Social presence, Flow, Continuance intention, and Sociability	Structural equation modeling.	The findings of the study support flow as the critical indicator of continuance intention. The intention to continue using MOOC platforms was higher among the learners who experienced higher flow levels. The results of the study also indicate that flow experience mediated the impact of social presence, telepresence, and intention to continue.	Further research is required to analyze the study's findings by applying them to different e-learning contexts and populations. Consider utilitarian and hedonic constructs. Conduct mixed study and adopt triangulation methodology containing self-report data, in-depth interviews, and observation.
16	(Cheng, 2020)	The objective of the study was to propose an integrated model based on the expectation confirmation model, human organization technology fit framework, and flow theory to analyze the key antecedents that influence the continuance intention of medical students to use the e-learning system.	Taiwan	medical professionals, 368	Quantitative	Confirmation, Perceived Usefulness, Satisfaction, Flow experience, Technology task fit, Organisational support, Human-human interaction, Human system interaction, and Continuance intention.	Structural Equation modeling.	The results of the study reveal that flow experience with a cloud-based e-learning system resulted in continuance intention.	Need for cross-cultural study, qualitative study, longitudinal study. Additionally, to explore the further dimensions of the flow experience, such as cognitive concentration, perceived control, perceived enjoyment, and temporal dissociation.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
17	(Zhang, et al., 2020)	The main objective of the study was to extend the expectation confirmation model incorporating flow experience to predict the Chinese student's continuance intention and satisfaction using virtual and remote labs.	China	Students, 240	Quantitative	Perceived Usefulness, Confirmation, Satisfaction, Flow (Time Distortion and Focused Attention), and Intention to continue	Structural Equation Modelling.	Flow experience was formed by time distortion and focused attention. There was no significant relationship between time distortion, focused attention (flow experience), and continuance intention. Authors assert that there are discrepancies in Flow as the direct or indirect predictor of continuance intention.	Data collection was restricted to only one university, and only two dimensions of Flow were contemplated. Need for testing the conceptual framework in another virtual context.
18	(Wang and Lin, 2021)	The study was designed to explore the factors that influence the intention of users to continue using mobile learning applications. Furthermore, the study examined the moderating impact of habit on continuance intention.	Taiwan	Users of e-learning, 229.	Quantitative	Users' Satisfaction, Perceived usefulness, Confirmation, Flow experience, Perceived skill, Perceived challenges, Habit, and Continuance Intention.	Structural Equation modeling	The findings of the study signify that continuance intention to utilize mobile learning applications was significantly influenced by flow experience. This implies that when course developers concentrate on designing applications that amplify enjoyability, it generates a positive feeling for learners to continue using the applications.	Future studies conduct longitudinal, qualitative, and compare users from diverse countries to test the generalizability of the findings of this study.

SL No.	Citation	Aim	Country	Sample Description and Sample Size	Study Design	Variables Observed	Analysis	Findings	Limitations/Future Scope
19	(Goh and Yang, 2021)	The study intended to investigate the relationship between e-learning engagement, flow experience, and continuance intention to use a learning management system through a mediated moderation interaction model.	China	Students, 92	Quantitative	Flow experience, E-learning engagement, Perceived ease of use, Perceived usefulness, E-learning engagement, and Continuance Intention	Structural equation modeling.	Flow experience was conceptualized as a second-order reflective construct comprising enjoyment, control, concentration, and telepresence as its dimensions. The results of the study exhibited that continuance intention was directly and indirectly influenced by flow experience. The moderating effect of e-learning engagement weakened the impact of flow experience on continuance intention to utilize e-learning systems.	The study was cross-sectional; the need for a qualitative study to capture cognitive, emotional, and cultural engagement; the need to conduct a study among working adults and senior learners to understand the influence of time, work-life balance, and organizational goals, learning styles, fatigue, and stress levels, collect the data from larger samples to generalize the outcome of the study. .
20	(Wang, et al., 2021)	The study aimed to analyze the relationship between perceived usefulness, integrative motivation, flow, and continuance intention of Chinese students to utilize English learning applications.	China	Students,500	Quantitative	Perceived Usefulness, Integrative Motivation, Continuance Intention, and Flow. Gender, grade, majority, using frequency and using experience (As control Variables)	Structural Equation Modelling	Flow significantly positively correlated with the continuance intention. In addition, flow experience mediated between perceived usefulness and continuance intention. The affirmative perception about the usefulness of the language learning applications promotes flow experience and continuance intention.	The study was cross-sectional, data was collected on self-reported measures, and further research can conduct an experimental study and replicate it to a diverse population for generalisability. Need to consider additional variables as mediators (perceived flexibility advantages)

Table 5: Critical Appraisal of Included Studies

Critical appraisal of included studies

[2-YES, 1-PARTIAL -1, 0 - NO, NA- NOT APPLICABLE]

Quantitative studies																	**Overall Quality score**
Checklist/ First author and year	Question/objective sufficiently described?	Study design evident and appropriate?	Method of subject/ comparison group selection or source of information/input variables described and appropriate?	Subject (and comparison group, if applicable) characteristics sufficiently described?	If the interventional and randomallocation was possible, was it described?	If interventional and blinding of investigators was possible, was it reported?	If interventional and blinding of subjects was possible, was it reported?	Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? means of assessment reported?	Sample size appropriate?	Analytic methods described/justified and appropriate?	Some estimate of variance is reported for the main results?	Controlled for confounding?	Results reported in sufficient detail?	Conclusions supported by the results?	Summary Score		
(Lee, 2009)	2	2	2	1	NA	NA	NA	2	2	2	2	2	2	2	Total sum (21)	Total possible sum (22)	Quant 0.95
(Joo et al., 2010)	2	2	2	1	NA	NA	NA	2	1 not describe 7selected samples	2	2	NA	2	2	Total sum (18)	Total possible sum (20)	Quant 0.90
(Lee and Choi, 2012)	2	1	2	2	NA	NA	NA	2	2	2	2	NA	2	2	Total sum (19)	Total possible sum (20)	Quant 0.95
(Joo et al., 2012)	2	2	1	2	NA	NA	NA	2	2	2	2	NA	2	2	Total sum (19)	Total possible sum (20)	Quant 0.95
(Chang et al., 2012)	2	2	1	2	NA	NA	NA	1	1 not describe how they selected samples	2	2	NA	2	2	Total sum (17)	Total possible sum (20)	Quant 0.85
(Cheng, 2014)	2	2	2	2	NA	NA	NA	2	1	2	2	NA	2	2	Total sum (19)	Total possible sum (20)	Quant 0.95

(Wang and Lin, 2021)	(Cheng, 2020)	(Zhang et al., 2020)	(Zhang and Li, 2019)	(Zhao, Wang and	(Chao Hong et al., 2019)	(Ting Wang et al., 2019)	(Mohamad and Irwan	(Rodríguez-Ardura and	(Rodríguez-Ardura and	(Guo et al., 2015)	(Rodríguez-Ardura and
2	2	2	2	2	2	2	2	1	2	1	2
2	2	2	2	2	1	2	1	2	1	2	1
2	1	2	2	2	2	1	1	2	1	2	2
2	2	2	2	2	2	1	1	2	2	2	2
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	1	2	2	2	2	2	2	2	2
2	2	2	2	2	1	2	2	2	2	2	1
1	2	1	1	1	2	2	2	2	2	2	2
NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2	2	2	2	2	2	1	2	2	2	2	2
2	2	2	2	1	2	1	1	2	2	2	2
Total sum (18) Total possible sum (20)	Total sum (19) Total possible sum (20)	Total sum (19) Total possible sum (20)	Total sum (18) Total possible sum (20)	Total sum (18) Total possible sum (20)	Total sum (18) Total possible sum (20)	Total sum (16) Total possible sum (20)	Total sum (16) Total possible sum (20)	Total sum (19) Total possible sum (20)	Total sum (18) Total possible sum (20)	Total sum (19) Total possible sum (20)	Total sum (18) Total possible sum (20)
Quant 0.90	Quant 0.95	Quant 0.95	Quant 0.90	Quant 0.90	Quant 0.90	Quant 0.80	Quant 0.80	Quant 0.95	Quant 0.90	Quant 0.95	Quant 0.90

(Thye Goh and Yang,	2	1	2	2	NA	NA	NA	2	1	2	1	NA	2	1	Total sum (16) Total possible sum (20)	Quant 0.80
(Wang et al., 2021)	2	2	2	2	NA	NA	NA	2	1	2	1	NA	2	2	Total sum (18) Total possible sum (20)	Quant 0.90
Quality interpretation	For quantitative articles: strong (summary score of >0.80), good (summary score of 0.71-0.79), adequate (summary score of 0.50-0.70), and limited (summary score of <0.50), and For qualitative articles: a score of ≥0.55 as an 'adequate quality article. A score of ≤0.54 was deemed as a 'low-quality article.															

Source: (Kmet et al., 2004; Lee et al., 2008; Maharaj and Harding, 2016; Regmi and Jones, 2020)

Enhancing Learning Engagement in the Flipped Classroom using a Video-Annotation Tool

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Abstract: In the realm of academia, there has been a burgeoning interest in examining student engagement within the context of the flipped classroom approach, particularly at the higher education level. Nevertheless, research pertaining to a pivotal facet of this pedagogical methodology—namely, student engagement during the individualized, at-home preparatory phase—remains limited. Within this void, the primary objective of this study is to delve into the prospective benefits offered by a video annotation tool in augmenting students' level of engagement during this autonomous study phase. Throughout the course of this investigation, a bespoke questionnaire was crafted, grounded in a multifaceted framework for evaluating student engagement, with a specific emphasis on dissecting four distinct dimensions: behavioral, emotional, agentive, and cognitive. This questionnaire is geared towards gauging student engagement within the domain of the Flipped Classroom model that relies on video-based instructional content—a facet heretofore poorly explored within the scholarly literature. Both quantitative and qualitative data were collected by administering the aforementioned questionnaire to a cohort of 68 undergraduate engineering students at Politecnico di Milano (Italy), all within the authentic context of a case study. The outcomes stemming from this empirical inquiry showcase a noteworthy enhancement in student engagement, with particular prominence accorded to the realms of emotional and agentive engagement. Moreover, this study establishes that the interactivity and proactive involvement necessitated by the video annotation tool do not obstruct students' behavioral and cognitive engagement levels. In summation, this research endeavors to illuminate the potentiality of bridging a pivotal juncture in the Flipped Classroom paradigm, specifically the phase characterized by independent at-home study. This bridge is facilitated by the utilization of a video annotation tool designed to heighten student engagement. This transformative approach effectively transmutes the traditionally passive at-home study phase of the Flipped Classroom into an active experience, thereby enhancing the overall efficacy of this pedagogical approach.

Keywords: Flipped classroom, Learning engagement, Student engagement, Video annotation tool, Video-based learning

1. Introduction

The adoption of the Flipped Classroom (FC) approach in higher education has gained momentum as a response to the need for student-centered learning environments (Lai et al., 2021). This approach reverses the traditional teaching sequence, requiring students to independently engage with course content at home, allowing in-class time for activities based on this content. The effectiveness of the in-person session relies heavily on the preparatory phase, where students access materials provided by the teacher. This "at-home" study phase is a crucial component of the Flipped Classroom approach, enabling active and personalized learning and promoting self-regulation skills for class participation, as demonstrated by (Yilmaz and Baydas, 2017). Among the challenges highlighted in the literature, some pertain to the phase of independent study. It is noted not only that students should be generally prepared for the approach (Al-Zahrani, 2015), but also that their motivation to watch pre-recorded video lectures or study course materials outside of class should be stimulated (Zainuddin, 2017). This can be facilitated by providing guidelines on how to prepare for the in-person session (Wanner and Palmer, 2015). Moreover, students do not have the opportunity to ask for help, nor can instructors intervene, as they are unable to monitor the students' progress. Active student engagement during the preparatory phase is thus crucial for the success of the Flipped Classroom (Rahman et al., 2015). The review by (Akçayır and Akçayır, 2018) found that the majority of the challenges of the Flipped Classroom are related to out-of-class activities, with inadequate student preparation prior to class being frequently reported.

Suggestions to improve this phase include providing students with clear instructions on their tasks, equipping them with diverse materials, encouraging note-taking, implementing gamification and using interactive tools (Baig and Yadegaridehkordi, 2023; Divjak et al., 2022). One possible solution is the use of Video Annotation Systems, which foster active learning and have the 'potential to shift the passive experience of watching an instructional video to a more active one' (Mirriahi et al., 2021).

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This study examines how a Video Annotation Tool (VAT) affects student engagement during the home phase of the Flipped Classroom. The tool enables students to express their understanding, ask questions, and share reactions while accessing teacher-provided learning content. The hypothesis is that these tools foster increased engagement by giving students a voice even during this typically independent phase.

Therefore, the research question is: "*Can a Video/Media Annotation tool increase students' learning engagement during the home session of the Flipped Classroom?*"

To answer this question, we analyzed data from a case study conducted in a real-life setting with 378 undergraduate students from Politecnico di Milano, the largest technical university in Italy. Over the course of a semester, the students were provided with the VAT Evoli that allowed them to express not only their level of understanding or confusion about the various topics of the videos and documents their instructors shared with them, but also to ask questions, express doubts, or show interest. The contribution of this study consists in exploring how a VAT can increase engagement during the preparation phase of the FC, investigating which specific types of engagement are affected. The study is based on the hypothesis that making students active through a VAT increases overall engagement, while it remains open as to which specific types of engagement are stimulated.

2. Literature Review

This section introduces the Flipped Classroom model and learning engagement as the two key pillars of the study. It also explores the intersection between these two pillars by reviewing studies that have investigated ways to increase learning engagement during the at-home preparation phase of the Flipped Classroom.

2.1 The Flipped Classroom

In this first section of the state of the art, we present the approach of the flipped classroom, with a particular focus on its component phases. The Flipped Classroom (FC) is an educational approach that reverses the traditional teaching model, with students accessing educational materials before class and using class time for practical activities, discussions and interaction. The teacher facilitates learning, provides support, responds to questions, and fosters participation (Lage, Platt and Teglia, 2000). The FC model can be divided into two phases:

- Independent study phase. In this phase, students are responsible for reviewing the instructional materials on their own, typically accessing online resources such as videos. This phase is focused on individual learning and allows students to work at their own pace and review the materials as many times as needed to understand the concepts.
- In-class learning phase. In this phase, students come to class prepared with a basic understanding of the concepts covered in the instructional materials, and the class time is devoted to interactive activities, case studies application and discussions that reinforce the concepts.

The FC approach has the potential to offer several benefits, including promoting active learning, providing a flexible learning environment, student motivation, and student-teacher interaction (Bryson and Hand, 2007; Halasa et al., 2020; Lage, Platt and Teglia, 2000; Strelan, Osborn and Palmer, 2020). It also poses significant challenges that need to be addressed. These challenges include the need for access to digital technology, which may disadvantage some students, and the importance of self-directed learning, which may be difficult for students who lack support or struggle with time management (Etemi et al., 2024). However, the greatest challenge is the lack of engagement during the preparation phase at home, which is critical for the success of in-class activities (Costley and Lange, 2017). Recent research corroborates the existence of pedagogical challenges experienced by students within this phase. These challenges encompass the absence of explicit guidelines, the constraint on seeking clarifications or aid, and the instructor's limited capacity to oversee students' interaction with educational resources. These inquiries propose that students' self-directed learning preceding classroom sessions can tend to be excessively solitary in nature.

To address this challenge, some studies have focused on the most effective technologies to support independent student preparation, like podcasts, screencasts, annotated notes and captured videos, as well as the use of pre-readings, automated tutoring systems, study guides, and interactive videos. However, these technologies still leave students isolated and compartmentalize the preparation phase from the classroom interaction. To address these issues, it is essential to bridge the gap between these two phases, to increase student engagement and project them towards the in-class session. In the following section, we will examine how the concept of 'learning engagement' has been conceptualized in the literature. Then, in the third and final section of the state of the

art, we will move on to considerations regarding the intersection between the flipped classroom approach and this construct.

2.2 Learning Engagement

Learning engagement refers to the degree of active and meaningful participation that students exhibit in the learning process (Marks, 2000). While there is no single, universally accepted definition of learning engagement in literature, it is widely recognized that it comprises multiple dimensions and components, the number of which varies depending on the perspectives of the authors, with some studies identifying two dimensions and others identifying up to four (Symonds et al., 2021; Fredricks et al., 2004). For instance, Audas & Willms (2001) focused on only two dimensions, namely affective/emotional and cognitive engagement, examining their correlation with school dropout rates. In contrast, Fredricks, Blumenfeld and Paris (2004) introduced a third dimension, "behavioral" engagement. More recently, a fourth dimension, agency, has been added to the construct of learning engagement (Reeve and Tseng, 2011).

The four-dimensional construct, which has been validated multiple times in the literature, has been chosen as the most comprehensive for the purpose of this study (Bergdahl et al., 2020; Wang et al., 2019). The four dimensions are:

1. Behavioral engagement. It refers to the observable actions and behaviors that indicate a student's active participation in learning activities, including attending class, completing assignments, and participating in discussions. Behavioral engagement is closely linked to academic achievement, as it reflects a student's willingness to invest time and effort in their learning (Fredricks, Blumenfeld and Paris, 2004).
2. Emotional engagement. It encompasses students' interest, values, and emotions related to academic activities. Emotional engagement is critical for promoting intrinsic motivation and a sense of personal relevance and value in learning. Students who are emotionally engaged are more likely to persist in their learning and to experience a sense of fulfilment in their academic pursuits (Fredricks, Blumenfeld and Paris, 2004).
3. Cognitive engagement. It relates to the mental effort, strategies, and investment that students bring to their academic tasks. It involves a deep level of thinking and a willingness to engage in challenging and complex tasks, to seek out feedback and support, and to persist in the face of obstacles and setbacks (Fredricks, Blumenfeld and Paris, 2004).
4. Agentic engagement. This fourth dimension focuses on the constructive contribution made by students in their learning process, emphasizing their ability to personalize and proactively enrich the instructional content and learning environment. Agentic engagement involves a sense of ownership and control over one's learning, and a willingness to take initiative for one's academic success (Reeve and Tseng, 2011).

Measuring student engagement presents a challenge due to the pronounced intercorrelation among its various dimensions. Distinct evaluation scales are available for overall engagement and each individual dimension. However, specific components might be attributed to different dimensions depending on how engagement facets are operationalized across various studies. This complexity hinders the ability to draw comparisons and arrive at definitive conclusions about what promotes each type of engagement. However, evidence from various studies suggests a positive relationship between engagement and academic performance (Fredricks, Blumenfeld and Paris, 2004).

2.3 Learning Engagement in the Flipped Classroom

The FC has been widely recognized as a promising approach to enhance teacher-student interaction and potentially increase student engagement (Bergmann and Sams, 2012). However, the effectiveness of this approach in achieving these goals is a controversial topic in literature. Reviews indicate that "the search for evidence of the effectiveness of and improvements engendered by the flipped or inverted classroom approach is becoming frequent", but "knowledge contributions [...] are relatively siloed and fragmented and have yet to stabilize. Academically and socially, the research is quite scattered, and only local evidence and experiences are available. The knowledge contributions within this field of interest seem to be anecdotal rather than systematically researched" (Lundin et al., 2018, p. 2). Some studies seem to conclude that the FC is capable of yielding better learning outcomes and increased learner engagement compared to traditional face-to-face lectures (Elmaadaway, 2018; Kazanidis et al., 2019; Lo and Hew, 2020), while others find substantial equivalence (Subramaniam and Muniandy, 2019). Evidence regarding the effectiveness of the FC in enhancing student

engagement remains limited and sometimes conflicting (Gilboy, Heinerichs and Pazzaglia, 2015). The main reason for this is the absence of a standardized approach to flipping the classroom (Bishop and Verleger, 2013). In practice, since there is no specific methodology or checklist to follow, each teacher applies the FC in a personalized manner and there is significant variation in the way instructors implement it (DeLozier and Rhodes, 2017, p. 142). For instance, instructors may opt for a partial flip, in which only some lectures incorporate a flipped approach (Seery, 2015). Furthermore, they may include a wide range of out-of-class activities beyond lectures, such as readings, homework, and supplemental videos. In-class activities also exhibit considerable diversity, including role-play, debates, quizzes or group presentations (O'Flaherty and Phillips, 2015).

Recent studies address learning engagement in the FC in specific learning environments, such as the fully online FC (Jia et al., 2023) and the FC augmented by Artificial Intelligence (Huang, Lu, Yang, 2023). The former emphasizes the need for instructional design guidelines to make the preparation phase engaging, while the latter highlights the potential of AI-enabled personalized video recommendations to improve learning engagement.

While the effectiveness of the FC in increasing student learning engagement remains inconclusive due to methodological variety, promising findings have been reported in vertical and context-specific studies. Recent attention has been given to the critical first phase of the FC, which our study focuses on as a less explored but highly relevant aspect (Burke and Fedorek, 2017).

3. Method

In order to address our research question, which is whether a VAT can enhance learning engagement in the preparatory phase of the FC, we analyzed a case study in a real life setting in which the students of two undergraduate courses at Politecnico di Milano (Italy) used the Evoli VAT (Cassano and Di Blas, 2024) to support the preparatory phase of a FC. Data was collected through a voluntary and anonymous online questionnaire at the end of the semester, which included closed (on a Likert scale) and open-ended questions. Two voluntary semi-structured interviews were also conducted with students. The numerical data was analyzed using statistical methods, while the qualitative data was analyzed through independent coding by two researchers working on the open-ended questions and the interviews' transcripts. The study covered an entire semester, from February to May 2023.

3.1 The Video/Media Annotation tool

The Video/Media Annotation tool "Evoli", developed by our laboratory, allows instructors to share various types of learning content and gather students' questions and feedback on their level of understanding. The instructor uploads media files, segmented into chapters, and provides students with a unique access code. Students can access the tool anonymously or with their name and surname and, at the end of each chapter, they rate their comprehension and provide a justification. Students can also ask questions and express doubts (Figure 1).

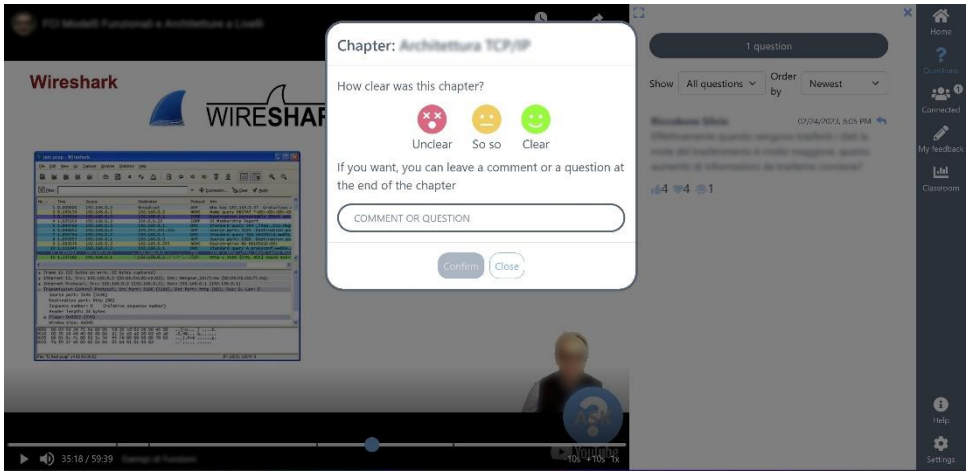

Figure 1: The student interface in Evoli. A modal window appears at the end of each chapter asking the student to rate her level of understanding

Evoli also allows students to see their classmates' questions/comments and shows an overview of their collective level of understanding, promoting a sense of community (Figure 2).

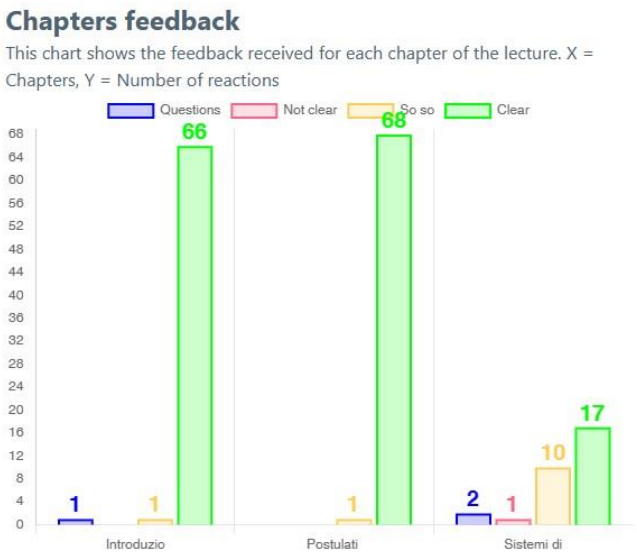

Figure 2: Students can check the understanding of a chapter by their classmates (columns 2, 3 and 4) as well as how many questions they have asked (column 1 - they can also see the questions, in a parallel section)

3.2 Participants and Settings

Two professors and their engineering students at Politecnico di Milano participated in the study. The courses' instructional design involved traditional lectures complemented with various FC sessions. Students prepared before class, and in-class time was used for deeper exploration, practical application, and guided discussion.

The first course was "Fundamentals of Communications and Internet," for undergraduate students in computer science engineering and telecommunications, with 228 students. Four FC sessions were conducted using Evoli. Table 1 presents the various learning units along with their durations and number of chapters.

Table 1: Learning units for "Fundamentals of Communication and Internet" course

Learning unit	Type	Duration	Chapters
Layered architectures	Video	59:40	6
Routing (introduction and algorithms)	Video	1:14:22	2
Routing protocols SDN	Video	1:30:05	2
VPN and IPv6	Video	1:05:23	2

The second course was "Nuclear Physics," attended by students from diverse engineering disciplines. Seven FC sessions were planned, with the aid of the Evoli platform. Table 2 shows the learning units with their durations and number of chapters.

Table 2: Learning units for the "Nuclear Physics" course

Learning unit	Type	Duration	Chapters
Angular momentum theory – part 1	Video	1:35:28	7
Angular momentum theory – part 2	Video	1:21:25	6
Special relativity – part 1	Video	1:48:46	3
Special relativity – part 2	Video	1:34:26	7
Preface nuclear physics texts	Document	20 pages	4
More on the Klein-Gordon equation. Dirac equation	Video	2:01:51	9
Introduction to meson physics	Video	1:12:28	6

3.3 Data collection

At the end of the semester, a questionnaire was administered, requiring participants to provide numerical evaluations indicating their level of agreement with specific statements. In addition, a series of seven open-ended questions was included to capture a more nuanced understanding of the participants' opinions. Furthermore, two semi-structured interviews were conducted, involving one female and one male student. The two courses involved in the study had a total of 378 students, of which 68 (18% approximately) responded to the quantitative part of the questionnaire, and 47 (12% of the total number) also provided answers to the open-ended questions. On the ethical front, it should be noted that the participants took part in the study on a voluntary and completely anonymous basis, without sharing any personal data. The design of our questionnaire was rooted in the questionnaire developed by Subramaniam & Muniandy (2019) for gauging learning engagement. However, some adaptation was necessary as the original questionnaire evaluated the FC approach as a whole, while our study focused specifically on the first phase – the independent study at home. In its turn, the Subramaniam & Muniandy (2019) questionnaire was developed from two earlier instruments, which did not specifically address the FC approach but were concerned with learning engagement in general (Marks, 2000). The Subramaniam & Muniandy (2019) questionnaire includes the concept of students' agency as a fourth dimension of engagement, introduced by Reeve & Tseng (2011).

The questionnaire comprised 11 paired questions designed to elicit participants' assessments of their perceived engagement within two distinct contexts. These contexts were defined as follows: the first context mirrored a 'traditional' educational setting, devoid of technological aids, a setting previously experienced by the students as a result of the university's widespread adoption of the FC methodology across multiple courses. The second context encapsulated the students' experiences during the semester in which Evoli, the Video Annotation tool, was employed This paired design allowed for a direct comparison between the two instructional approaches. Responses to the questions were recorded on a 5-item Likert scale, where 1 indicated "strongly disagree" and 5 "strongly agree". The first three statements were designed to assess behavioral engagement, with a focus on evaluating whether there had been an increase in attention and care for the learning content (statements B1 and B2) or an increase in commitment to the task (statement B3). The next four statements evaluate agentic engagement, aiming to understand if students take actions whenever they encounter difficulties in their studies, such as checking their peers' doubts and questions and contacting them (A1), communicating with the instructor (A2 and A3) or looking for help (A4). The following two statements address emotional engagement by assessing whether students perceive an improvement in their sense of involvement (E1) and in their preparedness for the in-class session of the FC (E2). The last two statements investigate cognitive engagement, specifically examining whether students exert greater effort during the session with Evoli (C1) and whether they can self-regulate their studying more effectively (C2). The questions, along with their scores, are listed in section 4.1.

The questionnaire also included seven open-ended questions designed to gather opinions and details that could shed light on the quantitative data. These questions were based on the themes of the 11 paired questions but approached from a different angle.

- Do you think that the use of Evoli improved your study at home?
- Do you think that the use of Evoli improved the in-class sessions within the course?
- Did you perceive Evoli as useful?
- Did the prompts by Evoli to self-assess your level of understanding help you become more aware of it?
- Was it helpful to see the understanding status and the questions by your classmates?
- In using Evoli, did you feel too much "exposed" to the teacher?
- Did you find using Evoli annoying, with respect to just watching the video / reading a document by yourself?

Finally, the semi-structured interview aimed to investigate the overall experience and the four components of learning engagement.

3.4 Data Analysis

The quantitative data was initially subjected to a descriptive analysis to visualize the mean values of the samples. Subsequently, the appropriate statistical test was applied depending on the normality of the samples. Specifically, the paired t-test was employed when both samples exhibited normal distribution, whereas the non-parametric Wilcoxon signed-rank test was utilized when the normality assumption was violated. To verify the normality assumption, the Shapiro-Wilk test was conducted. For the qualitative data, which included open-

ended responses and two interviews, a thematic analysis was performed. Two independent reviewers tagged all the open-ended responses into six categories: the four types of engagement, comments on the tool, and off-topic comments. They then compared their tagging results to align and group the responses. However, numerical treatments were not performed on these qualitative data due to the insufficient number of respondents. Open-ended responses and interviews were utilized to provide a concrete glimpse of the experiences and perceptions encountered by the students during the activity.

4. Results

To understand whether the cardinality of the sample of students who participated in the study by answering the questionnaire was adequate or not, we conducted a power analysis using G*Power software (version 3.1.9.7). A power analysis for a one-tailed paired-samples t-test indicated that the minimum sample size to yield a statistical power of at least 0.95 with an alpha of 0.05 and a medium effect size (d = 0.5) is 45. Since to perform t-tests the samples must obtain the assumption of normality, we repeated the power analysis for the Wilcoxon signed-rank test (matched pairs) reaching the same results. The students involved in the questionnaire in our case were 68, allowing us to reach a statistical power of 0.9925773.

4.1 Quantitative Data

To evaluate students' engagement, all the responses on a Likert scale from 1 to 5 of all 11 paired questions (FC in normal situation vs. FC with Evoli) of the questionnaire are considered. In particular, for each participant we calculated the mean value of the 11 questions about the engagement in the FC with Evoli and the engagement in the "Traditional FC". The groups are considered to be paired, since the same participants answered both the questions of the FC without and with Evoli. Table 3 shows the mean scores and the questions number for each learning engagement dimensions. Instead, a detail of the distribution plots and box plots can be seen in Figure 3 and Figure 4.

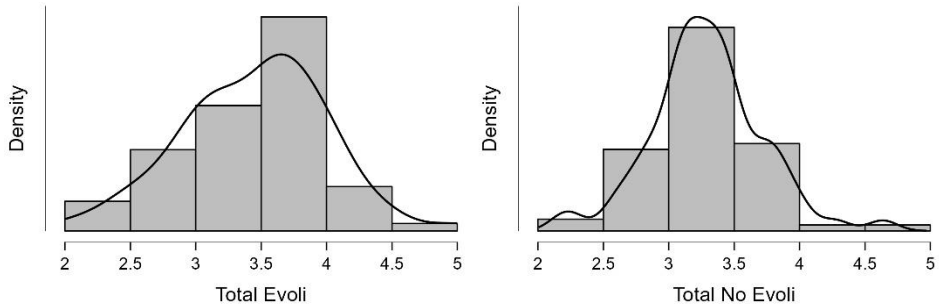

Figure 3: Distribution plots for the overall student engagement with the VAT tool (left) and without (right)

Table 3: Mean score for each dimension (and overall) considering the questions about the use of Evoli and the paired one about the traditional mode (without Evoli)

Dimension	Mean score with Evoli	Mean score without Evoli	Questions number
Behavioral	3.686	3.721	3
Agentic	3.165	2.849	4
Emotional	3.449	3.162	2
Cognitive	3.654	3.647	2
Student engagement	3.448	3.289	11

The descriptive statistics showed that the mean score was higher for the students' engagement for the FC with Evoli (M = 3.448, SD = 0.558) than the "Traditional FC" (M = 3.289, SD = 0.431). In order to generalize the result by a paired t-test, it is necessary that the two paired samples follow a normal distribution. To demonstrate this, we applied the Shapiro-Wilk test to ascertain normality.

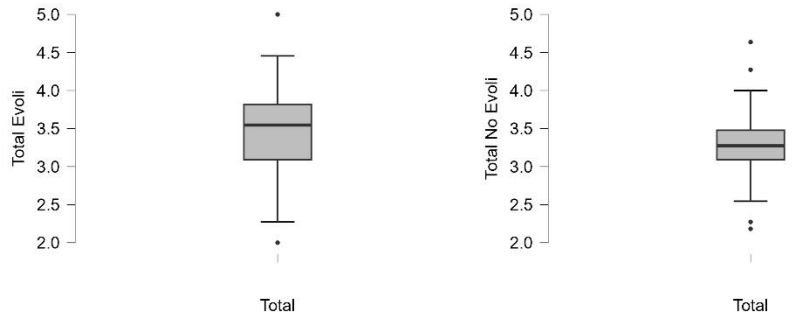

Figure 4: Box plots for the overall student engagement

First, we applied the Shapiro-Wilk test on the FC with Evoli sample with cardinality 68. The test yielded a Shapiro-Wilk statistic of 0.989 and a *p*-value of 0.828. These results indicate that the data in our sample exhibit a minor deviation from the normal distribution. The Shapiro-Wilk statistic, W, being close to 1, suggests that the data are relatively close to a normal distribution. Furthermore, the *p*-value of 0.828, which is well above the commonly used significance level of 0.05, provides strong evidence in support of the null hypothesis that the data follow a normal distribution. Based on these findings, we can conclude that the data in our sample can be considered approximately normally distributed. A similar result was reached applying the Shapiro-Wilk test on the paired "Traditional FC" sample. In this case we reach a value W = 0.981, which suggests that the data are relatively close to a normal distribution and the *p*-value = 0.378 indicates strong evidence in support of the null hypothesis. Thus, it is possible to conclude that both samples follow a normal distribution.

As the assumption of normality was met, a paired samples t-test was conducted to compare the means of the overall students' engagement FC with Evoli sample with respect to the "Traditional FC" paired sample. The null hypothesis of the paired t-test was that the means are not different, while the alternative hypothesis specifies that the mean of the students' engagement in the FC with Evoli sample is greater than the mean of the paired students' engagement in the "Traditional FC" sample. The results show a significant difference between the means of the two samples, t = 3.000 and p = 0.002. Therefore, the overall student engagement was higher in FC with Evoli with respect to the "Traditional FC".

4.1.1 Behavioral engagement

We repeated the analysis restricting only to the questions relative to the behavioral engagement. The descriptive statistics showed that the mean score was slightly higher for the behavioral engagement for the "Traditional FC" (M = 3.721, SD = 0.539) than the "FC with Evoli" (M = 3.686, SD = 0.612). Table 4 shows the related questionnaire items, while a detail of the distribution plots and box plots can be seen in Figure 5 and Figure 6.

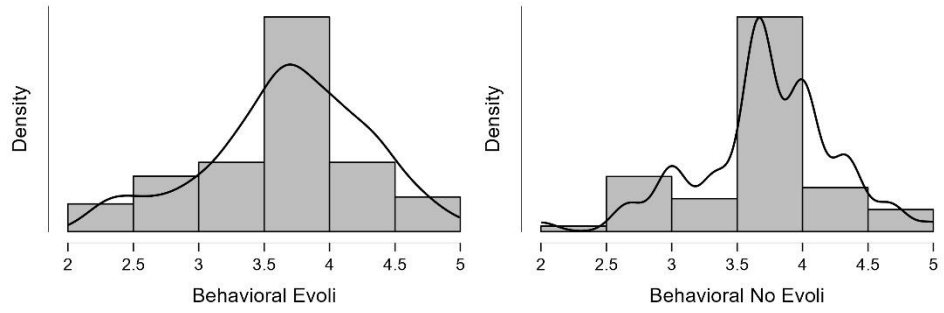

Figure 5: Distribution plots for the behavioral engagement with and without Evoli considering questions from B1 to B3

Table 4: Behavioral engagement questionnaire items with mean score and standard deviation

Item	Statement	Mean score	Std. Dev.
B1a	During the study at home of a traditional FC, I watch the video or read the documents given to me by the teacher very carefully	3.838	0.683
B1b	During the study at home of a FC with Evoli, I watch the video or read the documents given to me by the teacher very carefully	3.824	0.645

Item	Statement	Mean score	Std. Dev.
B2a	During the study at home of a traditional FC, I am able to maintain a constant level of attention	3.324	0.854
B2b	During the study at home of a FC with Evoli, I am able to maintain a constant level of attention	3.279	0.944
B3a	During the study at home of a traditional FC, If I don't understand what I read or see in a video, I go back and read or watch that part of the video all over again	4.000	0.810
B3b	During the study at home of a FC with Evoli, If I don't understand what I read or see in a video, I go back and read or watch that part of the video all over again	3.956	0.888

The normality assumption of the sample was assessed using the Shapiro-Wilk test, yielding a Shapiro-Wilk statistic (W) of 0.953 and a *p*-value of 0.013. These results suggest a moderate departure from normality and provide evidence to reject the null hypothesis of normality. Therefore, the data may not strictly follow a normal distribution. The same result is obtained for the behavioral engagement of the "Traditional FC" data points, since the Shapiro Wilk statistic (W = 0.946) suggests a moderate deviation from a normal distribution with an associated *p*-value (p = 0.005) that is significantly lower than the commonly used significance level of 0.05.

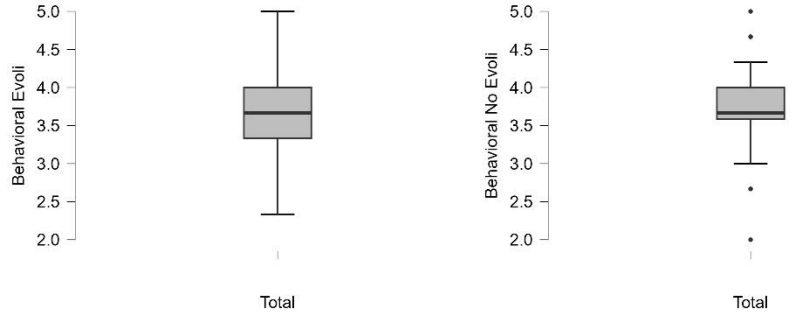

Figure 6: Box plots for the behavioral engagement items

Since the assumption of normality was not met, a paired Wilcoxon signed-rank test is used to compare the mean scores of the behavioral engagement in the FC with Evoli with respect to the paired "Traditional FC". Unlike the overall students' engagement result, the analysis revealed a non-significant difference, indeed despite a slight decrease in behavioral engagement observed with the use of Evoli, the analysis revealed a p-value of 0.556 (W = 411.500, z=0.595), which exceeds the chosen significance level of 0.05. Therefore, the results do not reach statistical significance.

4.1.2 Agentic engagement

Expanding the analysis for the agentic engagement questions (Table 5), it is possible to notice that the descriptive statistics shows that the mean score was higher for the agentic engagement for the "FC with Evoli" (M = 3.165, SD = 0.801) than the "Traditional FC" (M = 2.849, SD = 0.526), while a detail of the distribution plots and box plots can be seen in Figure 7 and Figure 8.

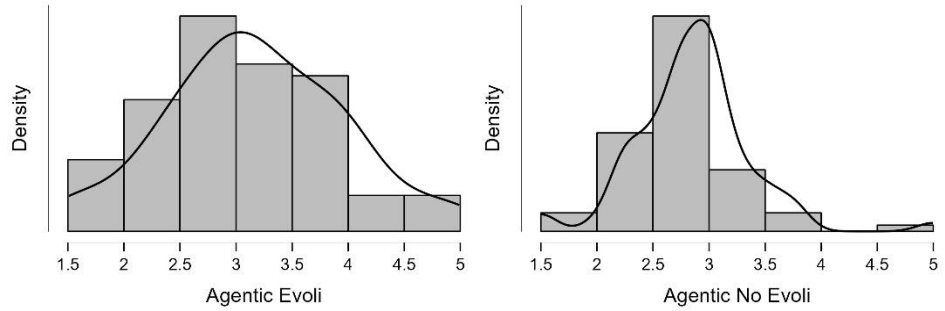

Figure 7: Distribution plots for the agentic engagement items

Table 5: Agentic engagement questionnaire items with mean score and standard deviation

Item	Statement	Mean score	Std. Dev.
A1a	During the study at home of a traditional FC, I check the doubts of my classmates (e.g. by calling them).	2.926	1.124
A1b	During the study at home of a FC with Evoli, I check the doubts of my classmates.	3.382	1.172
A2a	During the study at home of a traditional FC, If something is not clear, I let my teacher know (e.g. via email)	2.471	0.954
A2b	During the study at home of a FC with Evoli, if something is not clear I let my teacher know (e.g. by clicking on the sad emoticon or typing a question)	3.426	1.012
A3a	During the study at home of a traditional FC, I let my teacher know what I am interested in (e.g. via email)	1.912	0.859
A3b	During the study at home of a FC with Evoli, I let my teacher know what I am interested in (e.g. by typing a comment)	2.412	1.096
A4a	During the study at home of a traditional FC, If I don't understand something I look for help (e.g. asking someone or searching the Internet)	4.088	0.787
A4b	During the study at home of a FC with Evoli, If I don't understand something I look for help (e.g. typing a question)	3.441	0.937

This time, the Shapiro-Wilk test showed different results on the two different paired sample. Considering the agentic engagement in the "FC with Evoli" sample we obtained a Shapiro Wilk statistic (W = 0.981) that suggests a minor deviation from the normal distribution with an associated *p*-value (p = 0.376), significantly above the significance threshold of 0.05. Thus, there is no significant evidence to reject the normality assumption. Despite the first group followed an acceptable normal distribution, the second sample of the agentic engagement in the "Traditional FC" obtained a Shapiro-Wilk statistics (W = 0.918) that suggests a significant departure from a normal distribution. The associated *p*-value (p < 0.001) provides strong evidence to reject the null hypothesis of normality. Therefore, based on the Shapiro-Wilk test, the data cannot be considered to follow a normal distribution.

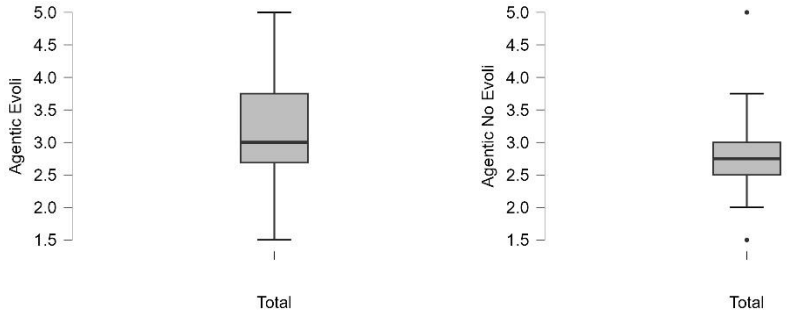

Figure 8: Box plots for the agentic engagement with and without Evoli

To compare the mean values we performed a paired Wilcoxon signed-rank test since the data didn't follow a normal distribution and so the t-test would have been invalid. The analysis revealed a significant difference (W = 1136.500, z = 3.392, p = < 0.001), providing strong evidence to support the alternative hypothesis that the mean score of the agentic engagement in the "FC with Evoli" is higher than the mean score of the agentic engagement in the "Traditional FC".

4.1.3 Emotional engagement

As for the emotional dimension, the process was similar to the agentic engagement analysis. Descriptive statistics showed higher mean scores for emotional engagement in "FC with Evoli" (M = 3.449, SD = 0.739) compared to "Traditional FC" (M = 3.162, SD = 0.720), while a detail of the distribution plots and box plots can be seen in Figure 9 and 10.

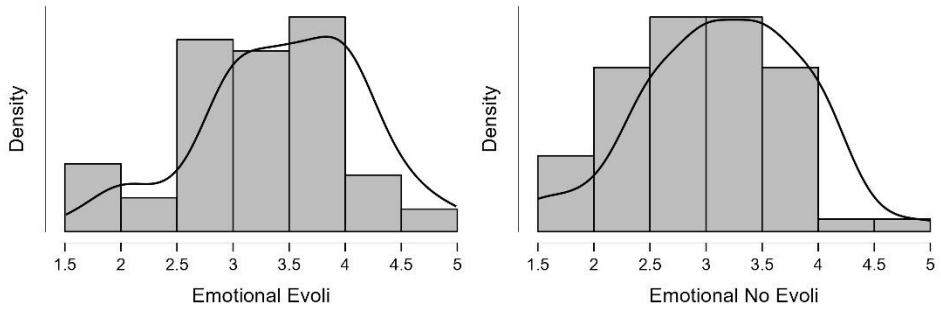

Figure 9: Distribution plots for the emotional engagement with and without Evoli considering questions E1 and E2

Table 6: Emotional engagement questionnaire items with mean score and standard deviation

Item	Statement	Mean score	Std. Dev.
E1a	During the study at home of a traditional FC, I realize that this mode makes me feel involved	2.838	0.908
E1b	During the study at home of a FC with Evoli, I realize that this mode makes me feel involved	3.353	0.842
E2a	During the study at home of a traditional FC, I feel I'm preparing well for the in-person lesson	3.485	0.801
E2b	During the study at home of a FC with Evoli, I feel I'm preparing well for the in-person lesson	3.544	0.836

The Shapiro-Wilk test showed that the samples relative to the two conditions did not follow a normal distribution. Indeed, for the sample about the emotional engagement in the "FC with Evoli" we obtain a Shapiro-Wilk statistic (W = 0.941) that suggests a significant departure from the acceptable normal distribution. The associated *p*-value (p = 0.003) provides strong evidence to reject the null hypothesis of normality. The same result was reached also for the sample relative to the emotional engagement in the "Traditional FC", in which we obtained a Shapiro-Wilk statistic W = 0.947 and a *p*-value p = 0.006. Therefore, based on the Shapiro-Wilk test we were able to compare the mean values of the two samples only with the paired Wilcoxon signed-rank test, and not with a traditional parametric paired t-test.

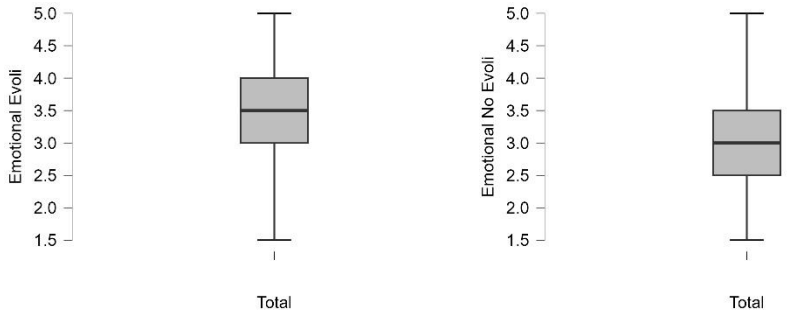

Figure 10: Box plots for the emotional engagement items

The results of the paired Wilcoxon signed-rank test indicate a significant difference between the mean scores of the two paired samples. The test yielded a signed-rank statistic (W) of 674.000 and a z-score of 3.155. Additionally, the associated *p*-value was less than 0.001, indicating strong evidence to reject the null hypothesis and conclude that the mean score of the sample about the emotional engagement in the "FC with Evoli" is significantly higher than the mean score of the emotional engagement in the "Traditional FC".

4.1.4 Cognitive engagement

For the analysis of the cognitive engagement, we considered the last two answers of the questionnaire shown in Table 7. The descriptive statistics showed a very small difference between the mean score of the cognitive engagement in the "FC with Evoli" (M = 3.654, SD = 0.744) and the mean score of the cognitive engagement in the "Traditional FC" (M = 3.647, SD = 0.697).

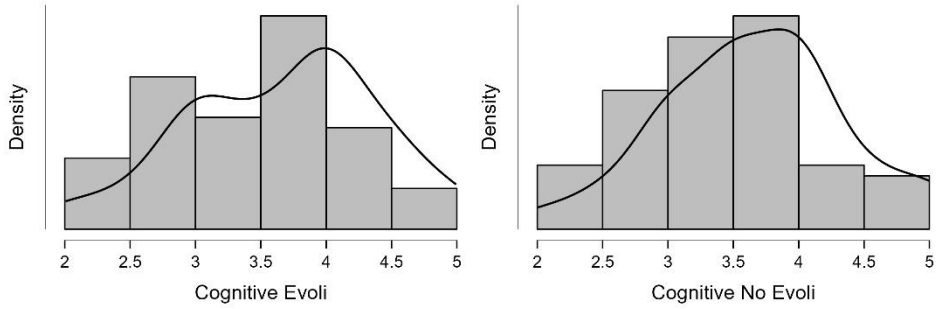

Figure 11: Distribution plots for the cognitive engagement questions

Table 7: Cognitive engagement questionnaire items with mean score and standard deviation

Item	Statement	Mean score	Std. Dev.
C1a	During the study at home of a traditional FC, I feel committed to the task of studying the material	3.618	0.811
C1b	During the study at home of a FC with Evoli, I feel committed to the task of studying the material	3.618	0.847
C2a	During the study at home of a traditional FC, I am able to self-regulate my study	3.676	0.921
C2b	During the study at home of a FC with Evoli, I am able to self-regulate my study	3.691	0.902

Again, the Shapiro-Wilk test showed that the two samples did not follow a normal distribution. For the first sample about the cognitive engagement of the "FC with Evoli," we obtained a Shapiro-Wilk test statistics (W = 0.941) and a p-value (p = 0.003) that confirmed a significant deviation from the normal distribution. The same conclusion can be confirmed for the paired sample, since we obtain a Shapiro-Wilk statistics W = 0.946 and a p-value p = 0.005.

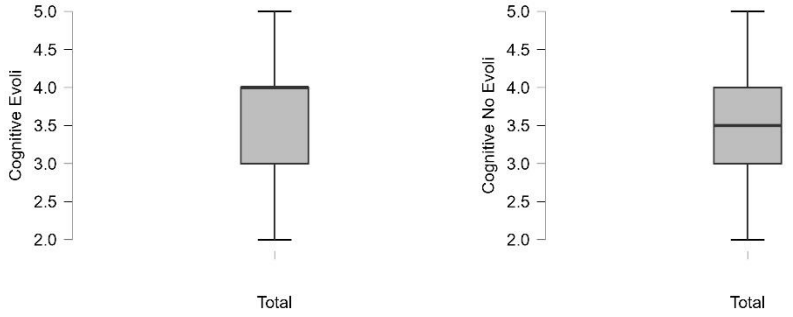

Figure 12: Box plots for the cognitive engagement items

We performed a paired Wilcoxon signed-rank test to examine the difference between the mean values of the two conditions, with Evoli and without Evoli. We chose a paired Wilcoxon signed-rank test because, again, the Shapiro-Wilk test showed that the samples of both conditions were non-normally distributed. The results of the paired Wilcoxon signed-rank test indicate that there is no significant difference between the mean scores of the two paired samples. The test yielded a signed-rank statistic (W) of 156.000 and a z-score of -0.175. Additionally, the associated p-value was 0.576, which is above the commonly used significance level of 0.05. Based on these results, there is insufficient evidence to reject the null hypothesis. Therefore, we can state that the use of Evoli does not result in significant differences in cognitive engagement.

4.2 Qualitative Data

The questionnaire contained seven open-ended questions, which received a total of 47 responses. As previously mentioned, although two independent reviewers tagged them according to six themes (the four types of engagement, comments on the tool, other off-topic comments) we did not conduct any numerical analysis on these data due to the low response rate. However, we present an overview of the students' opinions and include some quotes to provide fresh insight into the quantitative data.

According to the respondents, the behavioral engagement did not show significant improvements, as they felt that their study approach or efficiency remained largely unchanged. However, a subset of participants expressed positive views on the use of Evoli and its influence on their study at home. They valued the opportunity to provide and receive feedback and said that the interactivity provided by Evoli was superior to simply watching videos or reading documents. From the point of view of the agentic engagement, most participants identified the possibility to see their peers' comprehension status and questions as the most engaging feature. It allowed them to understand whether others had similar doubts and difficulties, providing a sense of community (that, consequently, increased the emotional engagement as well). Some participants found it particularly helpful to read other people's questions, as it prompted them to consider different perspectives. In the open questions, emotional engagement was investigated, particularly regarding the risk of students feeling exposed while using Evoli. Responses varied, with some feeling slightly exposed, while others not. Some noticed that asking questions by writing on Evoli instead of speaking up in class would benefit shy students. Concerns were raised about anonymity, with some suggesting an option for anonymous questioning. However, many participants did not feel embarrassed asking questions, emphasizing that seeking clarification is essential to the learning process. From a cognitive perspective, most participants found Evoli's self-assessment reminders to be helpful in increasing their self-awareness of their level of understanding. It is worth quoting *verbatim* the words of one respondent: "[the tool] improved the study experience. It made me aware of what I didn't really understand before the in-class lesson, so it provided me with more time to try and understand the concepts myself or ask the professor." By comparing their own responses to questions with those of their peers and expressing their level of understanding through smiley faces, students heightened their awareness of their preparedness and could better gauge their progress. Additionally, several participants acknowledged that the platform expedited explanations during in-class sessions and alleviated the sense of overwhelm during lessons, making the experience more beneficial overall.

Finally, we present some quotes extracted from the interviews on the four types of engagement. Regarding behavior, one interviewee said: "Using the tool takes away the attitude of 'I'll watch it later' because it gives you more, a sense of something that needs to be done, which motivates a student to watch the video." The two interviewed students also appreciated being invited to be more active, with one remarking: "Even simple questions like 'How well did you understand this topic?' or ''Are there any specific questions?' or seeing 'This is how much others have understood this topic,' are certainly an improvement over the passivity of just sending a YouTube link to the students and ask to watch the video." On the front of agency, one of the interviewed students noted how "with the right input from students, there was a difference, a desire to do more: even people who have no personal interest in telecommunications, for example, were curious and went to learn more about topics."

Regarding emotional impact, two quotes testify to its nature: "I also felt less alone, especially in relation to other students […] I was pleased when, half an hour before the lesson, while I was on the train, I was watching the video, and there were three other students connected. I said to myself, 'okay, I'm not alone,' so much so that we even chatted afterwards to talk about the video." Another participant said: "...I also know that many students are hesitant to ask questions in person, perhaps out of lack of self-confidence. A tool like Evoli also facilitates the exposure of one's doubts and helps the professor understand what the class has understood."

Finally, two quotes testify to the potential on the cognitive front: "The tool made me ask more questions," and "I had to gather my thoughts, ask myself if I had really understood, if I had any questions. I had to stop for a minute or two to collect my thoughts."

5. Limitations

Our study's primary limitation involves assessing the FC experience without a dedicated pedagogical tool relying on the subjective insights from participants' personal experiences, rather than a controlled experiment. However, this limitation is mitigated by the academic context of the university where the research took place, where students are accustomed to video-based FC, giving them a strong foundation in this pedagogical approach. Their extensive exposure to non-technology-assisted FC provides them with a deep understanding of the nuances within the flipped learning paradigm. Considering these factors, despite this inherent limitation, we maintain a high level of confidence in the participants' ability to thoughtfully assess their FC experiences, both with and without a supporting technological tool, based on their experiential depth acquired through prolonged engagement with the non-technology-assisted form of the FC model. Secondly, the voluntary nature of the participation may have introduced bias, as only 68 out of 378 students enrolled in the courses responded to the questionnaire. Thirdly, the study is based on a limited sample of undergraduate students in specific courses,

making the results potentially non-generalizable to other contexts or subjects. Therefore, caution is needed when interpreting the results, and further research with larger samples and in diverse contexts is necessary.

6. Conclusions

In this article, we presented a study aimed at investigating the potential of VATs to increase learning engagement in its four dimensions (behavioral, agentic, emotional, and cognitive) during the independent study phase of the FC. Our research question was: "Can a Video/Media Annotation tool increase students' learning engagement in the home session of the FC?". In a real-world setting, we conducted a case study in a real life setting and collected data through a questionnaire with both closed and open-ended questions, as well as via two interviews. The data collected seems to confirm what the literature already suggests, namely the ability of a VAT to increase engagement in the preparatory phase of the FC approach. Compared to the existing literature, it takes a step forward by specifically highlighting how the different facets of learning engagement are affected, particularly in the agentic and emotional dimensions. Regarding the agentic component, the data confirm what we expected, since a VAT, by its nature, encourages students to do more than passive consumption. The emotional component is increased by the sense of community that the tool creates, by reporting the presence and reactions of all students, and by making students feel already projected towards the interactive in-person session. A delicate emotional aspect, the embarrassment of "raising your hand" and asking questions, appears to be greatly mitigated by the mediation of a tool. Behavioral engagement does not appear to be particularly modified using the tool, although some students, in the open-ended questions, seem to suggest that the tool encourages greater commitment. It should be noted that regarding behavioral engagement, which has received attention in the literature on FC, there is no conclusive data even regarding the difference between a "normal" situation and an inverted situation (Lai et al., 2021), with some authors suggesting that there is an increase in behavioral engagement (Bond, 2020), while others do not find significant differences (Hodgson et al., 2017; Subramaniam and Muniandy, 2019). This topic certainly merits further investigation. Finally, on the cognitive front, the data support that, compared to a normal FC session, there are no appreciable differences, which is a positive element because it means that the demands placed by the tool were not annoying to the point of distracting from the content and increasing cognitive load. Overall, the study demonstrates that the use of a VAT can improve engagement in the FC, not affecting the cognitive load.

The findings of this study have practical implications for educators and designers of educational technology. Teachers are recommended to include VATs that allow for the collection of students' opinions during the preparatory phase of the FC, as this can increase engagement. Designers of educational technology should investigate which characteristics of a tool for collecting student reactions could enhance the behavioral and cognitive components of learning engagement.

Ethics statement

All participants involved were informed about the nature, purpose, and potential outcomes of the study. Data were collected in anonymous form and no personally identifiable information was collected or stored.

AI statement

During the preparation of this work the authors used ChatGPT in order to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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The Influence of Artificial Intelligence Tools on Student Performance in e-Learning Environments: Case Study

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Abstract: This study investigated the impact of AI-powered personalized learning tools on the academic performance and perceptions of pre-service student teachers enrolled in the Educational Technology course, a compulsory component of the Professional Postgraduate Diploma in Teaching program at Ajman University. A quasi-experimental design was employed with 55 students in the experimental group and 55 in the control group. The experimental group utilized AI-powered tools within the Moodle platform, while the control group received traditional instruction. Pre- and post-tests, along with a rubric-based assessment and a questionnaire, were administered to assess performance, knowledge retention, critical thinking, motivation, and engagement. Statistical analysis revealed significant differences between the groups, favoring the experimental group in terms of academic performance and knowledge retention. Additionally, students in the experimental group demonstrated higher levels of critical thinking, motivation, and engagement. These findings underscore the transformative potential of AI-powered personalized learning tools in teacher education. By integrating AI into educational practices, institutions can revolutionize e-learning by providing personalized instruction, intelligent tutoring, automated grading, and adaptive learning experiences. This can enhance student engagement, improve learning outcomes, and reduce the workload of educators. Ultimately, AI empowers institutions to create more effective and inclusive learning environments that cater to the diverse needs of students and prepare them for the future.

Keywords: Academic performance, Artificial intelligence, Educational environment, Pre-service teachers

1. Introduction

We are living in an era where everything keeps on changing and developing, and so do approaches and innovative techniques in teaching and learning. It is, therefore, imperative for these institutions, academicians, and researchers to keep tracking change once in a while (Alemán et al., 2019; Bahja, Kuhail and Hammad, 2022; Salama and Hinton, 2023). Pre-service teacher training institutes also make all their level best to keep an update on the latest practices and equip potential educators with skills to adapt to evolving information technology. And, over the past few years, artificial intelligence (AI) is fast emerging as one of the most crucial enablers in this pursuit (Pedró et al., 2019; De la Higuera, 2019; Alam, 2021; Eggert, 2021; George and Wooden, 2023). This marks the pursuit of leading-edge educational methods in the ongoing education revolution, representing only a very tiny part of the very big range that AI-driven tools offer teachers and trainers. These tools could be very handy in the reformation of old-aged pedagogical practices and may provide the students with a dynamic, immersive, and customized learning experience (De la Higuera, 2019; Gupta and Bhatia, 2019).

In this regard, AI can be taken as a very important determinant in the successes of the education revolution to the current generations of learners and teachers. Teachers can provide personally designed learning experiences with the aid of available tools to adjust instructions and learning material according to the needs and preferences of every student (Bhapkar and Ranjane, 2013; Kadaruddin, 2023; Christopoulos et al., 2020; Qushem et al., 2021; Gupta and Bhatia, 2019). For example, AI may eventually empower adaptive learning platforms to produce insights based on performance data and, in this way, suggest ways in which learners could be assisted to improve or get back on track (Pedró et al., 2019). In the same manner, chatbots and virtual assistants operating with the intelligence of AI can keep the students on the right track by answering queries and helping to navigate the content (De la Higuera, 2019; Adair, 2023; Chen, Chen and Lin, 2020). Additionally, through AI, the data will have to be sifted by the use of the AI algorithms for patterns and trends that will help educators take data-driven decisions on strategies of imparting knowledge and also on the development of data-driven curricula (Gupta and Bhatia, 2019; Adair, 2023).

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Given that we are at a crossroads from where technology and intelligence in education need to be connected, it is important that we reflect more emphatically on the influence of intelligence (Pedró et al., 2019; De la Higuera, 2019). The important fact is the understanding of the actual impacts and consequences on the achievements, state of readiness, and aspirations of educators to become an influence and significant role in shaping the world of contemporary education (Pedró et al., 2019; De la Higuera, 2019; Adair, 2023; Chen, Chen and Lin, 2020). In addition, the incorporation of intelligence technologies, in settings signifies a significant change, in teaching methods (Gupta and Bhatia, 2019; Adair, 2023; Chen, Chen and Lin, 2020). Examining how AI impacts education allows researchers and educators to understand its potential to boost student participation thinking abilities and academic achievements (Pedró et al., 2019; De la Higuera, 2019; Chen, Chen and Lin, 2020).

Therefore, it is necessary to conduct empirical research that explores the impact of integrating AI into teaching practices to inform evidence-based practices and policy decisions in education (Pedró et al., 2019; De la Higuera, 2019; Adair, 2023).

1.1 What is AI

Artificial Intelligence (AI) is a term that refers to the process of simulating human intelligence in computers, so that they can think and behave like human beings. The ultimate objective of AI is to manufacture machines that perform jobs typically done by intelligent people such as visual perception, speech recognition, making decisions, learning and translation (Fetzer, 1990). AI systems are designed to analyze and interpret data, learn from patterns, and make decisions based on that learning.

Fetzer (1990) define AI as "*the study of how to make machines behave intelligently, to solve problems and achieve goals in the kinds of complex situations in which humans require intelligence to achieve goals*."

John McCarthy one of the pioneers of AI, define it as "*It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.*" (McCarthy, 2007).

In its most basic essence, artificial intelligence is a discipline that merges computer science with comprehensive datasets to facilitate problem-solving. Additionally, it includes sub-domains such as machine learning and deep learning, often mentioned in tandem with artificial intelligence. These areas involve AI algorithms that aim to develop expert systems capable of making predictions or classifications by analyzing input data (Ertel, 2018).

1.2 AI in Education

Artificial Intelligence (AI) is increasingly making significant contributions to the field of education, transforming the way students learn, educators teach, and educational institutions operate (Loeckx, 2016; Seldon and Abidoye, 2018; Zhai et al., 2021; Zhang and Aslan, 2021). Loeckx (2016) mentioned that AI can serve as a valuable educational tool, alleviating the responsibilities of both teachers and students while fostering effective learning experiences. In addition to ongoing educational reforms like the digitization of educational resources, gamification, and personalized learning, there exist numerous prospects for the development of AI applications in education. One notable example is the systematic utilization of AI techniques to model interactive and adaptive educational programs, creating individualized learning environments. This compensatory approach addresses the scarcity of teachers through the implementation of Intelligent Tutoring Systems (ITS) (du Boulay, 2016).

ITS offers personalized learning experiences through four main avenues: monitoring student input, presenting appropriate assignments, providing effective feedback, and facilitating interfaces for human-computer communication (Seldon and Abidoye, 2018). The proliferation of ITS across various subjects suggests an evolving role for teachers, prompting a potential reconceptualization of education. Nevertheless, swift technological advancements inherently introduce numerous risks and challenges. For example, there are concerns among teachers about whether artificial intelligence poses a threat to their profession. Some researchers ponder whether the advancement of artificial intelligence might challenge or even replace teachers, akin to the way many jobs are being automated (Lacity and Willcocks, 2017). It is increasingly recognized that as AI continues to progress, teachers' professional roles will necessitate modification, leading to the emergence of new organizational structures.

Emerging challenges also encompass student attitudes toward these changes (Flogie and Aberšek, 2015). While students, as digital natives, can leverage AI to enhance learning outcomes, there exists the possibility that they

may struggle to employ AI techniques appropriately within a specific educational context, potentially resulting in negative attitudes toward learning (Ijaz, Bogdanovych and Trescaket, 2017).

In the realm of e-learning, AI has demonstrated remarkable potential to significantly improve both teaching and learning outcomes by offering personalized learning experiences, adaptive feedback, and streamlined data analysis. AI-powered systems, including intelligent tutoring and adaptive learning platforms, can process large amounts of student data in real-time, allowing educators to customize content according to each learner's unique needs, preferences, and progress (Luckin et al., 2016; Zawacki-Richter et al., 2019). These tools not only enhance personalization but also create dynamic and interactive educational environments, which foster greater student engagement and motivation (Baker, smith and Anissa, 2019). For instance, AI algorithms can detect gaps in a learner's knowledge and dynamically adjust the complexity of tasks, providing personalized feedback and targeted recommendations for improvement (Luckin et al., 2019). By offering such adaptive feedback, AI systems help learners develop critical thinking skills and encourage deeper learning (Chen, Chen and Lin, 2020).

Furthermore, AI enhances the efficiency of data analysis by continuously collecting and interpreting student performance data. This real-time monitoring allows educators to track learners' progress closely and intervene when necessary (Kulik and Fletcher, 2016). With these capabilities, teachers can manage larger class sizes more effectively and make data-driven decisions that refine instruction. By tailoring content to meet individual student needs, AI also promotes educational equity, ensuring that learners of different abilities and backgrounds receive the support they need (Woolf, 2018).

AI tools in e-learning environments not only improve individual learning outcomes but also equip educators with actionable insights to optimize teaching strategies. These technologies play a pivotal role in fostering flexible, personalized, and more effective learning experiences in both digital and blended learning settings.

This study seeks to investigate the impact of AI on pre-service teachers' academic performance and perspectives in an e-learning context. By focusing on AI-driven tools within the Educational Technology course.

This research explores how AI affects both measurable performance outcomes and the perceptions of future educators. In doing so, the study contributes to the growing body of knowledge on AI's influence in reshaping education and preparing teachers for the evolving demands of modern classrooms.

1.3 Previous Studies

A study conducted by Kuleto et al. (2021) explores the opportunities and challenges of implementing artificial intelligence (AI) and machine learning (ML) in higher education institutions (HEIs). It highlights how AI and ML can be used to enhance teaching and learning, such as through adaptive learning technology, AI-powered chatbots, and automating certain tasks to free up teacher time. The study also provides an overview of AI and ML, including the differences between supervised and unsupervised learning. The research methodology and results are also presented, including the use of partial least squares structural equation modeling (PLS-SEM) to analyze data from 103 students in Serbia. Its results point out that AI and ML have the potential to improve learning through the development of student skills, collaborative learning environments, and accessible research environments.

In their study, Ocaña-Fernández, Valenzuela-Fernández and Garro-Aburto (2019) extrapolate the effects of the new technologies associated with artificial intelligence (AI) in higher education. The researchers have conducted a literature review to explore the impact of AI on educational practices, the challenges and ethical considerations associated with its implementation, and the necessary digital competencies that universities should develop to prepare students for a technologically advanced future. The article synthesizes various sources, including academic papers, books, and reports, to provide an overview of the current state of AI in education and to discuss the potential of AI to transform educational experiences through personalized learning and intelligent tutoring systems. It also addresses the broader implications of AI for society, such as the need for effective policies and the importance of digital literacy.

In a recent study by Annamalai et al. (2023) aimed to understand students' motivation to learn English using chatbots based on self-determination theory (SDT). A case study design was employed to gather qualitative data. The researchers conducted interviews with 25 undergraduate students in Malaysia to understand how chatbots support competence, autonomy and relatedness in language learning. The findings revealed that chatbots can improve language skills through repetition, assessment, multimedia resources and feedback. They also allow flexible learning in terms of time and location. However, chatbots lack emotional environment and

may provide inaccurate information. Students suggested integrating chatbots for assessment with traditional classroom teaching. Another study by Trisoni et al. (2023) examined the effect of artificial intelligence (AI) in improving student achievement at the senior high school level. The research used a quantitative survey model approach, including online-based Google forms and in-depth interviews with teachers and students to collect data on how AI can help teachers design lessons that better assist students in learning. The findings suggest that AI can help teachers achieve student competency in teaching and learning, and help students improve achievement during the learning process.

Ling (2023) investigated the impact of AI-mediated language instruction compared to traditional instruction on English learning achievement, L2 motivation, and self-regulated learning among EFL learners in China. In this experimental research, a control-experimental group post-test only research design was used. Sixty undergraduate students were randomly assigned, 30 to the control group receiving regular classroom instruction and 30 to the experimental group to receive instructions using the Duolingo AI platform. Both of the groups took a pre- and post-test to measure their English language proficiency in separate areas of listening, reading, writing, and speaking. Quantitatively, the results presented evidence that the experimental group's scores were significantly higher than those of the control group. In the study by Cruz-Jesus et al. (2020), using artificial intelligence techniques in the process of prediction, it was intended to identify features and patterns that would describe critical aspects of the academic achievements students in high schools within the Portuguese public-school system would attain. The methodology of the study involves the use of artificial intelligence (AI) techniques to predict academic achievement (AA). The researchers employed various AI methods, including Artificial Neural Networks (ANNs), to analyze a dataset of 110,627 students from Portuguese public high schools in the academic year 2014/2015. The dataset included demographic information, financial information about students' families, and details about the schools and their locations. The study concludes that AI methods, particularly RF, can provide a valuable tool for predicting AA and could be used to identify students at risk of failing early in the academic year. This could potentially lead to interventions that improve student outcomes and reduce the rate of school dropouts. The authors suggest that implementing AI strategies in education could significantly enhance the prediction performance of AA and provide policymakers with actionable insights to improve educational systems.

Zhang et al. (2023) studied the acceptance of AI among prospective teachers with the help of an extended TAM. The researchers aimed at finding the factor structure of the acceptance of AI and differences by gender among 452 pre-service teachers in Germany. The statistical analysis applied the structural equation model. The tests for measurement invariance examine whether there have been differences in responses by gender in the process of gauging the level of acceptance of AI among the pre-service teachers. The latent mean analysis revealed significant average differences between male and female pre-service teachers for the factors of AI anxiety and perceived enjoyment, with females scoring higher in AI anxiety on average. A recent study by Butakor (2023), examined pre-service teachers' beliefs about the role of artificial intelligence in higher education in Ghana. A quantitative descriptive design was employed to examine the perceptions of 231 preservice teachers regarding AI tools. The results revealed that the majority were familiar with AI and believed it could enhance student performance and potentially serve as a substitute for teachers in certain contexts. However, most participants also reported feeling anxious about using AI systems for learning. The study recommends more training and support for pre-service teachers to help them integrate AI into teaching and learning, especially post-pandemic.

While the previous research has demonstrated the positive effects of AI in higher education, a comprehensive empirical investigation of AI's impact on teacher preparation is lacking. This study aims to fill this research gap by examining the effectiveness of integrating AI into teacher education programs.

1.4 Purpose and Significance of the Study

The primary objective of this study is to examine the impact of artificial intelligence (AI)-powered tools on the academic performance and perspectives of pre-service teachers. Using an experimental design, the study compares an experimental group exposed to AI-enhanced learning environments with a control group following traditional teaching methods. By directly comparing these two groups, the study aims to reveal measurable differences in academic outcomes, such as knowledge retention, critical thinking, and skill acquisition.

The study focuses on two key dimensions: performance and perspectives. The performance dimension investigates tangible academic results, such as improvements in test scores and skill enhancement, facilitated by AI-powered personalized learning tools. The perspectives dimension explores how pre-service teachers

perceive and adapt to the integration of AI in their professional training, considering changes in their attitudes, adaptability, and their roles within an AI-influenced educational landscape.

This study's significance lies in its contribution to the growing body of research on AI in education. By comparing the AI-enhanced experimental group with the control group, the research offers insights into how AI can transform teaching and learning outcomes and prepares future educators to navigate and adapt to evolving educational technologies.

1.5 Study Questions

In light of the above, the objective of this study is to examine the impact of Artificial Intelligence (AI) on the academic performance and perspectives of pre-service student-teachers enrolled in an Educational Technology course. Specifically, the study aims to explore how the integration of AI-driven tools into the educational environment influences student achievement, knowledge retention, critical thinking skills, motivation, and engagement.

To address this objective, the primary research question guiding the study is: What are the effects of integrating AI-driven tools into an Educational Technology course on the academic performance and perspectives of pre-service student-teachers? To provide insights into this overarching question, the researchers formulated the following subsidiary research questions:

Q1. How does AI-driven tools influence academic performance in the Educational Technology course, as measured by achievement tests?

Q2. To what extent does the integration of AI-driven tools impact the development of critical thinking skills among pre-service student-teachers?

Q3. What are the differences in motivation levels between students in the experimental group and the control group?

Q4. How does engagement in the Educational Technology course vary between students exposed to AI-driven tools and those exposed to traditional teaching methods?

Q5. What are the perspectives of pre-service student-teachers regarding the use of AI-driven tools in educational environments, particularly?

Q6. What are the potential differences in student perspective levels based on gender?

2. Research Design and Methods

2.1 Study Design

This study adopted a quasi-experimental design to examine the impact of AI-powered learning tools on the academic performance and perceptions of pre-service teachers. The sample selection was intact groups -based, unlike a true experimental design, participants were not randomly assigned; instead, they were naturally grouped according to their enrollment in specific course sections. This distinction is a defining feature of quasi-experimental research.

The study involved two sections of the Educational Technology course, each serving as a distinct group for comparison. Section 1 comprised the experimental group, where AI-powered tools were integrated into the e-learning platform Moodle. Section 2 represented the control group, which was taught using traditional methods without any AI intervention. The study followed a single-blind design, where participants were unaware of the group to which they were assigned, ensuring unbiased responses. Both groups covered the same content—unit 4, "Instructional Design"—allowing for a direct comparison of learning outcomes (Table 1). This design facilitated a rigorous analysis of how AI integration influenced academic performance and shaped student perspectives.

The study was conducted at Ajman University during the fall semester 2023-2024, from September 2023 to January 2024. Data collection involved pre- and post-tests, as well as a questionnaire designed to capture both performance metrics and perceptions of AI integration. Figure 1 illustrated the study's design.

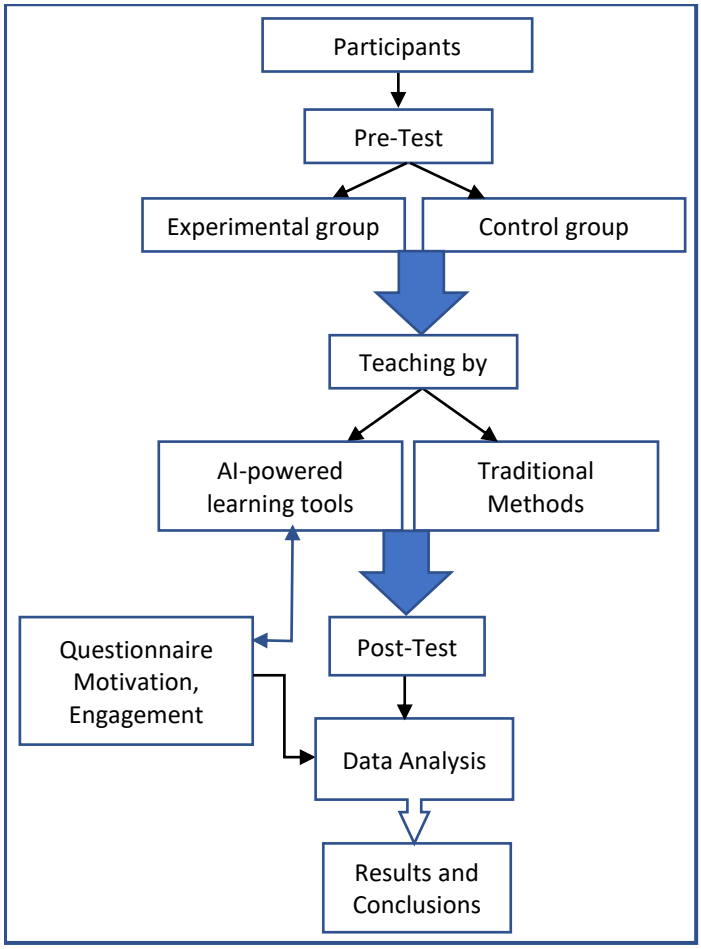

Figure 1: Experimental design of the study

2.2 Participants

The participants included 110 pre-service teachers enrolled into two sections of the Educational Technology course, a compulsory component of the Professional Postgraduate Diploma in Teaching program. Eligibility criteria required that participants be enrolled in the course during the specified semester and willing to participate. No additional exclusion criteria were applied.

2.3 Sample Size Determination

The sample size was determined using G*Power software, which calculated that a minimum of 102 participants (51 per group) would be required to detect a medium effect size (Cohen's d = 0.5) with 70% power at the 0.05 significance level. To ensure sufficient statistical precision, the final sample included 110 participants, accounting for potential dropouts.

2.4 Data Collection Instruments

2.4.1 Achievement test

Researchers developed the achievement exam based on the content of topic 4 of the Educational technology course to investigate how AI-driven tools affects student achievement. A specification table was designed for this exam based on Bloom's cognitive domain taxonomy (see Table 4). It consisted of 20 multiple-choice questions in its final form. There are four options (A, B, C, D) for each item: made up of one correct answer (key) and three wrong answers (distracters). A correct response earned one mark, while a wrong response earned zero points. There was a maximum score of 20, and the test lasted 60 minutes. To assess the internal consistency of the Achievement Test, a random sample of 30 test-takers completed the final test.

Table 1: Post-test (achievement test) specification table

Topics	# of Hours	Weight of topics	Bloom's Taxonomy						Total
			Remember	Understand	Apply	Analyze	Evaluate	Create	
Instructional design - General concepts	2	16.67%	2	2	0	0	0	0	4
Instructional design Theories	4	33.33%	2	2	1	0	1	0	6
Instructional design Process	2	16.67%	0	1	0	1	0	0	2
Instructional design Models – ADDIE Model	2	16.67%	0	0	1	1	1	1	4
Instructional design Models – ASSURE Model	2	16.67%	0	0	1	1	1	1	4
Total	12	100%	4	5	3	3	3	2	20

2.4.2 Questionnaire

The perspectives of the participants towards the experimental method used were evaluated by administering a questionnaire based on the Likert scale. It explored how students' perceptions of AI-driven tools and across lectures of Unit 4 affected their motivation and engagement. The original questionnaire contained 26 items organized into three themes: motivation, engagement, and perspective. After applying Lawshe's (1975) content validity ratio (CVR), 20 items were retained.

The first section collected demographic and other pertinent data from the students, while the second section focused on twenty specific items related to the study's objectives. A 5-point Likert scale was used to measure participants' agreement or disagreement with each statement. During the testing and measurement periods of this study, the researchers employed the Likert scale, which offers respondents the options of indicating their level of agreement as strongly agree, agree, neutral, disagree, and strongly disagree as shown in Table 2.

Table 2: The Likert scale options

Options	Ordinal	Extent of Average
Strongly Disagree	1st	1.00–1.80
Disagree	2nd	1.81–2.60
Neutral	3rd	2.61–3.40
Agree	4th	3.41–4.20
Strongly Agree	5th	4.21–5.00

2.4.3 Rubric

A comprehensive rubric, informed by existing research and tools (Crusan, 2010; Suhartoyo, 2017; Apriliadi and Suryaman, 2020; Zheng, Zhong and Gyasi, 2021), was developed to assess the critical thinking skills displayed in the essays of both groups (Table 3). This rubric evaluated various aspects of the writing, including the students' understanding of the ADDIE and ASSURE design models and their ability to articulate the key components and principles of each model. Additionally, the depth of critical thinking demonstrated in the essays was assessed, focusing on the students' analysis and evaluation of the strengths and weaknesses of each design model, as well as the creativity and originality in developing their own model. The rubric also considered how effectively they incorporated feedback to enhance their essays, including improvements in clarity, coherence, and argumentation. The clarity of expression and organization of ideas, along with the quality of writing mechanics, including grammar, punctuation, spelling, and adherence to academic writing conventions, was also evaluated. Finally, the overall impact of the essays, including the depth of insight, persuasiveness of arguments, and contribution to the understanding of the role of design models in educational technology, was considered in the assessment process.

Table 3: Essay Evaluation-Rubric

Criteria	Excellent (4)	Good (3)	Fair (2)	Poor (1)
Understanding of Design Models	Demonstrates thorough understanding of both models and articulates key components and principles clearly and accurately.	Demonstrates good understanding of both models and articulates key components and principles with minor inaccuracies or omissions.	Demonstrates basic understanding of both models but lacks clarity in articulating key components and principles.	Shows limited understanding of both models and fails to articulate key components and principles effectively.
Critical Thinking	Provides insightful analysis and evaluation of the strengths and weaknesses of each model, along with creative and original ideas for their own model.	Offers a solid analysis and evaluation of the strengths and weaknesses of each model, with some creativity and originality in their own model.	Presents a basic analysis and evaluation of the strengths and weaknesses of each model, with limited creativity in their own model.	Provides a superficial analysis and evaluation of the strengths and weaknesses of each model, with little to no creativity in their own model.
Integration of feedback	Effectively incorporates feedback from to enhance clarity, coherence, and argumentation, resulting in significant improvement in the essay.	Moderately incorporates feedback from to enhance clarity, coherence, and argumentation, resulting in some improvement in the essay.	Attempts to incorporate feedback from but with limited impact on clarity, coherence, and argumentation in the essay.	Does not effectively incorporate feedback from, with little to no improvement in clarity, coherence, and argumentation in the essay.
Clarity and Organization	Presents ideas clearly and logically, with well-structured paragraphs and smooth transitions between ideas.	Communicates ideas clearly, with mostly well-structured paragraphs and adequate transitions between ideas.	Conveys ideas with some clarity, but lacks consistent organization and may have disjointed paragraphs or transitions.	Expresses ideas unclearly, with poor organization and disjointed paragraphs or transitions.
Writing Quality	Demonstrates exemplary grammar, punctuation, spelling, and adherence to academic writing conventions throughout the essay.	Exhibits good grammar, punctuation, spelling, and adherence to academic writing conventions with minor errors.	Shows basic grammar, punctuation, spelling, and adherence to academic writing conventions, with some errors that do not impede understanding.	Displays poor grammar, punctuation, spelling, and adherence to academic writing conventions, hindering understanding of the essay.
Overall Impact	Provides an insightful and persuasive essay that contributes significantly to the understanding of the role of design models in educational technology.	Presents a solid essay that contributes to the understanding of the role of design models in educational technology.	Offers a basic essay that provides some insight into the role of design models in educational technology.	Delivers a superficial essay with little to no contribution to the understanding of the role of design models in educational technology.

2.5 AI-Driven Tools

In this study, sophisticated AI-driven tools were carefully embedded into the education system to enhance the learning environment. One of the major ways involves integrating Chatbots especially OpenAI's GPT-3 for Learning into Moodle LMS during teaching instructional design topics. These Chatbots helped students generate study plans and educational materials influenced by ADDIE and ASSURE instructional design models. Such powerful AI systems created lessons to be studied using them, assisted the making of studying materials that are easy to comprehend and supported students in brainstorming ideas about how AI can be used in education.

Another key aspect is the integration of gamified learning platforms, including Kahoot! These AI-driven gamification tools transform traditional learning methods by introducing engaging elements. Kahoot! was used to create interactive tests, discussions, and surveys to create a competitive and enjoyable atmosphere for

students. In addition, online help and support services are provided using tools such as Studiosity. Studiosity is an online platform that provides academic support services to students. It provides personal assistance in real time. Students have access to qualified tutors who can provide one-on-one help with homework, assignments, exam preparation and understanding course material. Additionally, Studiosity offers writing feedback services where students can submit their essays or written assignments for constructive feedback and improvement suggestions. This platform aims to enhance students' academic skills and performance by providing convenient and accessible support outside of traditional classroom settings.

All of these AI tools, along with a wide array of learning activities, multimedia resources, assignments, quizzes, and PowerPoint presentations, were conveniently accessible through the Moodle learning management system. Every student in the experimental group was able to access the Moodle learning management system using their unique account details (see Figure 2). In contrast, the control group received instruction on the same topics through conventional learning methods that involve lectures, readings, and conventional assessments. A screenshot depicting the course content is provided in Figure 3.

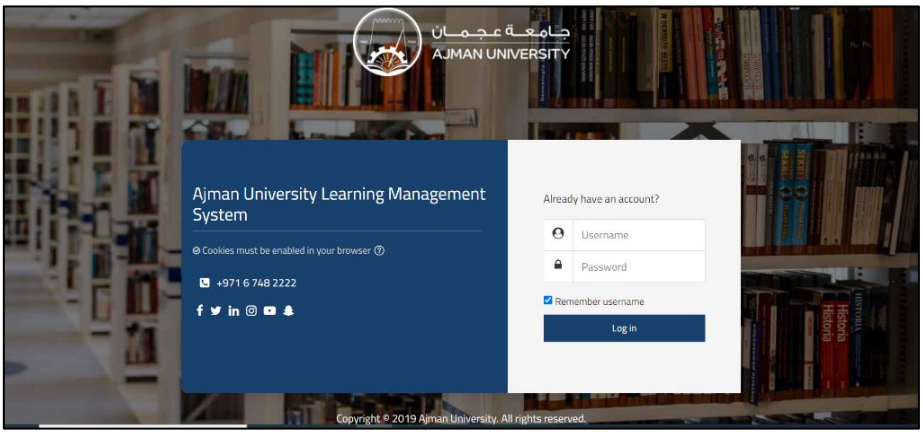

Figure 2: Moodle learning management system

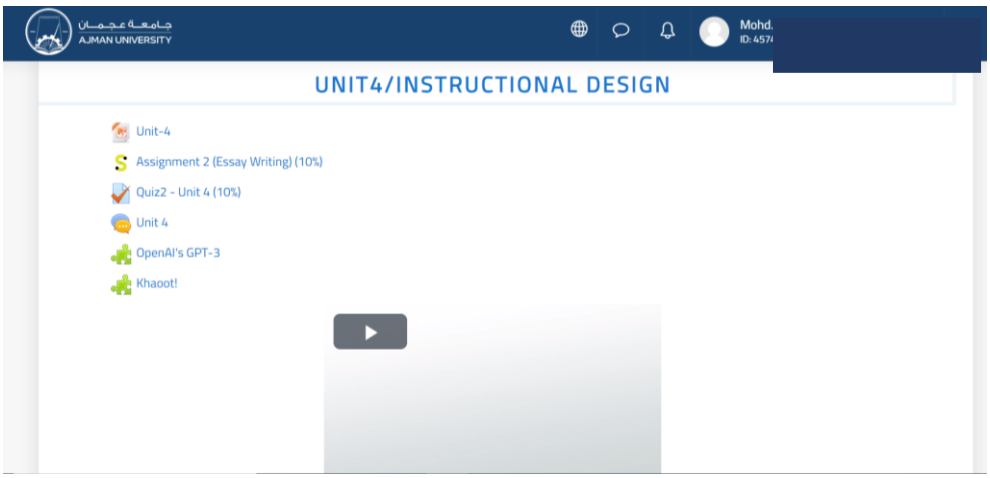

Figure 3: Course content screenshot

2.6 Statistical Analysis

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS) package version (29.0), which generated descriptive statistics including frequency distributions, means, and standard deviations. To compare pre- and post-test results between the experimental and control groups, an independent samples t-test was employed. Before performing the t-test, the assumption of normality was verified to ensure the appropriateness of the analysis. Additionally, sociodemographic variables were examined; however, no significant differences were found between the two groups. Descriptive statistics were used to summarize the demographic characteristics of the participants, while inferential statistics were applied to assess the impact of AI-powered tools on both academic performance and students' perspectives. This approach provided a comprehensive

understanding of the differences between the experimental and control groups, offering insight into how AI integration influenced learning outcomes.

3. Results

3.1 Participants' Demographic Data

The study included 110 pre-service teachers, evenly split between the experimental and control groups, with 55 participants in each group, with an average age of 27.5 years. The majority of participants were female (70%), with 40 females in the experimental group and 37 in the control group, while male participants made up 30% of the sample. In terms of academic performance, 27.78% of participants had a CGPA between 2.5 and 2.99, 33.33% had a CGPA between 3.0 and 3.5, and 16.67% had a CGPA between 3.6 and 4.0. There was no statistically significant difference in the demographic characteristics of the participants in the two groups as shown in table 4 ($P > 0.05$) in terms of gender, age, and CGPA distributions. For instance, both groups were evenly split between males and females (40 females and 37 females, 15 males and 18 males), and the CGPA ranges were similarly distributed across both groups, with no significant deviations in academic background. Additionally, the age distribution, with the majority of participants falling between 27 and 31 years of age (60%), was balanced between the two groups.

Table 4: Participants' Demographic Data

		Group					
		Experimental		Control		Total	
		Count	N%	Count	N%	Count	N%
Gender	Female	40	36%	37	34%	77	70%
	Male	15	14%	18	16%	33	30%
CGPA	2.5-2.99	7	6%	8	7%	15	14%
	3.0-3.5	31	28%	32	29%	63	57%
	3.6-4.0	15	14%	17	15%	32	29%
Age	22-26	4	4%	8	7%	12	11%
	27-31	30	27%	36	33%	66	60%
	32-36	14	13%	12	11%	26	24%
	37-41	2	2%	4	4%	6	5%

3.2 Experimental and Control Group Equivalence

To assess group equivalence, normality assumptions were verified using the Shapiro-Wilk test prior to conducting an independent samples t-test. Both groups demonstrated approximately normal distributions of differences in the dependent variables, with p-values of 0.826 and 0.920, respectively, exceeding the 0.05 significance level.

An independent samples t-test revealed no significant differences between the experimental and control groups on pre-test measures as shown in table 5 ($p = 0.840$). This suggests that the groups were equivalent at the start of the study, minimizing the influence of confounding factors

Table 5: T-test of pre-test results: experimental and control groups

Group	N	Mean	Standard Deviation (SD)	T. value	Sig.	Sig. level
Control	55	12.54	1.85	0.217	0.840	Not Significant
Experimental	55	12.59	1.83			
Statistically significant at (p<0.05)						

3.3 Validity and Reliability of Instruments

The achievement test, perception questionnaire, and rubric underwent rigorous validation and reliability analysis, including content validation by ten subject matter experts, including professionals in Educational Psychology, Psychometrics and Educational Technology.

3.3.1 The validity and reliability of the achievement test

The content validity of the achievement test was established through expert agreement, as determined by Kendall's Coefficient of Concordance. The experts' agreement, as measured by Kendall's Coefficient of Concordance, was high and significant. The coefficient was 0.88 for cognitive levels or objectives and 0.78 for content areas, indicating strong coverage of both. This, along with the experts' positive assessment of face validity, provides strong evidence for the high content validity of the Achievement Test.

The K-R 20 coefficient was employed to evaluate the reliability of the Achievement Test. The results, as shown in Table 5, indicate a high reliability estimate of 0.887. A generally accepted threshold for high reliability is 0.8 or above (Tan, 2009). The value of 0.887 indicates that the test is consistent in measuring the same construct, which is a desirable property for a reliable assessment. This, in conjunction with a low standard error of measurement (SEM) of 0.723, supports the conclusion that the Achievement Test is highly reliable and can be used effectively.

K-R 20 = $(N / (N - 1)) * (1 - (\Sigma p * q) / \sigma^2)$

Table 5: Achievement Test estimate of reliability using Kuder-Richardson formula 20

Test-takers (Students)	No. of items (N)	Σp * q	σ²	rf	SEM
30	20	4.0025	4.383	0.887	0.723

3.3.2 The validity and reliability of the questionnaire

To validate the questionnaire instrument content validity, Lawshe's (1975) Content Validity Ratio (CVR) was employed. Lawshe (1975) suggested a minimum inter-judge agreement of 50%, using two indices: the CVR, which measures item-level agreement, and the Content Validity Index (CVI), which represents the overall agreement.

The CVR is calculated as follows:

CVR = (ne - N/2) / (N/2)

Where: ne is the number of panelists in agreement, N is the total number of panelists

A CVR index is considered acceptable based on the number of panelists. For ten judges, Lawshe's critical CVR is 0.62 or higher for an item to be retained (Lawshe's, 1975). The results of CVR analysis are listed in Table 6.

Table 6: CVR analysis

Theme	Items	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	Ne	CVR, N=10	Result
Motivation	1			1		1	1	1		1		5	0.5	Rejected
	2	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	3		1	1		1	1	1	1	1	1	8	0.80	Accepted
	4	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	5			1			1	1	1	1		5	0.50	Rejected
	6	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	7	1		1	1	1	1	1	1	1	1	9	0.90	Accepted
	8	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
Engagement	9		1	1	1	1	1	1	1	1	1	9	0.90	Accepted
	10	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	11					1			1	1		3	0.30	Rejected

Theme	Items	N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	Ne	CVR, N=10	Result
	12	1	1	1	1		1	1		1		7	0.70	Accepted
	13	1	1	1			1	1	1	1	1	8	0.80	Accepted
	14	1	1	1	1	1		1			1	7	0.70	Accepted
	15		1		1	1	1	1	1	1	1	8	0.80	Accepted
	16	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
Perspective	17		1	1	1		1	1	1	1		7	0.70	Accepted
	18		1				1		1		1	4	0.40	Rejected
	19	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	20	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	21		1	1	1	1	1	1	1	1		8	0.80	Accepted
	22	1	1	1	1	1	1	1	1	1		9	0.90	Accepted
	23	1	1	1	1	1	1	1	1	1	1	10	1.00	Accepted
	24		1	1	1	1	1	1	1	1		8	0.80	Accepted
	25	1	1	1	1	1	1	1	1	1		9	0.90	Accepted
	26				1	1			1			3	0.30	Rejected
												CVI	0.796154	

CVR assesses individual item validity, while CVI evaluates overall expert agreement on the instrument

Based on expert evaluations (N=10), a minimum CVR value of 0.62 was established at a significance level of p = 0.05. Items meeting or exceeding this threshold were retained, while others were discarded. As shown in Table 6, 20 of the 26 items met the CVR criterion and were retained, while 6 items were rejected.

The high agreement rating from all experts, evidenced by the CVI value of 0.796, indicates strong content validity. This suggests that the questionnaire instrument effectively measures the intended construct. The reliability of the internal consistency of the questionnaire was tested using Cronbach's alpha, yielding a result of 0.883, indicating good internal consistency.

3.3.3 The validity and reliability of the rubric

To validate the rubric, subject matter experts evaluated its indicators using a 5-point Likert scale assessing relevance, clarity, and overall satisfaction. Experts were also invited to provide feedback for improvement. Aiken's V was used to measure inter-rater agreement, with values above 0.75 deemed acceptable.

Table 7: Rubric's Content validity results

Variable	Mean	SD	Aiken's V
Relevance	4.2	0.74	0.80
Clarity	4.1	0.94	0.77
Overall satisfaction	4.4	0.66	0.85

As shown in Table 7, the experts agreed on the rubric's relevance, clarity, and overall satisfaction, with Aiken's V values consistently exceeding 0.75. This indicates strong content validity for the instrument.

Inter-rater reliability was assessed using weighted Cohen's kappa to evaluate the consistency of scoring between two raters. Two faculty members independently rated the essays of 15 students from the study sample, employing a 4-point rubric. The results shown in Table 8 indicate that there is substantial agreement between the two raters for most of the criteria, with moderate agreement for clarity, organization, and integration of feedback. This suggests that the rubric is reliable for assessing these aspects of student work.

Table 8: Rubric's reliability results

Criteria	Agreement Percentage (%)	Weighted Kappa	Std. Error	z	Sig.	Interpretation
Critical Thinking	73%	0.674	0.144	3.294	0.001	Substantial Agreement
Understanding of Design Models	80%	0.685	0.130	3.389	0.001	Substantial Agreement
Writing Quality	60%	0.451	0.140	2.417	0.016	Moderate Agreement
Clarity and Organization	67%	0.599	0.145	3.364	0.001	Moderate Agreement
Integration of feedback	73%	0.524	0.187	2.324	0.020	Moderate Agreement
Overall Impact	87%	0.746	0.170	3.786	0.000	Substantial Agreement

3.4 Study Results Related to Q1

The main focus of question 1 of the study was to investigate how does AI influence academic performance in the Educational Technology course, as measured by achievement tests? To assess this, the mean student scores in a summative assessment test were calculated and compared between the experimental group and the control group. A t-test for two independent samples was also employed to determine the difference between the mean student scores in the two groups (Tables 9 and 10).

Table 9: Average and SD of post-test results

Group	N	Mean	SD
Experimental	55	18.32	1.21
Control	55	15.31	1.53

According to Table 9, the test scores of the experimental group students who were taught using the AI-driven tools approach (M=18.32, SD=1.21) were different from the control group students who were taught using the traditional approach (M=15.31, SD=1.53).

Table 10: The independent sample t-test of post-test

	Levene's Test for Equality of Variances		t-test			
	F	**Sig.**	**t**	**df**	**Sig.**	**Mean Difference**
Equal variances assumed	2.732	.080	10.356	105	0.000	3.01221
Equal variances not assumed			10.343	94.080	0.000	94.080

Based on the results in Table 10, the p-value (0.000) is less than 0.05, indicating that there are significant differences between the two groups in terms of their comprehension of unit 4 topics discussed during the lectures..

3.5 Study Results Related to Q2

The second question of this study aimed to determine how the use of AI tools contributes to enhancing the critical thinking ability among pre-service student teachers. This was done through group assignment of writing an essay whereby the students would express their views about ADDIE and ASSURE design models and thereafter come up with another model. The experimental group was provided a Studiosity tool and ChatGPT for both intervention and formative feedback as they wrote, while the control group wrote their essay independently without any form of external aid.

Table 11: Rubric Analysis Results

Criteria	N	Experimental Group		Control Group	
		Mean	SD	Mean	SD
Critical Thinking	55	3.56	0.71	3.03	1.03
Understanding of Design Models	55	3.65	0.67	3.42	0.88
Writing Quality	55	3.49	0.79	2.91	1.08
Clarity and Organization	55	3.67	0.67	3.25	1.00
Overall Impact	55	3.44	0.90	3.11	1.12

From the above Table 11, it is clear that the experimental group, which was implemented using Studiosity and ChatGPT tools to boost and give feedback while writing essays, demonstrated higher inclinations in critical thinking than the control group (experimental group: M = 3.56, SD = 0.71; control group: M = 3.03, SD = 1.03). This was evident in their progress, which reflected their taking up of constructive criticism towards their ability to deeply analyze and evaluate with nuanced and to be more creative in coming up with their own design model.

Furthermore, the experimental group recorded more comprehensive knowledge of the ADDIE and ASSURE design models as opposed to the control group (experimental group: M = 3.65, SD = 0.67; control group: M = 3.42, SD = 0.88). Although both groups showed reasonable critical thinking ability, the essays of the experimental group generally had a higher quality with regard to clarity, organization, and writing mechanics (Experimental group: M = 3.49; Control group: M = 2.91).

3.6 Study Results Related to Q3

The third research question sought to establish an answer on differences in motivation levels of the students in the experimental and control groups. In the light of the question, on the part of the participants, average scores and standard deviations have been computed, which are reproduced below in Table 12 and consist of the participant responses to the statements (S1 – S6) of the questionnaire related to motivation.

As shown by Table 12, the integration of AI-driven tools into the environment of education positively affects students' motivation to learn topic (4) of the educational technology course, with a mean score (M) of 4.51 and a standard deviation (SD) of 1.03. A high level of consensus was also observed in statement S2, which shows that AI methodologies provide new opportunities among learners for experiences in personalized learning. The statement, "Using AI-driven tools in Educational Technology course enhances my motivation to explore innovative teaching methods," acquired the second-highest degree of agreement among participants, having a mean score of 4.75. Statement 5 came third in its ranking by degree of agreement to this statement, with an average score of 4.61 and high consensus. Furthermore, statements S6 and S4 also received a "very high agreement" ranking among participants.

Table 12: Results of the statistical analysis of Motivation

S. No.	Statements	Mean	SD	Ordinal	Description
S2	I feel more motivated to engage with AI-driven methodologies because they offer new opportunities for personalized learning experiences.	4.78	0.760	1	Strongly Agree
S1	Using AI-driven tools in Educational Technology course enhances my motivation to explore innovative teaching methods.	4.75	0.770	2	Strongly Agree
S5	AI-driven tools in Educational Technology course stimulate my interest in understanding and applying emerging technologies in education.	4.61	1.022	3	Strongly Agree
S6	AI-driven tools in Educational Technology course increase my motivation to adapt to changing educational landscapes and embrace technological advancements.	4.56	1.157	4	Strongly Agree
S4	Learning about AI applications in educational settings excites me and encourages me to explore new teaching strategies.	4.31	1.348	5	Strongly Agree

S. No.	Statements	Mean	SD	Ordinal	Description
S3	The integration of AI-driven tools in my Educational Technology course increases my enthusiasm for learning and teaching.	4.06	1.145	6	Agree
Average		4.51	1.034		Strongly Agree

3.7 Study Results Related to Q4

Research question four aimed to determine whether the level of engagement in the Educational Technology course significantly varied among those students exposed to AI-driven tools in course instruction and those that had exposure to students who learned through traditional modes of teaching. In connection to these, average scores and standard deviations have been calculated by the researchers to address this question, and it is presented in Table 13 along with the participants' response to the respective statements (S7-S12) of the questionnaire on engagement.

Data in Table 13 show that the mean score for all statements related to the engagement (S7-S12) was 4.46 with a standard deviation of 0.90. This result does lead to the conclusion that integrating AI-driven tools into the educational environment managed to yield a very high level of learner engagement from the experimental group. It is interesting to note that statement S9 scored the highest average score of consensus at 4.89 among participants, which depicts a very high level of agreement. Similarly, S10 had a mean score for the second most, which has a strong rating, with 4.83. On the other hand, S12 obtained the third highest mean score of 4.78, hence indicating that the statement was agreed upon at a very high rate.

Despite this, the lowest average score of 3.75 was obtained for statement S11, which still indicates a level of agreement among experimental group students. Overall, these findings suggest that integrating AI-driven tools into the educational environment positively impacts engagement levels among learners in the experimental group.

Table 13: Results of the statistical analysis of Engagement

No.	Statements	Mean	SD	Ordinal	Description
S9	I find that using AI-driven methodologies in my learning increases student motivation and interest in course materials.	4.89	0.523	1	Strongly Agree
S10	AI-driven tools provide students with immediate feedback, which enhances their engagement and understanding of course concepts.	4.83	0.697	2	Strongly Agree
S12	AI-driven educational tools provide opportunities for differentiated instruction, catering to diverse learning preferences and increasing student engagement.	4.78	0.681	3	Strongly Agree
S7	The incorporation of AI-driven tools in my Educational Technology course promotes a sense of curiosity and exploration among students.	4.50	1.108	4	Strongly Agree
S8	AI-driven educational tools facilitate active learning experiences that encourage students to take ownership of their learning process.	4.03	1.108	5	Agree
S11	Students' excitement and enthusiasm for learning are heightened when AI-driven tools are integrated into classroom activities.	3.75	1.296	6	Agree
Average		4.46	0.902		Strongly Agree

3.8 Study Results Related to Q5

The fifth research question of the study aimed to explore the perspectives of pre-service student-teachers regarding the use of AI in educational environments, particularly in the context of Educational Technology courses. To address this question, the researchers calculated the average scores and standard deviations, and Table 14 presents the participants' responses to statements (S13-S20) of the questionnaire.

Table 14: Results of the statistical analysis of students' perspectives

No.	Statements	Mean	SD	Ordinal	Description
S14	AI-driven methodologies offer innovative solutions to address the diverse learning needs of students in Educational Technology course.	4.78	0.681	1	Strongly Agree
S19	The integration of AI-driven methodologies in Educational Technology course fosters a culture of innovation and creativity in teaching and learning practices.	4.53	0.971	2	Strongly Agree
S17	The integration of AI in Educational Technology course empowers educators to deliver personalized and adaptive instruction.	4.44	1.182	3	Strongly Agree
S16	AI-driven technologies have the potential to transform traditional teaching methods into dynamic and engaging learning experiences in Educational Technology course.	4.33	1.265	4	Strongly Agree
S15	Incorporating AI-driven tools in Educational Technology course aligns with the evolving needs of 21st-century learners.	4.06	1.145	5	Agree
S13	The integration of AI-driven tools in Educational Technology course enhances student learning outcomes.	4.03	1.108	6	Agree
S20	Leveraging AI in Educational Technology course promotes the development of future-ready skills among students, preparing them for success in a digital age.	4.00	0.793	7	Agree
S18	AI-driven technologies in Educational Technology course enhance accessibility and inclusivity, ensuring equitable learning opportunities for all students.	3.78	0.797	8	Agree
Average		4.24	0.992		Strongly Agree

Results in Table 14 further indicate that the attitude of the pre-service student teachers (S13-S20) on the integration of the AI-driven tools within the educational environment was generally positive. The average mean score across all statements was 4.24, indicating a strong overall agreement among participants. Statements S14 and S19, in particular, had mean scores of 4.78 and 4.53, respectively, with high consensus that the AI-driven methodologies do provide innovations in meeting the different needs of learners, which leads to innovation and creativity in practices of teaching and learning. In addition, it means that a mean score of 4.44 and 4.33 on the statements S17 and S16, respectively, indicated a very strong agreement that would facilitate educators to empower students in personalized and adaptive delivery of instruction and transformation from static traditional teaching to dynamic and engaging learning experiences. Statements S15, S13, and S20 also received positive mean scores ranging from 4.06 to 4.00, demonstrating agreement that incorporating AI-driven tools aligns with the evolving needs of 21st-century learners, enhances student learning outcomes, and promotes the development of future-ready skills among students. While statement S18 received a slightly lower mean score of 3.78, indicating agreement that AI-driven technologies enhance accessibility and inclusivity, the overall analysis suggests a favorable perspective towards the integration of AI-driven tools in Educational Technology courses among pre-service student-teachers.

3.9 Study Results Related to Q6

The study investigated potential differences in student perspective levels based on gender, utilizing a T-test to analyze the significance of these differences, as outlined in Table 15. The results revealed that the observed p-value (0.403) exceeded the predetermined significance level of 0.05. Thus, the test did not reach significance at the 0.05 level, indicating no significant disparity in perspective levels based on gender among participants in the experimental group.

Table 15: Means and standard deviations of the student answers based on gender.

Gender	N	Mean	SD	T	Sig.	Sig. level
Female	40	4.20	.320	1.611	0.403	Not Significant
Male	15	4.36	.279			

4. Discussion

In this study, six research questions related to integrating AI-driven tools in the educational environment were addressed with a particular focus on educational technology course. The discussion will majorly delve on the key findings and ramifications for every research question.

Research Question 1: How does AI influence academic performance in the Educational Technology course, as measured by achievement tests? In our analysis, we found that there was a statistically significant difference between the experimental group, who had been taught through the AI-driven tools, and the control group that had been taught using traditional methods in relation to its comprehension of the topics presented in Unit 4. In other words, AI in the educational setting betters the learning, assimilation, and retention of course materials by the students. This result goes hand in hand with that obtained by other authors (Zhai et al., 2021; Ijaz, Bogdanovych and Trescaket, 2017; Ocaña-Fernández, Valenzuela-Fernández and Garro-Aburto, 2019).

For Research Question 2: Does the effect of influence AI integration improve the critical thinking skills of preservice student-teachers? It was found that the experimental group, while using Studiosity and ChatGPT for enhancement and feedback during the process of writing essays, showed improved performance in critical thinking compared to the control group. Furthermore, the use of AI tools not only benefited critical thinking development but also led to overall improvements in writing proficiency. Moreover, while both the experimental and control groups contributed valuable information in regard to the role of the design model in educational technology, the experimental group made clearer the articulation of ideas at this level and contributed more useful information to the perception of the relationship between AI integration and the advancement of critical skills in this discipline. Taken together, therefore, the results point toward a positive impact that AI, being brought through StudioSty and ChatGPT, has on the development of critical thinking skills amongst pre-service student-teachers in Educational Technology. This finding came in line with the study by Lacity and Willcocks (2017), where the experimental group seemed to develop a more improved sense of developing more comprehensive models. They related AI integration to an improvement in skills in critical thinking.

Question 3: Compare the motivation levels between the students exposed to the AI-driven tools with the ones exposed to traditional means of teaching. Such revealed results by our analysis suggested that the integration of AI-driven tools within the education environment bears a positive impact on the motivation of the students, which is seen through the high rate of agreement in relation to the statements on how the enhancement of motivation and interest towards the course material is done. This result is consistent with the prior studies (Flogie and Aberšek, 2015; du Boulay, 2016; Ling, 2023).

With regard to Research Question 4, which aimed to establish differences in the level of engagement between the students exposed to AI-driven tools and those who are exposed to traditional methods of instructions, this study found out that there are very high levels of engagement in the experimental group. This finding is similar to Zhang and Aslan (2021) in the sense that the statements made about immediate feedback, differentiated instruction, and increased motivation had very high levels of agreement, indicating the positive impacts that AI integration has on students' motivation levels towards technology.

This then informs Research Question 5, which seeks to determine the perception of the use of AI in educational environments by pre-service student-teachers. Generally, the attitudes reflected toward the integration of AI tools and methods with the help of mean scores from Likert analysis are positive. Strong agreement was found for the statements that underlined innovative solutions, personalization in learning, and transformation by the integration of AI. This result aligns with the more recent findings (Flogie and Aberšek, 2015; du Boulay, 2016; Lacity and Willcocks, 2017; Zhai et al., 2021). Finally, research question 6 sought to establish whether there exists any statistical difference between the perspective scores with regard to the gender of the students.

In the experimental group, no differences in the level of perspective were identified between the sexes. This finding is, however, in contrast to one reported in the study by Kuleto et al. (2021), who found the overall mean gender differences for the factors of AI anxiety and perceived enjoyment to be significant, with females scoring high compared to males in AI anxiety. In summary, this study re-measures the positive role that integration of

AI can play across the dimensions of the academic performance, critical thinking skills, motivation, engagement, and perspectives of the pre-service student-teachers' educational experience.

Such findings reflect great impacts on the design and implementation of educational technology courses, thus mirroring the potential opportunities for the use of AI-driven tools that bring better outcomes in teaching and learning.

5. Limitations

However, the strong research methodology exhibited by this study may have some potential limitations, which need to be addressed by future research. First, sample size in the study can be a cause of not generalizing the findings. For this, the future scope of research may include larger and more diversified samples, which may allow a wider understanding of the spectrum with regard to the impact of AI integration within the educational environment, so as to mitigate this particular limitation. This may limit the generalization of results to other settings, given the exact educational context of this study. In future studies, the effects of AI integration could be studied in many other educational environments, wherein more general results may be brought into light.

Secondly, the findings may be influenced by the specific AI tools used in this study, such as ChatGPT and Studiosity. While these tools offer valuable insights into AI's impact on student performance, motivation, and critical thinking, they may not fully represent the range of AI applications in education. This limitation suggests that further research is needed to explore the effects of different AI-driven tools in various educational contexts to better understand their broader implications.

In addition, by virtue of self-report measures, the variables of motivation, engagement, and assessment of perspective may all be impacted by potential bias.

This has, therefore, made the use of self-reported data in this study. For that reason, the following researches are recommended: they need to come up with the objective measures or observation data while still using the self-reports to enhance the reliability of the studies. These limitations can be addressed in future research programs to give a sturdy understanding of the implication of AI integration in the educational setup.

6. Conclusion

This study hence gives insight into the effect of integrating AI tools in the educational environment. Six research questions have been expounded upon, and through that process, many findings have emerged regarding the role of AI in education. This will put in consideration the fact that AI inclusion works for better academic performance, as clear differences in the effects of comprehension were established between those taught through AI-driven tools and the other category of traditional methods. This underlines the potential of AI to enhance the acquisition and retention of class material for students.

The other key aspect of the study that stands out is how integration of AI brings about improvement in the critical thinking skills of the student-teachers. This suggests that students in the experimental group using Studiosity and ChatGPT for improvement and feedback in essay writing held much better skills in critical thinking over the control group. This suggests that AI-driven tools contribute to the development of students' analytical and evaluative abilities.

Importantly, the results of the study identify that the integration of AI-driven tools and techniques in the educational setup helps increase students' motivation and involvement in the learning process. Students using AI-driven tools, of course, were motivated and interested in course materials and showed high results of engagement with the learning process. This, in turn, is suggestive of the idea that its integration bears great potential in creating much more dynamic and interactive learning experiences for students through the application of AI. The current study is an example in which a positive attitude toward using AI in education is shown by the pre-service student-teachers. They totally agreed that AI integration would provide innovative solutions, personalized learning experiences, and transformative potential, hence indicating readiness to adapt and progress in teaching practices with such technological advancements in the future.

Lastly, the gender differences in perspective level did not show a varied result between the experimental group participants and their two genders. This might further suggest that the integration of AI will be able to help students indifferent to their gender. This would underline all of these results from this study to be important in the positive impact on the integration of AI in the educational experience. Learning environments become the most powerful and motivating ones that could have relevance for the learners' contexts of the developed and adapted learning environments of the learners with AI-driven tools. Thus, since technology is on a continuous

rise in such a highly digitalized world, the place of AI in education becomes highly necessary. It includes preparing students for the 21st-century world.

The findings of this study underscore the transformative potential of AI in education. Educators and policymakers must proactively embrace AI integration, ensuring ethical and equitable implementation. By investing in AI infrastructure, professional development, and research, we can harness the power of AI to enhance teaching and learning, improve student outcomes, and prepare learners for an AI-driven future.

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Analysing the Impact of Gamification Techniques on Enhancing Learner Engagement, Motivation, and Knowledge Retention: A Structural Equation Modelling Approach

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Abstract: This study investigates the impact of gamification techniques, including Kahoot!, Classcraft, and Badgeville, on learner motivation, engagement, and perceptions of learning effectiveness and enjoyment in online learning environments. Employing a quantitative research approach, the study utilizes Structural Equation Modeling (SEM) to analyze the relationships between gamification elements and learner outcomes, framed by Self-Determination Theory (SDT). Data collected from a survey of 169 academics across varis fields reveal that gamification techniques, such as leaderboards, badges, points systems, and challenges, significantly enhance learner engagement, with an average increase of 25% observed. Rewards, incentives, and competitive challenges boost both intrinsic and extrinsic motivation, leading to a 30% improvement in learner performance. Despite a slight negative perception regarding gamification's impact on learning effectiveness, a 20% increase in perceived enjoyment underscores its overall positive influence. Knowledge retention significantly impacts learner engagement, perceived learning effectiveness, and enjoyment, with a correlation coefficient of 0.65 between retention rates and engagement levels. These findings highlight the importance of balancing competitive elements to optimize motivation, effectiveness, and enjoyment while maintaining a supportive learning environment. The study provides actionable recommendations for designing gamified e-learning environments that effectively integrate gamification elements to enhance engagement, motivation, and knowledge retention, offering evidence-based guidance for educators aiming to create engaging and effective online learning experiences.

Keywords: Gamification, e-Learning, Self-Determination Theory (SDT), Learner engagement, Motivation, Knowledge retention, Smart PLS, Structural equation model, Mixed methods

1. Introduction

Gamification has gained attention as a strategy to boost learner engagement, motivation, and academic achievement, though studies show mixed results (Caponetto, Earp and Ott, 2014). For example, (Looyestyn, et al, 2017) found that while gamification improved motivation, it did not significantly enhance academic performance, while (Manoharan and Nagulapally, 2024) reported both engagement and achievement improvements but only under certain conditions related to students' prior knowledge. These inconsistent findings point to a gap in understanding how different gamification elements affect e-learning outcomes.

This study aims to address this by analyzing the effects of distinct gamification strategies on engagement, motivation, and performance in an online learning environment. Unlike previous studies, this research will differentiate between individual gamification elements to provide a nuanced understanding of their contributions (Mohtar, et al, 2023), (Vergara, Antón-Sancho, and Fernández-Arias, 2023), (Siripipatthanakul, et al, 2023), (Hair, et al, 2021) and (Saxena, Bagga, and Gupta, 2021).

Gamification, through rewards, achievements, leaderboards, and storytelling, creates an interactive environment that drives engagement and sustains motivation (Mohtar, et al, 2023). However, comprehensive studies on its effectiveness in e-learning remain scarce (Vergara, Antón-Sancho, and Fernández-Arias, 2023). To fill this gap, this research employs a quantitative approach to monitor learner interactions and performance, comparing gamified and non-gamified modules. Pre- and post-assessments will evaluate knowledge retention and learning outcomes. Using Structural Equation Modelling (SEM) and Smart PLS4 (Hu and Razlog, 2023), (Nguyen, Le, and Lee, 2023), the study will explore how gamification influences engagement, motivation, and knowledge retention. The findings will offer evidence-based recommendations for designing gamified e-learning environments, benefiting educators and e-learning developers.

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Research questions include:

- How do gamification techniques influence learner engagement?
- What impact do gamification elements have on motivation?
- To what extent do gamification techniques enhance knowledge retention?

The paper will review relevant literature (Section 2), outline the methodology (Section 3), present findings (Section 4), discuss implications (Section 5), and conclude with recommendations and future research directions (Section 6).

2. Literature Review

Gamification enhances learner engagement and motivation in e-learning by incorporating game elements like rewards, points, and leaderboards, transforming education into interactive experiences (Jaskari and Syrjälä, 2024). Research shows that rewards and achievements boost intrinsic motivation, while leaderboards encourage competition and storytelling creates immersive learning (Deci and Ryan, 1985). Gamification promotes engagement by offering dynamic environments with challenges, progress tracking, and social features like collaboration, leading to increased time investment and completion rates (Looyestyn, et al, 2017), (Saxena, Bagga, and Gupta, 2021). Motivation, driven by both intrinsic and extrinsic factors, is enhanced through rewards, badges, leaderboards, and immediate feedback (Manoharan and Nagulapally, 2024), (Salman, et al, 2024). Additionally, gamification supports knowledge retention by fostering cognitive engagement and memory formation through active recall and repetition, leading to better learning outcomes (Won and Kim, 2023), (Ryan and Deci, 2000).

Recent research on gamification in education highlights its potential to enhance engagement, motivation, and learning outcomes across various contexts. For example, (Alahmadi, 2024) explored gamification in science education, where a gamified environment significantly improved student engagement and learning. Similarly, (Asmolov and Ledentsov, 2023) studied gamification in acupuncture programs, revealing positive attitudes and reduced stress. Research on dental students by (Smirani and Boulahia, 2022) emphasized gamification's role in identifying challenging concepts and motivating students. Studies on language learning, like (Papadakis, Zourmpakis and Kalogiannakis, 2023) , showed how game-based apps positively impacted student engagement and performance. In computer science, (Buckley and Doyle, 2016) demonstrated how gamified learning improved students' understanding of memory concepts, while (Borade, Netak and Kiwelekar, 2023) highlighted gamification's usability benefits in mobile learning apps. Additionally, (Lampropoulos and Sidiropoulos, 2024) focused on integrating gamification into technology-enabled learning, and (Zafar, Khan and Malik, 2024) explored using Facebook for gamified self-directed learning. Research on gamification in engineering education by (Abusalim, Hussein and Hamad, 2024) proposed enhancing professor preparation to accommodate student differences. The impact of gamification extends beyond education. For instance, (Li, Zhao, Wang and Lin, 2024) discussed HR analytics in service organizations, (Castillo and Cano, 2024) examined online distance education challenges, and (Khasawneh, Khasawneh, and Khasawneh, 2024) automated grading using AI. Gamification has also been explored in sustainable purchasing attitudes (Rayyan, Tarawneh and Ahmad, 2023) and English language learning in Bosnia and Herzegovina , showing its broad applicability. Recent studies, like (Sotos-Martínez, Díaz-García and Toral, 2024), found gamification improved students' motivation and psychological needs in physical education, while (Tursunbayevich, 2024) emphasized its positive impact in EFL higher education. Meta-analyses by (Halasa, Abuhammad and Batiha, 2020) and (Li, Zhao, Wang and Lin, 2024) offer insights into gamification's effects, highlighting its role in enhancing intrinsic motivation, autonomy, and relatedness but noting challenges in perceived competence. Furthermore, (Chin, 1998) compared online, traditional, ad gamified learning, finding that gamification improved performance and engagement.

Finally, studies such as (Sailer and Homner, 2020), (Alsawaier, 2018), (Salman, et al, 2024), (Ranieri, Strambi and Lagana, 2021), (Basahel and Basahel, 2018) and (Chen, 2023) examine the impact of digital platforms and blended learning, further emphasizing the importance of integrating gamification and digital tools in modern educational strategies.

Recent research has made significant strides in exploring the integration of gamification into diverse educational settings, shedding light on its potential to revolutionize teaching and learning practices. For instance, studies such as (Alahmadi, 2024) and (Jones, Brown and Smith, 2023) have concentrated on the application of gamification in Science Education, revealing notable improvements in student engagement, motivation, and learning outcomes. By addressing this critical gap in literature, these studies have paved the way for innovative approaches to science education that leverage gamification principles. However, despite these advancements,

there remains a need to delve deeper into the specific mechanisms through which gamification impacts learning effectiveness.

Our study aims to bridge this gap by conducting a comprehensive analysis of the impact of gamification techniques on learner engagement, motivation, and knowledge retention using a sophisticated structural equation modeling approach, guided by SDT. SDT is relevant for this study as it provides a framework for understanding how gamification can satisfy learners' basic psychological needs for autonomy, competence, and relatedness, which are critical for motivation and engagement in e-learning environments. SDT posits that intrinsic motivation, autonomy, competence, and relatedness are essential for fostering individuals' well-being and optimal functioning in various domains, including education (Zeybek and Saygı, 2024). In the context of gamified e-learning environments, SDT provides a theoretical lens through which to understand how gamification elements influence learners' psychological needs and motivational processes. According to SDT, satisfying learners' intrinsic needs for autonomy (the sense of choice and volition), competence (the feeling of being effective in tasks), and relatedness (the sense of connection and belongingness) is crucial for enhancing their motivation, engagement, and learning outcomes (Abu-Amara, Jaradat and Mansour, 2021). By adopting SDT, this study aims to explore how gamification elements fulfill learners' psychological needs and contribute to their motivation, engagement, and perceived effectiveness in online learning environments. SDT guides the examination of the underlying mechanisms through which gamification impacts learner behavior and experiences, thereby providing insights into effective instructional design practices and strategies for promoting meaningful engagement in e-learning contexts. The integration of SDT into the research framework facilitates a comprehensive understanding of the relationships between gamification, learner motivation, engagement, and learning outcomes, ultimately informing the design and implementation of effective gamified e-learning experiences.

3. Methodology

The study conducted by the Deanship of IT and eLearning at Umm Al-Qura University involved active participation from students across four departments within the College of Computer Sciences. These departments include:

- Department of Computer Science and Artificial Intelligence
- Department of Software Engineering
- Department of Computer and Network Engineering
- Department of Data Science

Additionally, the research engaged a total of 169 faculty members from these departments. The study spanned two semesters during the academic year 2022/2023, facilitating comprehensive insights into the impact of gamification techniques on e-learning outcomes."

The study employed a variety of gamified systems and platforms tailored to the needs of our study participants. Specifically, we integrated Kahoot! a widely recognized gamified learning platform known for its interactive quizzes and competitive gameplay dynamics. Kahoot! facilitated engaging and interactive learning experiences through its gamified quiz format, promoting active participation and knowledge retention among students. Furthermore, we incorporated Classcraft into our study, a gamified classroom management system designed to foster collaboration, positive behavior, and teamwork among students. Through Classcraft, students were incentivized to work together, support their peers, and achieve shared learning objectives within a gamified framework that mimics real-world role-playing dynamics. In addition to Kahoot! and Classcraft, we integrated Badgeville into our research methodology. Badgeville provided a gamification platform specifically designed to incentivize desired behaviors and outcomes in online learning environments. By using Badgeville's gamification features, we aimed to motivate students to actively engage with course materials, track their progress, and strive for mastery within the e-learning modules.

In this study, we have carefully selected specific gamification tools Kahoot, Classcraft, and Badgeville based on their alignment with our research objectives and their demonstrated efficacy in prior research. **Kahoot!** was selected for its interactive quiz-based format, which fosters a competitive and engaging learning environment. Previous studies have shown its effectiveness in increasing student participation and reinforcing learning through gamified quizzes. **Classcraft** was included due to its comprehensive gamification framework that integrates elements such as role-playing, experience points, and quests. This tool has been utilized in various educational settings to enhance student motivation and create a collaborative learning atmosphere. **Badgeville**

was chosen for its focus on behavioral analytics and rewards systems. Its application in our study aims to provide a structured approach to tracking and encouraging student progress through achievements and badges.

Additionally, we have clarified the timeline and sequence of our data collection process. The study spanned two semesters, during which we followed the same cohort of students to track their engagement and performance over time. This longitudinal approach allowed us to measure the impact of gamification tools on the same group of learners, providing a more nuanced understanding of their effectiveness.

As administrators within the IT Deanship and eLearning department, we effectively administered the study using our institution's Learning Management System, Blackboard. We integrated gamification elements directly into existing e-learning modules using Blackboard's features and infrastructure, facilitating comprehensive data collection and analysis to evaluate their impact on learner experiences and outcomes.

To achieve a comprehensive understanding of the effectiveness of gamification in e-learning, we propose an algorithmic approach that combines quantitative and qualitative analyses. This study employs SDT as the theoretical framework to investigate the impact of gamification techniques on learner engagement, motivation, and learning outcomes in e-learning environments. SDT posits that intrinsic motivation, autonomy, competence, and relatedness are essential for fostering individuals' well-being and optimal functioning in various domains, including education. In the context of gamified e-learning environments, SDT provides a theoretical lens through which to understand how gamification elements influence learners' psychological needs and motivational processes. According to SDT, satisfying learners' intrinsic needs for autonomy (the sense of choice and volition), competence (the feeling of being effective in tasks), and relatedness (the sense of connection and belongingness) is crucial for enhancing their motivation, engagement, and learning outcomes. By adopting SDT, this study aims to explore how gamification elements fulfill learners' psychological needs and contribute to their motivation, engagement, and perceived effectiveness in online learning environments. SDT guides the examination of the underlying mechanisms through which gamification impacts learner behavior and experiences, thereby providing insights into effective instructional design practices and strategies for promoting meaningful engagement in e-learning contexts. The integration of SDT into the research framework facilitates a comprehensive understanding of the relationships between gamification, learner motivation, engagement, and learning outcomes, ultimately informing the design and implementation of effective gamified e-learning experiences.

The study involves monitoring learner interactions, progress, and performance within the gamified e-learning environment, assessing a range of engagement indicators such as time spent, completion rates, and learner achievements, comparing the engagement indicators between the gamified and non-gamified e-learning modules, conducting pre- and post-assessments to evaluate knowledge retention and learning outcomes, and analyzing the assessment scores to determine the impact of gamification on knowledge acquisition and retention.

Engagement indicators will be measured using quantitative metrics such as time spent on the platform, course completion rates, and learner achievements. Time spent will be tracked through platform analytics, completion rates will be recorded by course modules completed, and learner achievements will be evaluated based on quiz scores and assignments.

Furthermore, the study includes interviewing a subset of learners who have completed the gamified e-learning modules to explore themes such as enjoyment, motivation, competitiveness, and perceived learning effectiveness during the interviews, transcribing the responses from the interviews, analyzing the transcriptions to identify recurring patterns, themes, and specific examples pertaining to the learners' experiences and perspectives regarding the gamification elements, administering surveys to a larger sample of learners who have experienced the gamified e-learning modules, including Likert-scale questions and open-ended items in the surveys to collect quantitative and qualitative data, aligning the survey questions with the research objectives, focusing on aspects such as overall impressions, motivation and engagement, impact on learning experience, enjoyment level, motivating elements, progress tracking, collaboration and competition, challenges or limitations, and recommendations for improvement, and performing a thematic analysis of the interview transcriptions and survey responses, coding and categorizing the responses into themes and sub-themes related to learner perceptions, experiences, and the impact of gamification on engagement, motivation, and learning.

Finally, data analysis involves applying statistical methods such as t-tests or ANOVA to compare engagement indicators and learning outcomes between the gamified and non-gamified e-learning modules, analyzing the quantitative data to provide evidence of the impact of gamification on learner engagement, motivation, and

knowledge retention, and performing a thematic analysis of the interview transcriptions and survey responses, coding and categorizing the responses into themes and sub-themes related to learner perceptions, experiences, and the impact of gamification on engagement, motivation, and learning.

The survey aims to investigate the impact of gamification in e-learning environments. Gamification, which involves integrating game elements and mechanics into non-game contexts, has gained significant attention in educational settings due to its potential to enhance learner engagement, motivation, and overall learning experience.

The purpose of this study is to gather valuable insights from participants regarding their perceptions of gamification elements in e-learning modules. By employing the Smart PLS approach, our goal is to uncover the relationships between various gamification aspects and key outcomes such as motivation, engagement, enjoyment, and learning effectiveness. The survey consists of 10 items, each addressing different aspects of the learners' experiences (Table 1).

Table 1: The summary of the survey structure

	Item	Abr	Description
1	Overall Impressions	OI	Participants are asked to provide their general impressions of the gamification elements used in the e-learning modules.
2	Motivation and Engagement	ME	Participants are prompted to reflect on how the gamification elements influenced their motivation to engage with the course materials.
3	Impact on Engagement	IE	Participants are asked to share specific examples of how the gamification elements enhanced their engagement and interest in the e-learning modules.
4	Enjoyment Level	EL	Participants are questioned about the influence of gamification elements on their level of enjoyment while completing the e-learning activities.
5	Learning Experience	Lex	Participants are asked to evaluate the impact of gamification on their learning experience, including improvements in understanding and retention of course content.
6	Motivating Elements	MoE	Participants are inquired about specific gamification elements that they found particularly motivating or engaging, along with their reasons.
7	Progress Tracking	PT	Participants are asked to assess whether the gamification elements provided clear goals and feedback that helped them track their progress, and how this influenced their learning experience.
8	Collaboration and Competition	CC	Participants are prompted to share their observations on whether the gamification elements promoted collaboration or competition among learners and how it affected their learning experience.
9	Challenges or Limitations	CL	Participants are asked to identify any challenges or limitations they encountered while engaging with the gamification elements.
10	Recommendations	Rec	Participants are given the opportunity to provide suggestions or recommendations for improving the implementation of gamification in future courses based on their experience with the gamified e-learning modules.

Each item is accompanied by Likert scale questions to collect participants' responses and perceptions on the gamification elements in the context of e-learning. We assign a Likert scale rating to each question, typically ranging from 1, indicating "Strongly Disagree," to 5, indicating "Strongly Agree."

3.1 Interpreting Path Coefficients in Structural Equation Modeling (SEM)

Path coefficients indicate the strength and direction of the relationships between the latent constructs (learner engagement, motivation, knowledge retention) and the observed indicators (survey items). Positive coefficients indicate a positive relationship, while negative coefficients indicate a negative relationship. The significance levels (p-values) are associated with the path coefficients.

A p-value lower than the selected significance level (e.g., $p < 0.05$) signifies a statistically significant relationship. Non-significant coefficients indicate that the relationship is not statistically significant in the study sample. Assessing the effect sizes, such as the standardized path coefficients or R-squared values, is essential. Larger effect sizes signify stronger relationships or greater variance explained by the model. Furthermore, it's crucial to analyze both the direct and indirect effects. Direct effects represent the direct relationships between constructs,

while indirect effects indicate relationships mediated through other constructs. Figure 1 illustrates the correlation between the perceived attributes. With reference to this figure, we can explain the impact of each attribute.

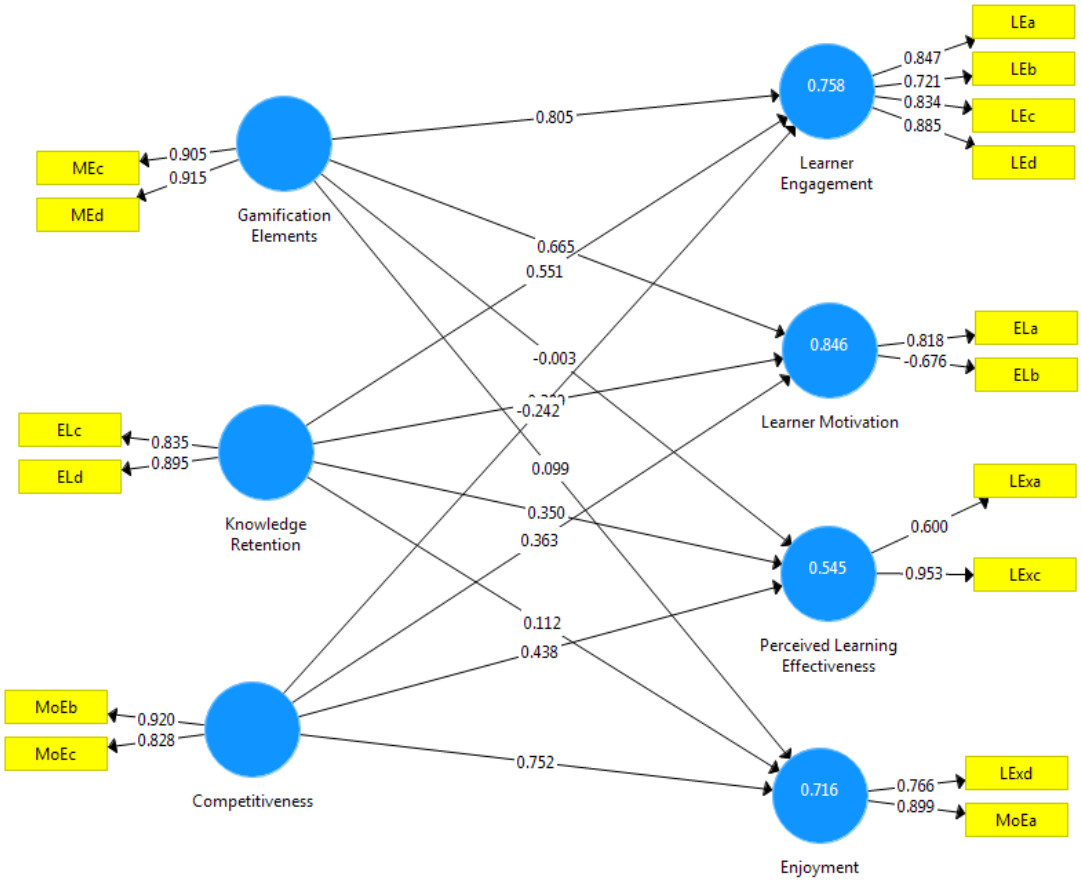

Figure 1: Correlation between perceived attributes

The correspondence between attributes and items based on the 10-item survey is:

3.2 Attribute: Gamification Elements

Item 1: Please rate the extent to which you found the points system in the gamified e-learning module motivating.

Item 2: To what extent did you perceive the badges and achievements as effective in improving your engagement with the e-learning content?

Item 3: To what degree did the leaderboard feature in the gamified e-learning platform influence your motivation to perform better?

Item 4: Please rate the level of challenge provided by the gamification elements in the e-learning modules.

3.3 Attribute: Learner Engagement

Item 5: How much time did you typically spend on the gamified e-learning platform per session?

Item 6: Did you complete all the modules and activities in the gamified e-learning environment? (Yes/No)

Item 7: How often did you engage with other learners or the instructor through the discussion forums or chat modules?

Item 8: Please rate your overall level of active participation and involvement in the gamified e-learning modules.

3.4 Attribute: Learner Motivation

Item 9: To what extent did the rewards and incentives offered in the gamified e-learning platform motivate your engagement with the content?

Item 10: Please rate the extent to which the competitive nature of the gamified e-learning environment increased your motivation to perform well.

3.5 Attribute: Knowledge Retention

Item 11: Before starting the gamified e-learning modules, please complete the following pre-assessment to evaluate your initial knowledge of the subject. Item 12: Following your completion of the gamified e-learning modules, please fill out the following post-assessment to evaluate your knowledge retention and learning outcomes. **Attribute: Perceived Learning Effectiveness**

Item 13: Overall, how effective were the gamification techniques in enhancing your learning experience? Item 14: To what extent the gamified e-learning modules were effective in improving your engagement with the course material? Item 15: How satisfied were you with the learning outcomes achieved through the gamified e-learning environment? **Attribute: Enjoyment**

Item 16: Please rate the level of enjoyment you experienced while engaging with the gamified e-learning modules. Item 17: How entertaining and enjoyable did you find the gamification elements integrated into the e-learning platform? **Attribute: Competitiveness**

Item 18: Did the inclusion of leaderboards and rankings in the gamified e-learning environment make you more competitive? Item 19: Please rate the extent to which the competitive challenges in the gamified e-learning modules motivated you to outperform others. We ensure that the items are clear, concise, and accurately capture the intended constructs.

3.6 The Results

Structural Equation Modeling (SEM) is a robust statistical method used in scientific research to examine and analyze multivariate causal relationships. In this study, we employed Smart PLS, a user-friendly software with a graphical interface, to perform variance-based SEM using the PLS path modeling approach.

This method is widely adopted in the existing literature (Alahmadi, 2024). Our analytical approach involved two steps: First, conducting a psychometric assessment of the measurement scales, and second, evaluating the structural model using Smart PLS (Asmolov and Ledentsov, 2023). To assess the reflective measurement, we considered Gamification Elements, Learner Engagement, Knowledge Retention, Perceived Learning Effectiveness, Competitiveness, Enjoyment, and Learner Motivation as the measured constructs.

The constructs exhibited high internal consistency, evidenced by composite reliability values exceeding 70 percent. In terms of the measurement model's results, we examined outer loadings, average variance extracted (AVE), and composite reliability (CR) to confirm convergent validity.

The outer loadings for the seven constructs ranged from 0.841 to 0.931 for "Gamification Elements," 0.728 to 0.878 for "Learner Engagement," 0.843 to 0.888 for "Knowledge Retention," 0.729 to 0.848 for "Perceived Learning Effectiveness," 0.740 to 0.886 for "Competitiveness and Learner Motivation," 0.769 to 0.896 for "Enjoyment," and 0.745 to 0.758 for "Competitiveness." The AVE values for the constructs varied from 0.354 to 0.874, while the CR values ranged from 0.867 to 0.921. Convergent validity was confirmed by assessing the AVE values, all of which exceeded 50 percent, and the outer loadings. Furthermore, the latent variable correlations showed values of 0.711 for "Gamification Elements," 0.812 for "Learner Engagement," 0.854 for "Knowledge Retention," 0.741 for "Perceived Learning Effectiveness," 0.721 for "Competitiveness," 0.854 for "Enjoyment," and 0.869 for "Learner Motivation."

We also ensured discriminant validity by examining the cross-loadings, which confirmed that each item was predominantly loaded on its respective construct (Chin, 1998). Additionally, we assessed the validity of the Fornell-Larcker criterion (Fornell and Larcker, 1981), as outlined in Table 2.

Table 2: Discriminant Validity: Cross Loading

	Gamification Elements	Learner Engagement	Knowledge Retention	Perceived Learning Effectiveness	Competitive ness	Enjoyment	Learner Motivation
Mec	**0.931**	0.125	0.259	0.112	0.254	0.257	0.321
Med	**0.841**	0.254	0.158	0.325	0.098	0.177	0.258
Lea	0.147	**0.840**	0.330	0.335	0.180	0.233	0.189
LEb	0.255	**0.728**	0.228	0.150	0.133	0.211	0.156
LEc	0.128	**0.841**	0.266	0.133	0.213	0.255	0.265
Led	0.410	**0.878**	0.094	0.213	0.369	0.123	0.321
ELc	0.351	0.245	**0.843**	0.258	0.546	0.258	0.325
ELd	0.013	0.214	**0.888**	0.269	0.259	0.269	0.321
LExa	0.094	0.105	0.315	**0..729**	0.422	0.215	0.366
LExc	0.208	0.037	0.182	**0.848**	0.318	0.269	0.214
MoEb	0.454	0.049	0.258	0.158	**0.921**	**0.295**	**0.215**
MoEc	0.482	0.535	0.461	0.268	**0.826**	**0.321**	**0.219**
LExd	0.159	0.265	0.521	0.212	**0.321**	**0.769**	**0.123**
LExc	0.268	0.215	0.258	0.321	**0.261**	**0.896**	**0.254**
Ela	0.123	0.254	0.231	0.320	**0.259**	**0.125**	**0.758**
ELb	0.268	0.412	0.256	0.123	**0.351**	**0.254**	**0.745**

4. Discussion

In this section we will discuss and explain the impact of each attribute.

4.1 Gamification Elements and Learner Engagement

The analysis indicates a positive impact of gamification elements on learner engagement, with a weight of 0.805 This implies that integrating gamification techniques in e-learning modules increases learner engagement. Gamification elements, such as point systems, badges, leaderboards, or challenges, can motivate learners to actively engage with course materials and spend more time on the e-learning platform. The positive relationship between gamification elements and learner engagement is consistent with previous research, which suggests that gamification can improve learner involvement, attentiveness, and interaction with educational content. The introduction of game-like elements may lead to feeling more immersed in the learning process, ultimately resulting in increased engagement and active participation.

4.2 Gamification Elements and Learner Motivation

The analysis shows a positive impact of gamification elements on learner motivation, with a weight of 0.665. This suggests that incorporating gamification techniques in e-learning modules can enhance learner motivation. Gamification elements, such as rewards, incentives, and competitive challenges, can stimulate both intrinsic and extrinsic motivation in learners, encouraging them to engage with the course materials and perform effectively. Gamification leverages learners' desire for achievement, recognition, and progress, enhancing their motivation to actively participate and complete learning activities. By providing tangible rewards or fostering a sense of competition, gamification elements can fuel learners' drive to succeed and excel in the e-learning environment.

4.3 Gamification Elements and Perceived Learning Effectiveness

The analysis suggests a negative impact of gamification elements on perceived learning effectiveness, with a weight of -0.003. This implies that learners tend to perceive gamification as having a slightly negative effect on their perception of learning effectiveness. It is essential to emphasize that negative weight does not necessarily imply a significant decrease in perceived learning effectiveness, but rather a slight attenuation compared to the other attributes. The negative relationship might stem from the perception that gamification elements could be seen as superficial or distracting, diverting attention away from the actual learning outcomes. Furthermore, learners may regard the game-like features as primarily entertaining rather than making a significant contribution to their understanding and retention of the course content.

4.4 Gamification Elements and Enjoyment

The analysis reveals a positive impact of gamification elements on enjoyment, with a weight of 0.099. This implies that incorporating gamification techniques in e-learning modules can enhance learners' enjoyment of the learning experience. Through the inclusion of game-like elements, such as challenges, rewards, and engaging interactions, learners may discover the e-learning modules to be more enjoyable and entertaining. Enjoyment plays a crucial role in fostering engagement and motivation. When learners find the learning process enjoyable, they are more inclined to be actively engaged, enthusiastic, and motivated to sustain their learning journey. Gamification elements offer opportunities for learners to attain a sense of achievement, progress, and excitement, thereby contributing to a more enjoyable learning experience.

4.5 Knowledge Retention and Learner Engagement

The analysis indicates a positive relationship between knowledge retention and learner engagement, with a weight of 0.551. This implies that learners who retain knowledge from the e-learning modules are more inclined to engage in the learning process. When learners effectively recall and apply the course content, they may might experience a sense of accomplishment, leading to increased participation in subsequent learning activities. The positive relationship between knowledge retention and learner engagement aligns with the idea that a solid understanding of the subject matter fosters deeper engagement and participation. When learners retain information, they are better equipped to interact with the course materials, pose questions, and engage in discussions, resulting in an overall increase in engagement.

4.6 Knowledge Retention and Learner Motivation

The analysis reveals a negative relationship between knowledge retention and learner motivation, with a weight of -0.242. This suggests that there is a slight decrease in learner motivation as knowledge retention increases. It is crucial to note that the negative weight does not signify a significant decrease in motivation, but rather a slight attenuation compared to the other attributes. The negative relationship can be attributed to several factors. For instance, learners who have already retained knowledge might feel less motivated to engage with the same content repeatedly or may experience a reduction in novelty. Additionally, learners who consider themselves as having mastered the material might exhibit lower motivation to continue their learning journey.

4.7 Knowledge Retention and Perceived Learning Effectiveness

The analysis indicates a positive impact of knowledge retention on perceived learning effectiveness, with a weight of 0.350. This implies that learners who retain knowledge from the e-learning modules tend to view their LEx as more effective. When learners can recall and apply the acquired knowledge, they develop a sense of competence and confidence in their learning outcomes, which contributes to a positive perception of learning effectiveness. The positive relationship between knowledge retention and perceived learning effectiveness suggests that the capacity to retain knowledge enhances learners' confidence in their learning achievements. Learners who believe they have successfully retained information are more inclined to perceive the learning process as effective in fulfilling their educational objectives.

4.8 Knowledge Retention and Enjoyment

The analysis demonstrates a positive impact of knowledge retention on enjoyment, with a weight of 0.112. This implies that learners who retain knowledge from the e-learning modules are more likely to find enjoyment in the learning process. When learners can remember and apply the learned content, they may experience a sense of mastery and satisfaction, resulting in a more enjoyable learning experience. The positive relationship between knowledge retention and enjoyment indicates that successful retention of knowledge enhances learners' overall satisfaction and positive emotions throughout the learning process. The ability to recall and apply information

fosters a sense of progress and achievement, subsequently elevating the enjoyment of the e-learning experience.

4.9 Competitiveness and Learner Engagement

The analysis indicates a negative impact of competitiveness on learner engagement, with a weight of -0.242. This indicates that as competitiveness increases, learner engagement decreases. It implies that a highly competitive environment may hinder learner engagement in the e-learning modules. The negative relationship between competitiveness and learner engagement could be attributed to various factors. Excessive competition might foster a stressful or pressurized atmosphere, diverting learners' attention from the learning material. Furthermore, intense competition may redirect learners' attention more toward outperforming others rather than engaging with the content itself.

4.10 Competitiveness and Learner Motivation

The analysis shows a positive impact of competitiveness on learner motivation, with a weight of 0.363. This implies that as competitiveness increases, learner motivation also increases. It suggests that a competitive environment within the e-learning modules can act as a motivating factor for learners.

The positive relationship between competitiveness and learner motivation suggests that learners may be inclined to excel when a competitive element is present. The presence of leaderboards, rankings, or competitive challenges can foster a desire to outperform others and achieve higher results, thus enhancing learner motivation.

4.11 Competitiveness and Perceived Learning Effectiveness

The analysis indicates a positive impact of competitiveness on perceived learning effectiveness, with a weight of 0.438. This suggests that as competitiveness increases, learners perceive their LEx as higher. A competitive environment within the e-learning modules appears to have a positive impact on learners' perception of their learning outcomes.

The positive relationship between competitiveness and perceived learning effectiveness suggests that competition can create a sense of accomplishment and improvement in learners' understanding and skills. The drive to outperform others may motivate learners to invest more effort and engage in deeper learning, resulting in a perception of higher learning effectiveness.

4.12 Competitiveness and Enjoyment

The analysis shows a positive impact of competitiveness on enjoyment, with a weight of 0.752. This implies that as competitiveness increases, learners' enjoyment of the e-learning modules also increases. A competitive environment appears to enhance the overall enjoyment experienced by learners. The positive relationship between competitiveness and enjoyment shows that competition can generate a sense of excitement, challenge, and satisfaction for learners.

The opportunity to compare their performance with others and strive for better results can enhance the overall enjoyment of the learning experience. Finally, based on the provided weights, the analysis suggests that competitiveness negatively affects learner engagement but positively affects learner motivation, perceived learning effectiveness, and enjoyment.

These findings highlight the importance of carefully designing competitive elements within e-learning modules to ensure they enhance motivation and perceived effectiveness without compromising learner engagement. Striking a balance that fosters healthy competition while maintaining a supportive and engaging learning environment is essential. The analysis suggests that knowledge retention has a positive impact on learner engagement, perceived learning effectiveness, and enjoyment. However, there is a slight negative impact on learner motivation. These findings emphasize the importance of designing e-learning modules that promote knowledge retention while ensuring that learner motivation remains high.

Educators and instructional designers should incorporate strategies that maintain motivation throughout the learning process, even as learners retain knowledge and deepen their understanding of the content. Furthermore, the analysis suggests that competitiveness has a negative impact on learner engagement while positively influencing learner motivation, perceived learning effectiveness, and enjoyment. These findings highlight the importance of carefully designing competitive elements within e-learning modules to ensure that they enhance motivation and perceived effectiveness without compromising learner engagement. Striking a

balance that promotes healthy competition while maintaining a supportive and engaging learning environment is essential.

The literature on gamification in education reveals a broad spectrum of findings concerning its effectiveness. For instance, Deterding et al. (2018) demonstrated that point systems and leaderboards significantly enhanced student motivation, yet they noted that these elements could sometimes lead to increased anxiety among learners. In contrast, Hamari et al. (2019) found that while badges and rewards positively influenced engagement, they had little effect on long-term knowledge retention.

These varied outcomes underscore the complexity of gamification as a pedagogical tool, particularly in online learning environments. Previous research has often treated gamification as a monolithic construct, without adequately differentiating between the effects of its individual components. Our study addresses this limitation by examining specific gamification elements—such as points, badges, and leaderboards—and their distinct impacts on learner outcomes in an e-learning context. By doing so, we aim to fill a critical gap in the literature and provide more targeted insights for educators seeking to implement gamification in their courses. Our research seeks to provide valuable insights into the effectiveness of gamification techniques and contribute to the design and implementation of gamified online learning environments. Through a comprehensive literature review and empirical studies, this study aims to deepen the understanding of the relationship between gamification and learner outcomes in online education. Through examining the utilization of gamification elements and the utilization of surveys, interviews, and data analysis, the study's objective is to collect insights from a diverse sample of online learners and examine the benefits of gamification in improving engagement, motivation, and knowledge retention.

The study findings reveal that there is a positive relationship between gamification elements on learner engagement and motivation. Integrating game-like elements, such as points systems, badges, and challenges, enhances learner engagement and increases their enjoyment of the learning experience. Furthermore, gamification techniques have a positive impact on knowledge retention, as learners who retain knowledge tend to be more engaged in the learning process. However, there is a slight negative impact on perceived learning effectiveness, potentially arising from the perception of gamification as superficial or distracting.

This research makes a significant contribution to the existing literature by providing evidence of the positive impact of gamification on learner engagement, motivation, and knowledge retention in online education. By filling the gap in comprehensive research on gamification in online learning environments, the study aims to provide evidence-based recommendations for the effective integration of gamification into educational practices. The study holds significant implications for educators, instructional designers, and policymakers, highlighting the potential of gamification techniques to improve learner outcomes in online education.

5. Conclusion

This study delved into the impact of gamification techniques on e-learning outcomes, focusing on learner engagement, motivation, knowledge retention, perceived learning effectiveness, enjoyment, and competitiveness. Our findings provide valuable insights into how gamification elements influence these constructs, guided by the theoretical framework of SDT.

Key findings from our study include:

1. **Enhanced Learner Engagement and Motivation**: Gamification elements significantly boost learner engagement and motivation, with weights of 0.805 and 0.665, respectively. These elements act as catalysts, encouraging learners to interact more deeply with course materials and actively participate in learning activities.

2. **Increased Enjoyment**: The incorporation of gamification techniques enhances learners' enjoyment of the learning experience, evidenced by a weight of 0.099. Enjoyment plays a crucial role in sustaining engagement and motivation throughout the learning process.

3. **Complex Impact on Perceived Learning Effectiveness**: Despite the positive effects on engagement and enjoyment, gamification elements exhibit a slight negative impact on perceived learning effectiveness, with a weight of -0.003. This suggests that while gamification can make learning more engaging and enjoyable, it is crucial to ensure that these elements do not overshadow the primary educational objectives.

4. **Positive Correlation between Knowledge Retention and Engagement**: Knowledge retention shows a strong positive correlation with learner engagement (weight of 0.551) and perceived learning effectiveness (weight of 0.350). Effective retention strategies are vital for enhancing learners' perceptions of their learning achievements and sustaining their engagement.
5. **Divergent Impacts of Competitiveness**: Competitiveness in gamification positively influences learner motivation, perceived learning effectiveness, and enjoyment (weights of 0.363, 0.438, and 0.752, respectively). However, it negatively affects learner engagement, with a weight of -0.242. This indicates the need for a balanced approach to incorporating competitive elements, maximizing their motivational benefits while minimizing their potential to reduce engagement.

Implications for Practice: Our study provides robust evidence supporting the efficacy of gamification techniques in e-learning. By leveraging insights from statistical analyses and theoretical frameworks like SDT, educators and instructional designers can craft tailored gamified e-learning environments. Key recommendations include:

- **Integrate Meaningful Gamification Elements**: Design gamification elements that align closely with educational objectives to ensure they enhance, rather than distract from, learning outcomes.
- **Foster a Balance in Competitive Elements**: Implement competitive elements that motivate learners while maintaining a supportive and engaging environment to prevent excessive pressure or stress.
- **Promote Knowledge Retention**: Employ strategies that actively engage learners to promote knowledge retention, thereby enhancing perceived learning effectiveness and overall satisfaction with the learning experience.

Gamification holds significant potential to enrich e-learning experiences by increasing engagement, motivation, and enjoyment. However, careful design and implementation are essential to balance these benefits with the need to maintain focus on core learning objectives. These findings contribute to the growing body of literature on gamification in online education and offer practical guidelines for educators and instructional designers aiming to optearning environments

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Unlocking Insights: Harnessing Primary School Children's Experiences and Reflections on Emergency Remote Learning to Shape K-12 e-Learning in the Post-Pandemic Era

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Abstract: The study aimed to investigate the impact of the COVID-19 pandemic on primary education in Cyprus and to discern the implications for the post-pandemic era, specifically focusing on the Emergency Remote Learning (ERL) experiences and reflections of upper primary students (ages 9-12). Grounded in socio-constructivist learning theory, which emphasizes the importance of active student engagement and social interaction in the learning process, the research explored the challenges students faced during the rapid shift to remote education. A mixed-methods design was employed, using an in-depth online survey that incorporated both quantitative and qualitative questions. Data were collected from a sample of 204 students selected through non-probability, convenience sampling. The analysis revealed that students experienced several challenges, including technology constraints, lack of interaction, and difficulty maintaining concentration, which are consistent with global findings on K-12 ERL. Among demographic factors, the type of school attended (public vs. private) had a significant influence on most aspects of students' ERL experience. Private school students reported more favourable conditions than their public school counterparts, which facilitated a smoother shift to both asynchronous and synchronous ERL, resulting in a more positive overall ERL experience. Regardless of the type of school attended, students overwhelmingly expressed a strong preference for face-to-face learning. Comparisons with other studies conducted in Cyprus during the same period involving older student age cohorts suggest significant age-related differences. The young students in our study encountered greater challenges during the transition to ERL, which can be attributed to their heightened need for scaffolding and external regulation to learn in the virtual space, as well as the higher importance they attached to the social aspects of school life taken away by ERL. Despite their largely negative experiences with ERL, a high proportion of the children advocated integrating the e-learning tools and technologies they got acquainted with during ERL into the normal context of schooling. These findings underscore the importance of further research into effective instructional strategies tailored to young learners in both online and blended learning settings. They also highlight the potential benefits of incorporating e-learning tools into conventional classrooms to enhance the teaching and learning process.

Keywords: COVID-19, Primary education, Students' perceptions, Emergency remote learning, Online learning, e-Learning

1. Introduction

The conditions imposed by the outburst of the COVID-19 pandemic, which led to a general lockdown and social distancing had a major impact on all areas of human activity, with education being one of the sectors most severely affected. The suspension of face-to-face education presented unprecedented challenges, causing the most significant and widespread disruption in educational history (UNESCO, 2020), affecting nearly all students worldwide, and causing major implications for both the delivery and experience of education (Meinck, Fraillon and Strietholt, 2022). Nonetheless, educators and educational systems globally made massive efforts to sustain the educational process, swiftly transitioning to online forms of instruction to mitigate the repercussions of school closures on student learning. Students were hurried to online learning platforms and to what has come to be known as Emergency Remote Learning (ERL), a term coined to depict the sudden shift to an alternate instructional mode during crisis situations (Barbour et al., 2020), and to distinguish it from intentionally planned and executed online learning in non-crisis circumstances (Johnson et al., 2023).

During the pandemic's first peak in 2020, researchers globally engaged in empirical research aimed at examining the impact on education of the seismic shifts in both school as a physical structure and schooling as a broader concept (Stone-Johnson, 2020). While a considerable amount of research has examined the pandemic's impact on education, much of it has focused on higher education and specific disciplines (Tang, 2023). Studies on primary education are limited, and even fewer have investigated how young students, particularly in primary schools, adapted to the abrupt shift to ERL. Understanding how younger students navigated this transition is crucial, as they may have faced distinct challenges compared to older students, especially in terms of digital literacy, learning environments, and educational support at home. This study addresses the gap by focusing

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specifically on upper primary school students (ages 9-12) in Cyprus, exploring their experiences during the initial lockdown in March 2020 and reflecting on the implications for K-12 education post-pandemic.

The core educational problem this study aims to investigate is how the abrupt shift to ERL impacted primary students' learning experiences and outcomes. In particular, this research seeks to examine the challenges students faced, the effectiveness of the ERL implementation, and the broader implications for future education in the post-COVID-19 era. By focusing on students' own perspectives, this study aims to provide valuable insights into the needs and adaptations required for young learners in ERL situations.

The following research questions guided the study:

- What were students' technological background and level of technology use at home and school prior to COVID-19, and how did these vary based on demographic characteristics (gender, grade level, type of school)?
- How was ERL implemented during the first lockdown and how did this vary based on students' demographic characteristics?
- What issues and challenges did students face during the transition from face-to-face to ERL and how did these vary based on demographic characteristics?
- What were students' reflections on their ERL experience and suggestions for the post-COVID-19 era?

2. Literature Review

The COVID-19 crisis acted as an accelerator for educational change, providing a unique opportunity for digitalizing education and transforming educational infrastructures and services into a new, unprecedented reality. The sudden transition to ERL, compelled educators of all levels worldwide to rapidly integrate modern internet technologies into teaching and learning processes, as these became the sole medium available (Xu and Xue, 2023). This was instrumental for the promotion of e-learning platforms and tools (Tang, 2023). Despite the abruptness of this transition, educators demonstrated remarkable resilience, adapting traditional face-to-face instruction to virtual environments while exploring innovative pedagogical approaches (Kosmas et al., 2022). This shift, which starkly contrasted with the slow pace of technological adoption in mainstream classrooms pre-pandemic (Sofianidis et al., 2021), allowed educators to cultivate valuable skills in online learning environment design and management (Kosmas et al., 2022). However, the process was fraught with challenges, as most educational systems were ill-equipped for the swift changes required in course design, delivery, and infrastructure, which occurred too rapidly to enable a systematic and organized move to the virtual space (Schueler and West, 2023). Educators grappled with restructuring curriculum, pedagogy, and assessment methods for virtual instruction, facing heightened levels of anxiety and burnout amidst limited support and resources (Santagata et al., 2023).

Students also had to cope a wide range of educational, psychological, social, and technological challenges during the transition to ERL (Giannoulas et al., 2021; Meletiou-Mavrotheris et al., 2022). These challenges can be partly explained by Self-Determination Theory (Deci and Ryan, 2000), which posits that students' motivation and well-being are driven by their need for autonomy, competence, and relatedness. During the transition to ERL, students' experiences of autonomy in learning were hindered by the lack of direct engagement with teachers and peers, while technological hurdles and academic losses weakened their sense of competence (Giannoulas et al., 2021). Additionally, social isolation eroded students' sense of relatedness, increasing stress and diminishing their sense of community within the learning environment. The transition to online education also undermined the adoption of pedagogical models driven by the socio-constructivist theory (Vygotsky, 1978), which highlights the importance of social interaction and collaboration in the process of knowledge construction. In a traditional classroom setting, students depend on direct interactions with peers and teachers to create meaningful learning experiences. However, during the ERL period, they were largely deprived of this social environment, which may have impeded the process of knowledge construction. Studies indicate that many students found it difficult to engage with ERL, as it offered fewer opportunities for the kind of collaborative learning essential to socio-constructivism (Kosmas et al., 2022).

In an effort to comprehensively present the impact and implications of COVID-19 on K-12 and tertiary education, Tang (2023) conducted a systematic review of the relevant literature using the PRISMA model. The review showed that the shift to ERL affected learners and educators across all levels in multiple ways, especially in relation to learning loss, limitations in methods of instruction and assessment, technology constraints, and adverse effects on psychosocial well-being. These impacts were exacerbated by disparities in resource distribution and socio-economic, gender, ethnic, and disability-related inequities. Tang's (2023) review of 41

studies found a focus on higher education, with only 10 papers addressing the impact of COVID-19 on pre-primary/primary education. Survey studies on primary education mainly involved teachers and parents due to limitations in children's participation. Non-survey studies focused on quantifying learning gain or learning loss, with findings indicating learning loss or slower gains, especially among students from disadvantaged backgrounds. Regarding students' engagement in ERL, studies highlighted challenges such as increased screen time, technological hurdles, and connectivity issues. The review also identified numerous challenges faced by teachers, including technological and pedagogical issues, resource scarcity, and limited student engagement. . It also revealed parents' concerns about the quality and time-consuming nature of ERL, mirroring teachers' challenges in student engagement and effective tool selection. Regarding children's psychological well-being, home confinement was reported to negatively impact their social, physical, and mental well-being, with insights primarily drawn from parental and/or teacher observations.

Yun (2023) conducted a systematic review of articles focused on the challenges faced by the education sector during the crisis period, again using the PRISMA approach. Four themes emerged. The first theme highlighted challenges of transition to online teaching and learning, which fell into three main sub-clusters: technological tools, digital competences, and acceptance of e-learning. The second theme highlighted professional digital competence and pedagogy challenges faced by teachers due to limited prior exposure to e-learning tools and online pedagogy. The third theme underscored educational inequality and psychological challenges, including unequal access to reliable internet and devices widening learning gaps, and student well-being concerns (e.g. excessive workload, mental stress). The final theme centred on challenges to the sustainable development of digitalized learning and highlighted the importance of digital literacy in strengthening and advancing sustainable education while promoting inclusive opportunities for all students post-COVID. Yun's (2023) review findings are consistent with Self-Determination Theory (Deci and Ryan, 2000), as inequitable access to resources weakens students' sense of autonomy and competence, leading to decreased motivation and engagement.

Xu and Xue (2023) conducted a meta-analysis spanning two decades, involving 93,686 participants across 26 countries, to assess online education satisfaction. They found student, teacher, and parent satisfaction rates of 59.5%, 75.3%, and 70.7% respectively, with students exhibiting significantly lower satisfaction. The authors attributed this to differing evaluation criteria, stressing the influence of social interactions with teachers and peers on student satisfaction, while noting that such interactions have lesser impact on teacher and parent satisfaction. Comparing satisfaction levels in ERL to non-emergency settings, they found significant drops for both students (47.1% vs. 62.3%) and teachers (40.6% vs. 79.5%). The abrupt shift to ERL, compounded by teachers' insufficient lesson design and lack of online pedagogy training, contributed to decreased satisfaction and negatively impacted mental health and academic performance. Regarding educational level, Xu and Xue (2023) found that a significantly higher proportion of adult education learners expressed satisfaction with online study compared to K-12 and university students.

Most of the studies reviewed by Yun (2023) and Xu and Xue (2023), similarly to Tang's (2023) review, centred on higher education, reflecting the dominant research focus on tertiary-level education amid the pandemic. Only few studies explored the impact of COVID-19 on primary and secondary education. Moreover, given that, in contrast to K-12 settings, online teaching and learning has been established in higher and adult education for years (Martin, Xie and Bolliger, 2022), most of the pre-pandemic online learning literature also originated from higher or adult education (Barbour, 2018). The extent to which the findings of this literature generalize to K-12 settings remains unclear (Schueler and West, 2023).

In summary, the abrupt closure of schools during the COVID-19 lockdown and the rapid shift to ERL was an unprecedented and dramatic experience for the global educational community. The limited research on K-12 students' experiences, particularly those of primary students, during this transition prompted the current study, which aimed to explore how upper primary students in Cyprus navigated the educational changes brought on by the pandemic and how these insights can inform post-pandemic education. Grounded in Self-Determination Theory (Deci and Ryan, 2000), the study sought to provide a deeper understanding of the challenges that students faced during ERL. This theoretical foundation also offered a framework for interpreting students' reflections and suggestions for the development of more resilient and adaptive educational practices in the post-pandemic era.

3. Methodology

3.1 Research Design

The study employed a mixed-methods design, combining both quantitative and qualitative data to provide a comprehensive understanding of upper primary school students' experiences with ERL. The rationale behind choosing a mixed-methods approach was to triangulate the findings with both quantitative data and qualitative insights, thereby strengthening the study's overall validity (Creswell and Plano Clark, 2018). Quantitative data helped to identify general trends in students' ERL experiences, while qualitative data allowed for deeper exploration of students' personal reflections and challenges during this transition. The convergence of these methods ensured that both the breadth and depth of students' ERL experiences were captured, with qualitative insights enriching the interpretation of the quantitative results.

The research adopted a convergent parallel mixed-methods approach, where qualitative and quantitative data were collected concurrently and analysed independently. The results were then merged during the interpretation stage to provide a comprehensive account of students' ERL experiences. This approach allowed the qualitative data to deepen the understanding of patterns identified in the quantitative results, yielding a richer and more perspective on the research problem and questions.

3.2 Instrument Development and Constructs

A survey instrument targeting upper primary school students (Grades 4–6, ages 9–12) was carefully designed to address the study's primary aim and research questions. To enhance content validity, its development was informed by both the relevant international research literature and earlier surveys conducted by the first author during the early stages of the pandemic (EDUCAUSE, 2022; Meletiou-Mavrotheris et al., 2023; Sofianidis et al., 2021), ensuring that the measured constructs were reliable and relevant to the pandemic's impact on primary education. The survey primarily consisted of closed-ended Likert-scale and multiple-choice questions, with a few open-ended items included to allow for elaboration on students' ERL experiences.

The instrument was initially pilot-tested with five students (who were later excluded from the final sample) to evaluate its clarity, validity, and relevance. Feedback from the pilot phase led to refinements in wording and structure, ensuring the instrument was both age-appropriate and aligned with the study's aim.

The final version of the survey comprised 34 questions: 28 closed-ended and 6 open-ended, organized into five sections. Section 1 collected demographic information: gender, school grade, type of school (public or private). The remaining sections examined three key constructs, carefully selected in alignment with the Self-Determination Theory framework (Deci and Ryan, 2000), which asserts that students' motivation and learning experiences are influenced by their feelings of autonomy, competence, and relatedness. These constructs were deemed appropriate for understanding the challenges students encountered during ERL, especially in terms of how the pandemic influenced their motivation and engagement with learning. The constructs are as follows:

- **Technological Background and Usage:** This construct explored in Section 2 of the survey (Technology Access and Usage prior to the pandemic), was informed by research on digital literacy and students' readiness for online learning (Barbour, 2018). It investigated children's access to devices and personal study space, and their technological background and use of ICT at home and in school before the lockdown, factors which are critical to shaping learning in online contexts (Schueler and West, 2023).
- **ERL Implementation:** Sections 3 and 4 of the survey were developed based on literature on ERL (Johnson et al., 2023; Barbour et al., 2020). These sections aimed to capture the different modalities (synchronous vs. asynchronous) and platforms utilized during ERL, as well as the challenges students encountered during this sudden shift. The questions were designed to reflect the distinct nature of ERL as an emergency-driven approach, separate from traditional online learning models. Section 3 examined technology use post-lockdown, including the initiation of asynchronous material sharing, the tools and applications employed during ERL, and the availability of synchronous sessions. Section 4, completed by students who participated in synchronous ERL, inquired about the timing and platforms used during synchronous sessions, along with any difficulties experienced during the shift to ERL.
- **Challenges and Reflections:** Section 5 featured reflective open-ended questions designed to students' perspectives on the implementation of ERL. Drawing from research on student engagement and psychological well-being during ERL (Kosmas et al., 2022), these questions explored the key challenges students faced, including social isolation and technological obstacles. They also inquired about

measures taken by teachers to foster interaction and socialization, students' coping strategies to manage stress and anxiety, and which ERL practices students hoped would continue after the return to regular classroom settings. The open-ended format allowed students to provide thoughtful feedback on their ERL experiences and offer suggestions for improving post-pandemic education.

3.3 Data Collection and Analysis Procedures

The survey was conducted between mid-July and early September 2020, coinciding with the summer holiday period. A non-probability, convenience sampling method was used, as direct distribution to schools was not feasible due to pandemic restrictions and the timing of administration. After obtaining approval from the Cyprus Centre of Educational Research and Evaluation and the Ministry of Education, invitation letters explaining the study's purpose and providing a survey link were sent via email to the teachers' trade union board and to primary school parent associations. The teachers' trade union board, representing most primary school teachers in Cyprus, informed its members about the study and encouraged them to contact the parents/guardians of students in their class/school that had been enrolled in Grades 4-6 during the 2019-2020 school year. Likewise, parent associations' representatives distributed an invitation letter with a survey link to their members. Parents/guardians who consented, then forwarded the survey to their child for completion. Participation in the survey was voluntary and anonymous, with no personal information collected.

The quantitative data from the survey, consisting of 28 closed-ended questions, were analyzed using IBM SPSS Statistics software, employing descriptive and inferential statistics to address the research questions. Descriptive statistics (e.g. frequencies, percentages, means) summarized student responses, while inferential statistics (Mann-Whitney U tests, Kruskal-Wallis tests, t-tests, ANOVA) were used to identify variations in responses based on demographic characteristics (gender, grade level, type of school).

For the six open-ended questions, a qualitative thematic analysis approach was employed (Braun and Clarke, 2006). This involved coding the responses, identifying recurring themes, and grouping them into broader categories. Both inductive and deductive approaches were used to ensure that the analysis accurately captured the nuances of students' experiences while aligning with the research questions. This thematic analysis provided deeper insights into students' emotional and reflective responses, complementing the statistical findings from the quantitative data and offering a more comprehensive understanding of their transition from traditional to ERL environments.

3.4 Participants' Demographic Characteristics

The survey distribution method allowed for a wide reach across Cyprus, though it relied on teachers and parents to forward the survey to eligible students. A total of 204 primary school students completed the survey, with an even distribution of boys (n = 106, 52.0%) and girls (n = 98, 48.0%). Grade distribution was relatively balanced: 38% in Grade 4 (n = 77), 31% in Grade 5 (n = 64), and 31% in Grade 6 (n = 63). The majority of students (85%, n = 173) attended public schools, while 15% (n = 31) were enrolled in private schools, reflecting fairly well the typical distribution of primary school students in Cyprus. Thus, while the sample was non-random, the demographic composition of the participants closely mirrored that of the broader population of upper primary students in Cyprus in terms of gender, grade distribution, and the proportion of public vs. private school attendees. As such, the sample was considered sufficiently representative of the study's target population (ages 9-12 in Grades 4-6) for the purposes of this research.

4. Results

The survey findings have been organized into the following four sections, reflecting the research questions.

1. Technological background and technology use pre-pandemic
2. The transition to ERL
3. Issues and challenges during the transition to ERL
4. Students' reflections on their ERL experience.

The impact of students' demographic characteristics (gender, grade, type of school) on their technological background and ERL experience was explored during the analysis. Relevant results are presented in the sections that follow.

4.1 Technological Background and Technology use Pre-Pandemic

4.1.1 Technological background

The survey utilized a five-level Likert scale (1 = None at all…5 = Excellent) to gauge participants' proficiency in using PCs/laptops and tablets/smartphones. Around four-fifths (82.9%), rated their PC/laptop skills at intermediate level or higher, with one-fifth (21.6%) considering themselves to have excellent skills. Conversely, nearly everyone (88.7%) rated their proficiency with mobile devices as very high or excellent, with no participant indicating complete lack of familiarity.

Table 1 displays the results of Mann-Whitney U tests, revealing no gender-related differences in students' self-reported proficiency for either PCs/laptops (p = -0.203 > 0.05) or tablets/smartphones (p = 0.939 > 0.05). However, significant differences were observed between public and private school students for both PCs/laptops *(p < 0.01)* and tablets/smartphones *(p < 0.01)*. Additionally, Kruskal-Wallis tests revealed significant grade-related differences for both PCs/laptops *(p < 0.01)* and tablets/smartphones *(p < 0.01)*.

Table 1: Mann Whitney U tests for impact of gender and type of school, and Kruskal Wallis H for impact of grade level on self-reported level of proficiency in the use of PCs/Laptops and tablets/smartphones

Statement1	Gender differences			Type of school			Grade level	
	U(106, 98)	z	p	U(173, 31)	z	p	H(2, n=204)	p
PCs/laptops	4677.0	-1.27	-0.203	680.0	6.855	**<0.01**	42.35	**<.01***
Tablets/smartphones	5166.0	-0.08	0.939	1788.0	3.392	**<0.01**	9.814	**<.01***

*Statistically significant at a=0.05

As shown in Figure 1, students' self-reported level of proficiency tended to increase with grade/age.

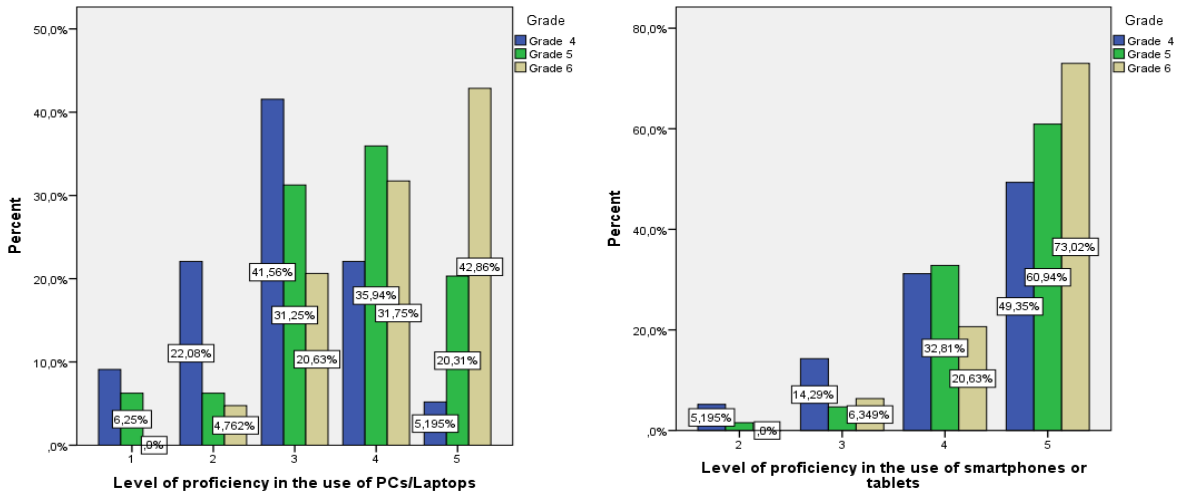

Figure 1: Self-reported levels of proficiency with PCs/laptops and tablets/smartphones, separated by grade level

Public school students tended to rate their proficiency lower, especially with PCs/laptops (see Figure 2).

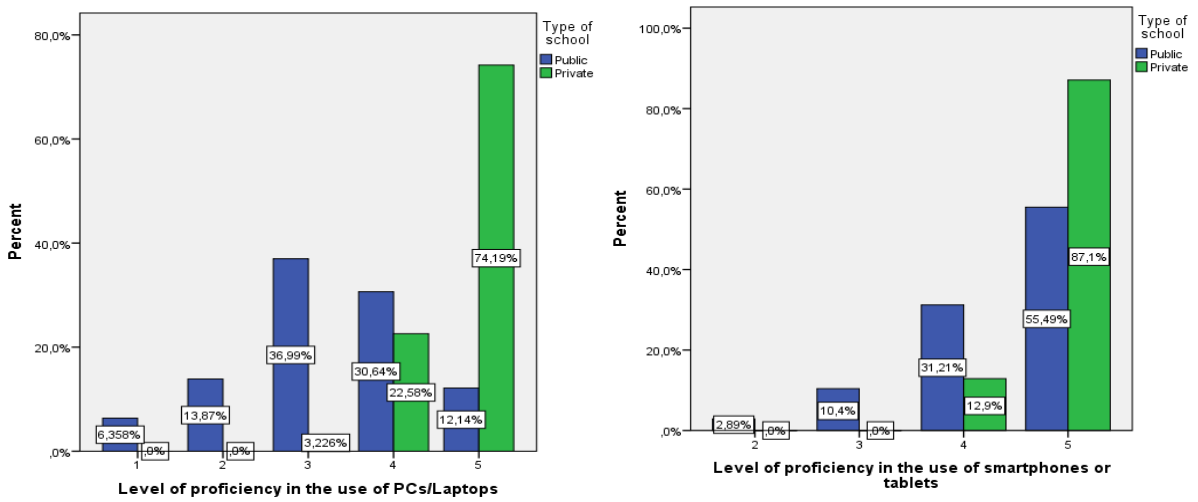

Figure 2: Self-reported level of proficiency with PCs/Laptops and Tablets/Smartphones, separated by school type

While almost all private school students (96.8%) rated their proficiency with PCs/laptops as high (4 or 5), only around 40% of public school students did. A notable proportion of public school students (20.2%) rated their skills as low (1 or 2), indicating limited or no familiarity with PCs/laptops.

4.1.2 Access to and use of technology at home and school prior to COVID-19

During ERL, home setting emerged as a critical factor affecting students' experience. Access to the internet and to a reliable device, in particular, were essential for participation in ERL. Nearly all students (98.5%) reported having access to at least one device at home, with two-thirds (66.7%) owning a smartphone, and slightly over half (55.9%) owning a tablet. Personal access to PCs/laptops was more limited, with only one-third (32.4%) owning one. The majority shared one with family members.

Almost all students (98.0%) used a mobile device at least 1-2 times a week at home, and more than half (58.7%), used a PC/laptop with the same frequency. By contrast, the majority of students reported having rarely or never used a mobile device (75.0%) and/or a computer (58.3%) at school.

As seen Table 2, grade level significantly impacted the frequency of use at school of both PCs/laptops *($p < 0.01$)* and tablets/smartphones *($p < 0.01$)*, with Grade 6 and Grade 5 students using them more often than Grade 4 students. Additionally, there were significant differences based on type of school for both PCs/laptops *($p < 0.01$)* and tablets/smartphones *($p < 0.01$)*.

Table 2: Results of Mann Whitney U tests for impact of type of school, and Kruskal Wallis H tests for impact of grade level on frequency of use at school prior to the pandemic of PCs/laptops and tablets/smartphones

Statement	Type of school			Grade level	
	U (173, 31)	z	p	H (2, n=204)	p
PCs/laptops	456.0	-8.254	<0.01*	37.0	<0.01*
Tablets/smartphones	1162.5	-6.613	<0.01*	18.06	<0.01*

*Statistically significant at a=0.05

Private school students reported much more frequent use of both devices prior to the pandemic (see Figure 3).

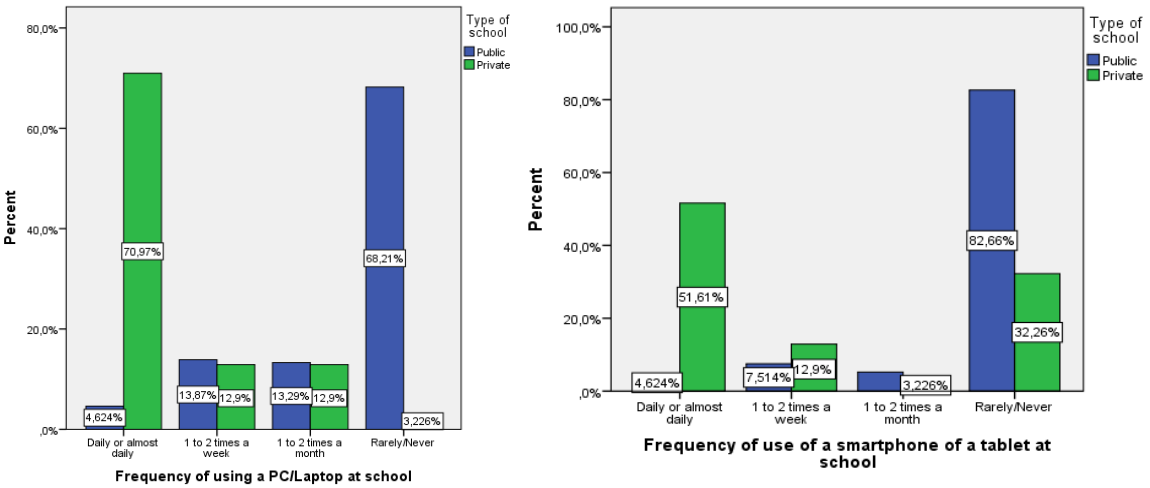

Figure 3: Students' self-reported frequency of use of PCs/laptops and tablets/smartphones at school pre-pandemic, separated by type of school

While 71% of private school students reported daily or almost daily use of PCs/laptops at school prior to COVID-19, only 5% of public school students did. In fact, two-thirds of public school students (68.2%) indicated having rarely or never used PCs/laptops at school. Similarly, while 65% of private school students indicated having used smartphones/tablets at school at least 1-2 times a week, only 12% of public school students did. Moreover, 82.7% of public school students reported having rarely or never used a smartphone/tablet at school.

Nearly all students (94.1%) reported having a dedicated study space and internet access at home. However, 12 students (5.9%) lacked internet access at home. During lockdown, to engage in education, these children had to find places with internet access outside their homes to download learning material sent by their teachers and/or attend virtual sessions.

4.2 The Transition to ERL

4.2.1 Organization of communication, educational material, and teaching methods

Following the closure of schools in Cyprus in mid-March 2020, teachers began exploring ways to engage with students remotely. Initially, they adopted asynchronous instruction, sending study materials and assignments. All participants reported being offered asynchronous ERL during the lockdown. More than half (53.4%) started receiving study materials within the first week, and around 90% within 2-3 weeks. Synchronous ERL took longer to initiate, with two-thirds (72.1%) starting synchronous sessions after at least 2-3 weeks, and about one-third (31.4%) after at least a month. Thirty students (14.7%) were not offered synchronous instruction at all.

As seen as Table 3, grade level had a statistically significant influence on the onset of both asynchronous ERL *($p < 0.01$)* and synchronous ERL *($p < 0.01$)*, with Grade 6 students having started both types of lessons earlier than students in Grades 4 and 5. There were also significant differences based on the type of school attended for both asynchronous ($p < 0.01$) and synchronous *($p < 0.01$)* ERL.

Table 3: Mann Whitney U test results for impact of type of school, and Kruskal Wallis H for impact of grade level on time it took to start asynchronous and synchronous ERL

Statement	Type of school			Grade level	
	U (173, 31)	z	p	H (2, n=204)	p
Asynchronous ERL	560.5	-7.446	**<0.01***	16.757	**<0.01***
Synchronous ERL	269.0	-8.045	**<0.01***	23.112	**<0.01***

*Statistically significant at a=0.05

Private schools initiated both asynchronous and synchronous ERL much earlier than public schools, as they were more prepared to cope with the challenges posed by the pandemic (see Figure 4 and Figure 5).

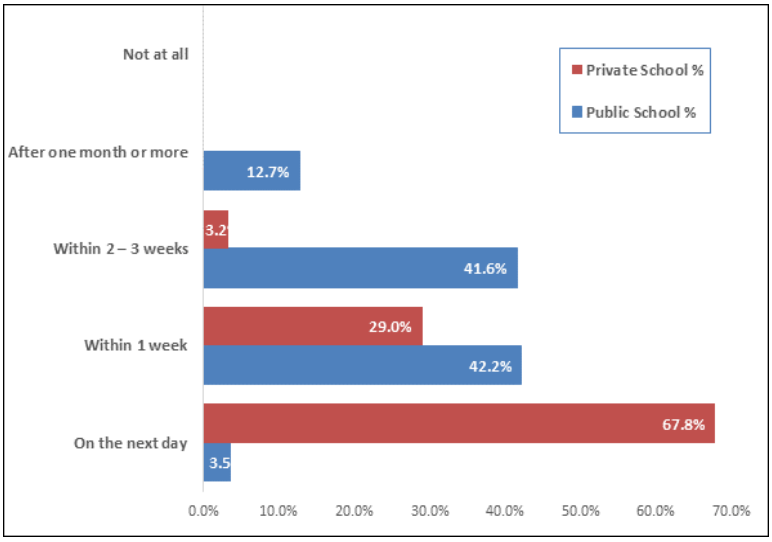

Figure 4: Time it took for asynchronous ERL to start, by type of school

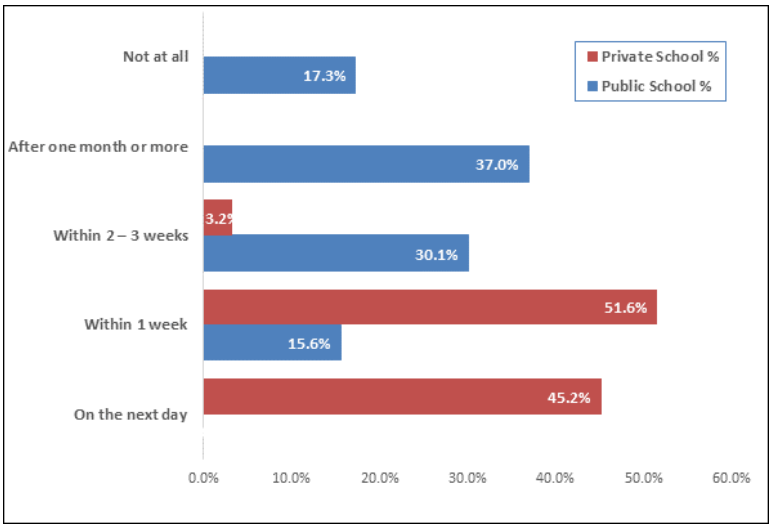

Figure 5: Time it took for synchronous ERL to start, by type of school

As discussed in Sofianidis et al. (2021), teachers in several private schools had received prior training on the use of online platforms like Microsoft Teams, enabling them to efficiently transition to ERL within a couple of days of the lockdown.

4.2.2 Technological tools employed during ERL

Various digital tools were used for teaching and learning during ERL. Figure 6 shows, in ascending order, the percentage of students who reported that their teacher incorporated each technology/technological tool into their teaching during ERL.

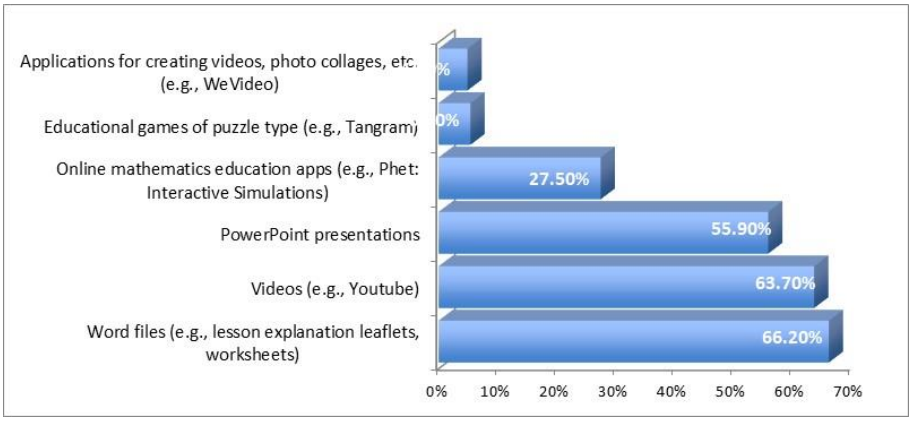

Figure 6: Digital tools employed during ERL

Approximately two-thirds reported the use of Word documents, while a similar percentage the use of YouTube videos and around half the use of PowerPoint presentations. However, fewer than one-third indicated the integration of online applications for mathematics and physics, and only a small minority the use of interactive tools like video makers or educational puzzle games like Tangram.

4.3 Challenges During the Transition to ERL

Students faced several challenges in the transition to ERL, related to infrastructure and technology access, to teachers' and students' preparedness for ERL, and to the pedagogical, social and practical aspects of ERL

4.3.1 Challenges related to infrastructure and technology access

As previously noted, not all students engaged in synchronous ERL. The 174 students (85.3%) who did, responded to questions about the challenges they encountered during the transition to ERL. A key challenge reported by students was access to appropriate technological infrastructure, including suitable devices, good internet connection, and reliable communication software. Additionally, the readiness of both teachers and students to support and manage the sweeping changes was crucial.

As already noted, almost all of the study participants had access to at least one electronic device (PC/laptop/tablet/smartphone) for individual use. This is probably the reason why, in a related question, a high majority responded that they encountered no problems at all (57.8%) or only minor problems (17.2%) in securing access to a reliable digital device. No significant differences based on gender *(U(90, 84) = 3674,50, z = -0.385, p = 0.70 > 0.05)*, grade *(H(2, n=174) = 3.661, p = 0.16 > 0.05)*, or type of school *(U(143, 31) = 1818.0, z = -1.90, p = 0.057 > 0.05)* were observed.

A reliable internet connection is vital for the needs of ERL. Looking at Figure 7, which shows students' responses to a question inquiring them about possible problems they faced related to internet connection, it becomes obvious that slow internet connection was a major issue for students in Cyprus during the lockdown.

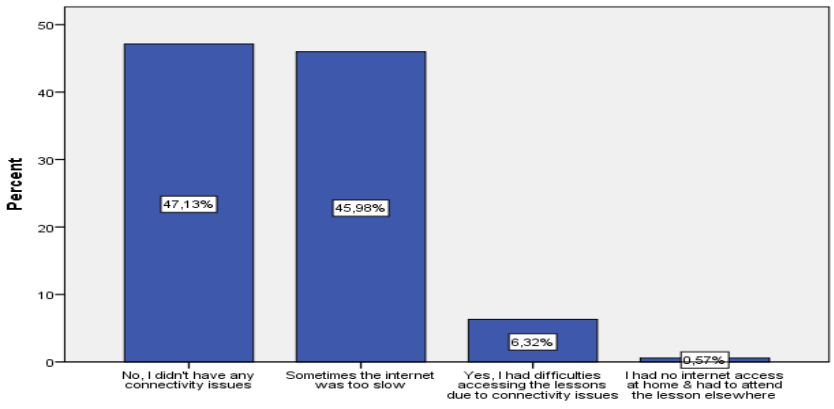

Figure 7: Students' issues in accessing a trusted internet connection

The main platform used by nearly all the surveyed students during synchronous sessions was MS Teams (92.1%) as it was endorsed in official guidelines and supported by the Ministry of Education. However, one-third also indicated use of Zoom (36.8%), and a sizeable proportion (17.2%) of some other platform (e.g. WebEx, Jitsu, Skype). The shift to ERL in the public sector took several weeks to officially start, and teachers experimented in the meantime with other platforms to maintain the educational process. When asked about the ease of accessing these platforms, the vast majority of students (94.2%) stated that they found them easy to use, encountering no problems or only minor ones (see Figure 8). However, a small proportion (5.9%) reported having encountered several problems that took a long time to resolve. No significant differences based on demographic characteristics were observed: $U_{gender}(90, 84) = 3486.500$, $z = -0.576$, $p = 0.565 > 0.05$; $H_{grade}(2, n=174) = 0.995$, $p = 0.61 > 0.05$; $U_{school}(143, 31) = 1757.500$, $z = -1.90$, $p = 0.058 > 0.05$.

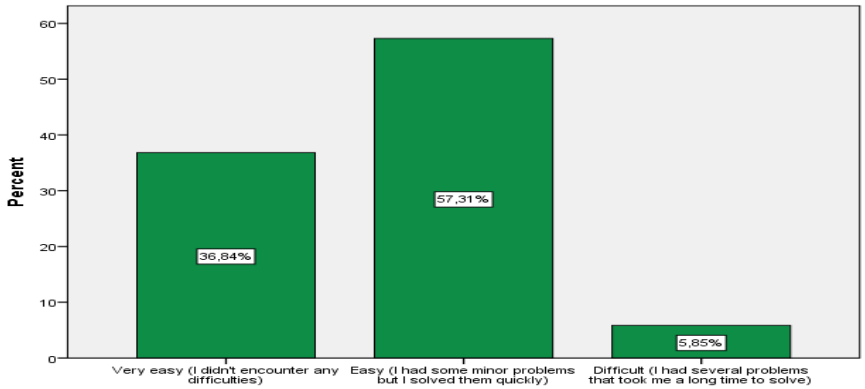

Figure 8: Students' ease of access to the e-learning platform(s) used during ERL

4.3.2 Challenges related to teachers' and students' level of preparedness for ERL

Students' challenges in transitioning to synchronous ERL were influenced by both their teachers' preparedness for ERL and their own readiness. Regarding students' perceptions about their teachers' level of familiarity with the technologies and/or tools needed for synchronous ERL, the majority (79.9%) stated that their teachers faced only minimal difficulties. Still, for 35 students (20.1%), their teachers' lack of familiarity with e-learning tools was a challenge that negatively affected, to a large or moderate extent, their transition to ERL (see Figure 9).

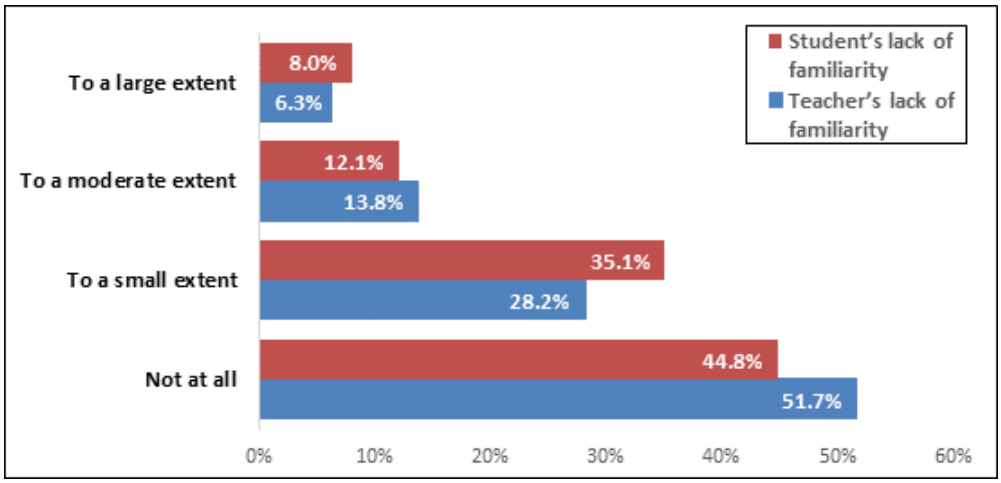

Figure 9: Extent to which their teachers' and/or their own lack of familiarity with e-learning tools and technologies made students' transition to synchronous ERL difficult

Students' perceptions regarding their own level of familiarity with e-learning tools and technologies were similar. Although most respondents (79.9%) reported that they experienced minimal problems during the transition to ERL, 35 students (20.1%) indicated that their own discomfort or lack of familiarity with the required technologies or tools was a challenge negatively impacting their transition to ERL.

The factors gender *($U_{teachers}(90, 84) = 3724.500$, $z = -0.183$, $p = 0.855 > 0.05$; $U_{students}(90, 84) = 3569.500$, $z= 0.682$, $p = 0.495 > 0.05$)* and grade *($H_{teachers}(2, n = 174) = 0.868$, $p = 0.648 > 0.05$; $H_{students}(2, n = 174) = 4.656$, $p = 0.097$*

> 0.05) did not have a significant effect on students' perceptions regarding their own level of readiness or that of their teachers. In contrast, the type of school attended did have an impact on perceptions of both teacher readiness *(U(143, 31) = 1634.0, z = -2.505, p = 0.012 < 0.05)* and students' *readiness (U(134,31) = 1142.50, z = -3.274, p = 0,001 < 0.05),* with private school students considering both their teachers and themselves to be more familiar with the technologies employed in online class sessions than public school students did.

4.3.3 Challenges Related to the Pedagogical, Social and Practical Aspects of ERL

Students that participated in synchronous ERL (n = 174) were asked to indicate, using a four-level Likert scale (1 = To a large extent, 2 = To a moderate extent, 3 = To a small extent, and 4 = Not at all), the extent to which a number of educational, social, and practical issues made it difficult to switch to ERL. Figure 10 shows, in ascending order, the percentage indicating that each issue was a challenge to a moderate or large extent.

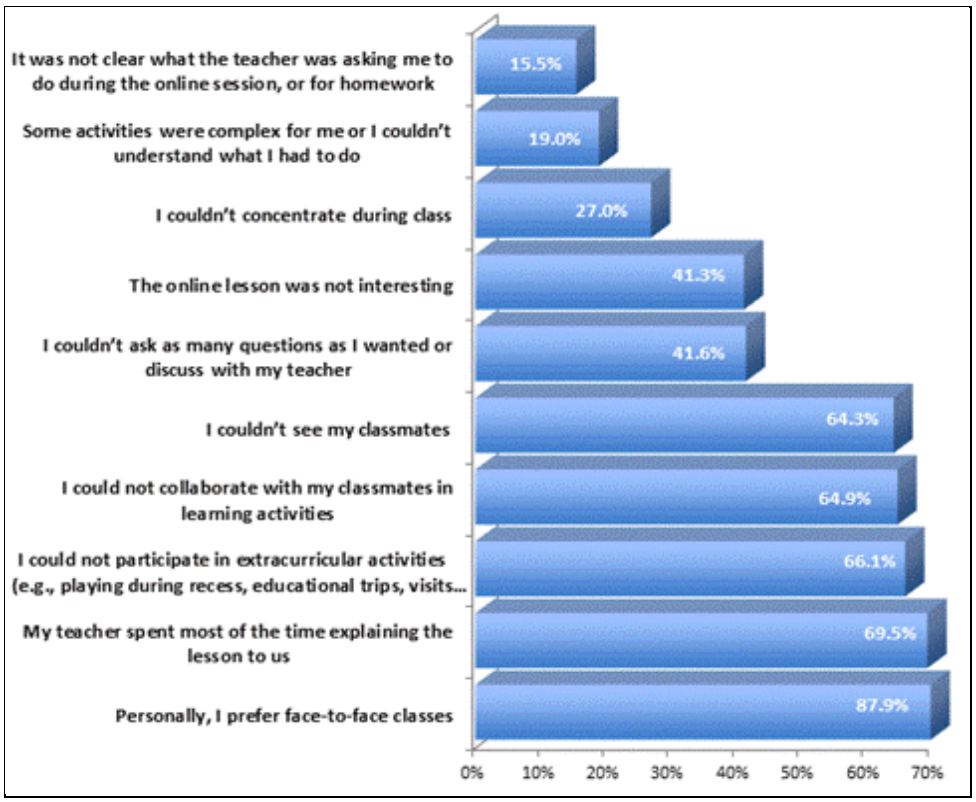

Figure 10: Percentage of students for whom each issue was a challenge "to a moderate extent" or "to a large extent". during the transition to ERL

Nearly 90% of participants (87.9%) expressed preference for face-to-face instruction which made it difficult for them to switch to ERL. This seems to be linked to teachers lecturing during most part of the lesson (69.5%), making online classes less interesting (41.3%) and harder to concentrate in (27.0%), with limited opportunities for discussion or posing of questions (41.6%). Additionally, the inability to see their classmates (64.9%) and engage in collaborative learning (64.9%) or extracurricular activities (66.1%), also seems to have influenced students' preference for face-to-face instruction. Smaller but still sizeable proportions indicated finding online activities challenging (19.0%) or having difficulties understanding teacher instructions (15.5%).

Students' responses to the open-ended questions echo quantitative data, indicating their preference for face-to-face instruction. They stressed limited opportunities for communication/interaction with their classmates and the teacher during ERL, and the teacher's tendency to mainly lecture. Several children expressed feelings of loneliness and disconnection from peers, exacerbated by the inability to activate video cameras during synchronous sessions (in Cypriot public schools, cameras were centrally disabled for safety/privacy reasons):

S42 It would be nice to see each other, but this is not the teacher's choice.

S98 I could not see my classmates/friends on camera.

Most students expressed a desire for collaborative work, lamenting its absence during ERL. Nonetheless, some reported positive experiences fostering a sense of closeness through activities like breakout groups. Regarding the lack of extracurricular activities, many longed for pre-pandemic events like school excursions.

Mann Whitney U tests were conducted to examine the impact of gender and school type and Kruskal Wallis H tests the impact of grade level on students' ratings of the extent to which each issue posed a challenge for them during their transition to ERL. The results are illustrated in Table 4.

Table 4: Mann Whitney U test results for gender and type of school, and Kruskal Wallis H for grade level

Statement	Gender differences			Type of school			Grade level	
	U(90, 84)	z	p	U(143, 31)	z	p	H (2,n=174)	p
Personally, I prefer face-to-face classes	3464	-1.213	0.225	2138	-0.393	0.694	0.002	0.999
My teacher spent most of the time explaining the lesson to us	3740	-0.126	0.899	940.5	-5.265	**<.001***	14.707	<.001*
I could not participate in extracurricular activities	3772	-0.027	0.979	992	-5.357	**<.001***	13.289	0.001*
I could not collaborate with my classmates in learning activities	3686.5	-0.3	0.764	805.5	-5.92	**<.001***	12.819	0.002*
I couldn't see my classmates	3594.5	-0.607	0.544	1428.5	-3.365	**<.001***	2.322	0.313
I couldn't ask as many questions as I wanted or discuss with my teacher	3489.5	-0.913	0.361	1051	-4.785	**<.001***	2.843	0.241
The online lesson was not interesting	3348	-1.349	0.177	1668.5	-2.235	**0.025***	0.564	0.754
I couldn't concentrate during class	3304.5	-1.514	0.13	1581.5	-2.641	**0.008***	1.605	0.448
Some activities were complex for me or I couldn't understand what I had to do	3113	-2.162	**0.031***	1425.5	-3.348	**<.001***	6.662	**0.036***
It was not clear what the teacher was asking me to do during the online session, or for homework	3453.5	-1.093	0.274	1625	-2.586	**0.01***	0.887	0.642

*Statistically significant at a=0.05

Grade level significantly influenced students' ratings of four issues in Table 4, while gender affected only one. In contrast, the type of school attended significantly influenced students' ratings of all issues except for preference for face-to-face classes. Private school students had higher Mean Ranks for all issues compared to public school students, indicating milder experiences with ERL. This is evident when comparing the percentage of private school students considering each issue a moderate or large challenge during the transition to ERL, compared to the corresponding percentage of public school students (see Figure 11).

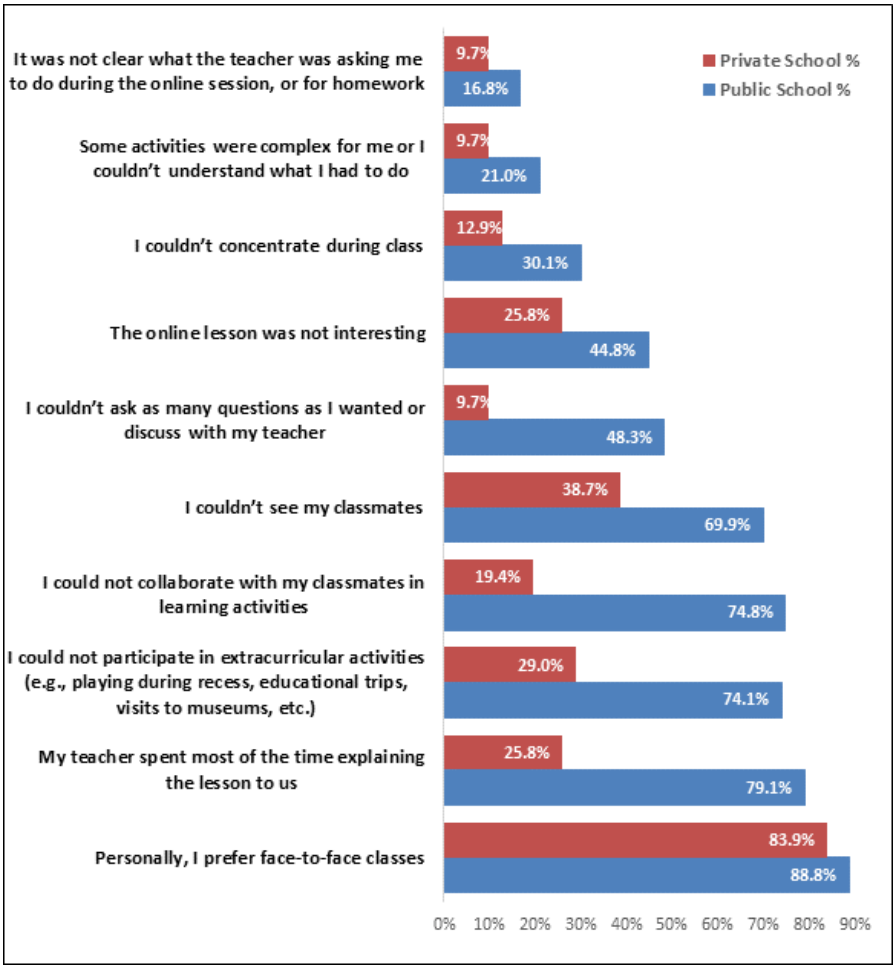

Figure 11: Percentage of students for whom each issue was a challenge "to a moderate extent" or "to a large extent". during the transition to ERL, separated by type of school

As depicted in Figure 11, public and private school students expressed a similarly strong preference for face-to-face instruction. However, the percentage of private school students indicating that each of the remaining issues posed a serious challenge during their transition to ERL was notably lower. This suggests that private school students may have experienced a more student-centred and interactive virtual learning environment, possibly due to their teachers having received prior training in online education and its pedagogy (e.g., managing breakout rooms for collaborative group work).

The qualitative analysis delved deeper into students' experiences during ERL. While a minority (13.2%) reported minimal stress during the lockdown, others reported coping with stress by communicating with friends and relatives and engaging in leisure activities like reading, exercise, music, and games. Regarding their biggest concern about COVID-19's impact on education, nearly 45% had no response or expressed no concerns. However, the majority had serious concerns about the negative impact of online education on their learning.

> *S52 My biggest concern is that if this continues, I will not be able to learn the course material adequately well to be able to start secondary school without facing difficulties.*
>
> *S180 I am worried that schools will be closed again and we will not proceed with our learning. We will move to the next grade with gaps in our knowledge.*

4.4 Students' Reflections on their ERL Experience

4.4.1 Use of tools and practices employed during ERL in the post-COVID classroom

In the last survey question, students were asked if they wanted teachers to continue any practices from the lockdown once normal school operations resumed. Almost half (47.1%) responded negatively with comments such as.

S41 No, because things at my school were much better before the pandemic.

S169 Nothing. I want things to be exactly like they used to be before COVID-19.

Among the other half who responded positively, the majority expressed a desire for teachers to integrate the tools and technologies used during ERL period into their courses:

S36 I liked the videos and apps the teacher sent us.

S80 To have the course material in electronic format.

S170 To communicate electronically with teachers if I have questions or when I miss classes due to illness.

S204 To continue using Teams in order to collaborate in groups and exchange ideas.

S12 To use tablets in the classroom.

S85 The quizzes the teacher sent us on the computer and other applications we used.

S186 Each day, we were learning more about technology and how to use it. I would like this to continue.

4.4.2 Overall ERL experience

When asked if they found it easier or more difficult to participate in synchronous sessions compared to the face-to-face classroom, two-thirds (62.1%) responded that they found it more difficult. Only 15 students (8.6%) found online classes easier. Examining the influence of demographic characteristics, a Mann Whitney U test indicated no gender-related impact on students' ease of adaption to e-learning *(U(90, 84) = 3478.500, z = 1.059, p = 0.29 > 0.05)*, in contrast to grade level where significant differences were observed *(H(2, n = 174) = 8.497, p = 0.014 < 0.05)*, with older students tending to adapt more easily. Also, the type of school attended had a statistically significant effect on ease of adaption to online learning *(U(143, 31) = 1100.500, z = -5.119, p < 0.01)*, with private school students adapting more easily.

Finally, a measure (*ERL_Experience*) was constructed from the 10 statements included in Figure 10 to measure students' overall ERL experience. The value of this new variable was obtained by calculating the average of students' responses to the 10 statements (Cronbach's alpha = .85). As mentioned earlier, students' responses to these statements were based on a four-point Likert scale (1 = To a large extent, 2 = To a moderate extent, 3 = To a small extent, and 4 = Not at all). Therefore, the higher the value of the variable *ERL_Experience*, the lower the extent to which the issues in Figure 10 posed a challenge to participants. Looking at the centre (mean=2.49, median=2.4) and overall distribution of *ERL_Experience* shown in Figure 12, one can conclude that *ERL_Experience* values tend to concentrate around 2.0-2.5, i.e. between moderate and moderate-low.

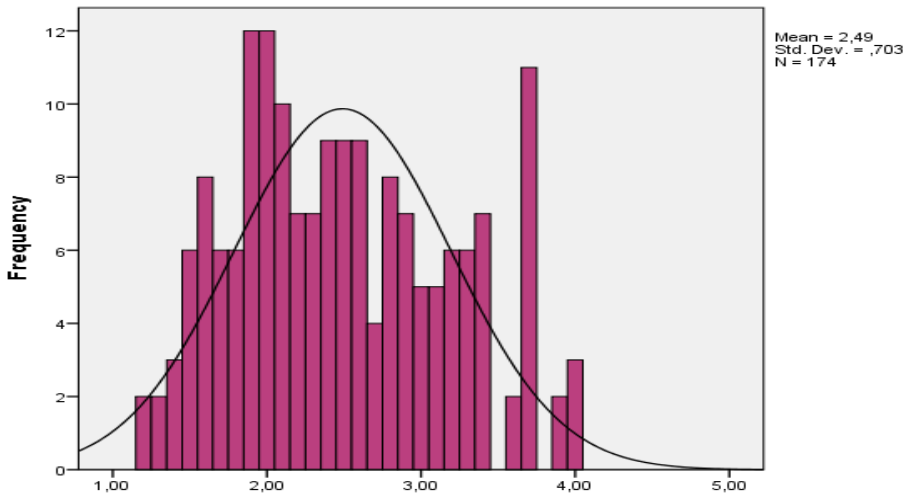

Figure 12: Frequency histogram of students' experience with emergency remote learning

An independent samples t-test revealed no gender-related differences in students' overall ERL experience *(t(172) = 1.140, p = 0.950 > 0.05)*, but a statistically significant impact of type of school attended (*t(172) = -6,449, p < 0,01),* with private school students reporting a more positive overall ERL experience (3.15 > 2.35). A one-way ANOVA showed a statistically significant effect of grade level *(F(2, 171) = 4.155, p = 0.017)* on *ERL_Experience*.

Post-hoc paired comparisons using Tukey's HSD indicated that Grade 6 students had a more positive overall ERL experience than Grade 4 students (2.69 > 2.33).

5. Discussion

This study explored the impact of the initial COVID-19-related school closure on primary education in Cyprus, with a focus on upper primary students' (ages 9-12) perspectives and experiences during the transition to ERL. While the analysis provided valuable findings, certain limitations must be acknowledged, particularly concerning the study's methodology and its implications for the validity and reliability of the findings.

The self-selected nature of survey participants and reliance on students' subjective views and perceptions limit the generalizability of the results. However, the analysis of the collected data was conducted rigorously, utilizing both quantitative and qualitative methods, which enhanced the credibility of the findings. The mixed-methods approach allowed for the triangulation of quantitative survey responses with qualitative thematic insights, offering a comprehensive understanding of students' ERL experiences. Nonetheless, the non-probability sampling method and online survey distribution may have resulted in underrepresentation of students without access to digital resources, potentially affecting the results. Additionally, given the young age of participants, parental assistance in completing the survey could have influenced their responses. The timing of the survey (summer 2020), may have also influenced participants' responses, potentially yielding different results compared to conducting it during or after subsequent lockdowns, when teachers and students became more accustomed to distance education.

Despite these limitations , the study offers some unique insights that concur with and add to the sparse literature on K-12 students', and particularly primary students', experiences during the transition to ERL. The findings indicate that the children in our study faced several challenges in their transition to ERL, similar in nature to those reported globally for K-12 and higher education students (Tang, 2023, Yun, 2023): technology constraints, internet connectivity issues, disparities in access and/or accessibility to ICT tools and resources, gaps in teachers' and students' digital literacy skills, feelings of loneliness, teacher-centred environments with limited interactions, concentration issues, concerns about learning loss, psychological well-being issues.

A key finding of the study was the huge impact of the type of school attended on students' ERL experience. In contrast to gender, which showed no significant effect on any aspect of ERL, and grade level which affected only some aspects (e.g., an earlier shift for Grade 6 students to both asynchronous and synchronous ERL), the type of school attended had a significant impact on almost all aspects of students' ERL experience. Private school students, typically from middle or upper socioeconomic backgrounds, had more favourable conditions compared to their public school counterparts. They reported greater familiarity with technology and readiness for ERL along with higher technology use at school prior to the pandemic. Additionally, they benefited from teachers with prior e-learning training and experienced a much swifter transition to both asynchronous and synchronous ERL. Consequently, they transitioned more smoothly to ERL, adapting more easily to the virtual environment and reporting a more positive overall ERL experience than public school students. Thus, our findings are consistent with international research showing that the pandemic's impact on students was worsened by socioeconomic disparities (Davidovitch, 2022; Tang, 2023). These results emphasize how COVID-19 amplified existing educational inequalities, underscoring the need for educational policies that address these disparities.

Our findings also suggest that younger students, particularly those in primary education, faced greater challenges adapting to remote learning compared to older students. The overwhelming majority of the children expressed preference for face-to-face instruction and the desire to return to conventional education. Almost 90% agreed that this preference made difficult the transition to ERL. To provide context, we compare these findings with prior research conducted in Cyprus by the first author on secondary and tertiary students' transition to ERL (Meletiou-Mavrotheris et al., 2022; Meletiou-Mavrotheris et al., 2023; Sofianidis et al., 2021). These studies employed survey instruments with several identical or similar questions to those in the present study. When posed the same question, secondary and tertiary students in the studies by Meletiou-Mavrotheris et al. (2022) and Sofianidis et al. (2021) similarly expressed a clear preference for face-to-face instruction. However, the percentages agreeing that this preference hindered their transition to emergency remote learning (ERL) were lower than in this study: 76% of secondary students, 70% of undergraduates, and 40% of graduate students. These statistics suggest that younger students are more inclined towards face-to-face instruction, implying that age and developmental stage played a significant role in students' transition to ERL. This trend reinforces the idea that a student's developmental stage plays a crucial role in how students engage with online learning environments.

Another factor contributing to the strong preference for face-to-face learning among the young students in our study was the loss of socialization associated with school life. In line with the international literature (Giannoulas et al., 2021; Tang, 2023; Xu and Xue, 2023; Yun, 2023), social distancing from classmates, teachers, and friends made it particularly challenging for the primary school children to adapt to the ERL environment. Missing interactions with classmates and the cancellation of extracurricular activities were significant obstacles for 64% and 66% of participants, respectively.

Students' expressed preference for face-to-face instruction may also be linked to the teacher-centred approach adopted during ERL, which resulted in less engaging virtual lessons. Similarly to educators globally (Yun, 2023), most teachers in Cyprus lacked familiarity with online pedagogy and the real affordances of e-learning technologies for promoting student-centred, collaborative learning. This limited opportunities for active participation, interaction, and collaboration in virtual classrooms, which are central to socio-constructivist views of learning.

A further indication of primary students' strong preference for face-to-face learning in our study is that nearly half of the participants reported not wanting any aspects of the ERL period to continue in normal school operations. The heightened challenges faced by these younger students, along with their stronger preference for in-person instruction compared to older counterparts, can be partially explained through Self-Determination Theory (Deci and Ryan, 2000), which highlights the importance of autonomy, competence, and relatedness in fostering motivation and engagement. Given their developmental stage, primary students are less independent and require more scaffolding (Martin et al., 2022), making it difficult for them to meet these psychological needs in a remote learning environment, where teacher support was often lacking due to the sudden and unplanned transition to ERL. The loss of direct interaction with teachers and peers, essential for satisfying the need for relatedness, and the absence of structured guidance typical of face-to-face learning, crucial for building competence and autonomy, proved particularly challenging for younger learners.

Although nearly half of the children, upon reflecting on their ERL experience, stated they did not wish for any elements of that period to be carried forward into regular school operations, the other half expressed a desire for their teachers to integrate e-learning tools and technologies into conventional instruction. Although this proportion is considerably lower than the percentage of secondary and higher education students in Cyprus that expressed a similar wish (Meletiou-Mavrotheris et al., 2022; Sofianidis et al., 2021), it still signifies that many children found the online tools beneficial in the normal context of schooling. The majority of Cypriot public primary school teachers in the Meletiou-Mavrotheris et al. (2023) survey study also advocated the integration of e-learning tools and practices into face-to-face instruction, with over 70% expressing their intent to continue using such tools post-pandemic. Indeed, a study by Kosmas et al. (2022) which investigated the reality in K-12 schools after return to face-to-face instruction, found that a significant percentage of teachers continued to integrate distance learning tools and practices to enhance learning and communication in their conventional classrooms.

Our findings have important implications not only for research and practice in ERL situations but, more broadly, for K–12 online teaching and learning. They suggest that the established research base on the essential components of online instruction for adult learners may not be directly applicable to K-12 education due to the diverse developmental needs, situational characteristics, and support systems required for school-age children (Johnson et al., 2023; Barbour, 2018). Knowles' principles of andragogy, which underpin online pedagogy, emphasize adults' autonomy in learning (Groenestijn, 2007). The greater openness to online learning generated by the pandemic (Schueler and West, 2023), underscores the urgency for further research focused on K-12 learners to comprehend and cater to their developmental needs. As Johnson et al. (2023) stress, and as confirmed by our study, while developmental characteristics vary among same-age learners, there is a correlation between human development and chronological age influencing students' learning approaches and thus necessitating tailored pedagogical approaches for online learning. Younger students tend to require more scaffolding and external regulation to learn in the virtual space (Martin et al., 2022), as evidenced by studies conducted during the pandemic which indicated inadequate skills for independent online learning even among upper secondary students (Bhaumik and Priyadarshini, 2020). Future research targeting young learners can contribute to enhancing our understanding of effective instructional practices in both remote and blended learning contexts.

6. Conclusions

Several methodological limitations of the current study, such as the self-selected sample, subjective responses, and non-representative sampling, limit the generalizability of its results. To strengthen the validity of future research, more rigorous sampling methods and the inclusion of diverse student populations are essential.

Despite the limitations, the study findings offer important insights into primary school students' experiences with ERL during the early stages of the COVID-19 pandemic. The research has highlighted significant challenges encountered by students, including technology-related barriers and psychological difficulties. Future studies should aim to refine this focus further. Instead of broadly addressing students' overall ERL experience, it would be beneficial to investigate more specific aspects, such as digital literacy, accessibility issues, and mental health outcomes. This approach will facilitate a deeper understanding of how various student groups were impacted by remote education.

The results also underscore the importance of addressing socioeconomic disparities in access to education, which were exacerbated by the pandemic. The educational inequalities laid bare during the shift to ERL, should serve as an impetus for systemic reform in the post-COVID era. Educational systems must seize this opportunity to evaluate and tackle practical barriers to learning, including limited access and accessibility to technological devices, and to promote-e-education equity. Embracing pedagogical approaches and frameworks that foster motivating and inclusive learning environments will ensure that all learners, irrespective of socio-economic background, have access to high-quality learning experiences.

Although this research highlights the downsides to virtual learning that make in-person instruction preferable for K-12 students (Schueler and West, 2023), it also points to the potential for integrating e-learning tools into conventional classroom settings. The e-learning skills and experiences that teachers gained during ERL should be leveraged to instigate sustainable, positive changes to the schooling system (Santagata et al., 2023). However, any integration of e-learning tools in online and blended learning environments must be done thoughtfully, with careful consideration of young learners' unique developmental needs. Ongoing professional development in e-learning pedagogy, informed by research focused on K-12 online teaching and learning, is essential for educators to acquire the knowledge and skills necessary to utilize e-learning technologies in pedagogically sound ways that promote student engagement, inquiry-based learning, and the development of 21st century competencies like self-directed learning, communication, collaboration, and ICT proficiency (Choy and Cheung, 2022).

In conclusion, while this study has shed light on primary school students' experiences during the COVID-19 school closures, it has also highlighted several avenues for further investigation. More specific, targeted studies that explore the differential impact of ERL on various student subgroups are needed to inform educational strategies moving forward. By doing so, we can ensure that all students have the opportunity to thrive in a post-pandemic educational landscape.

Ethics statement: The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Cyprus Center of Educational Research and Assessment and by the Department of Secondary Education of the Ministry of Education of the Republic of Cyprus (protocol code 7.4.01.2, 26 May 2020).

AI statement: No AI was employed during the research conduct or initial drafting of this paper. During the manuscript refinement phase, ChatGPT was used selectively for language editing when deemed beneficial. This assistance was aimed at enhancing the clarity, coherence, and style of the text, while ensuring the integrity of the original content was preserved.

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Leveraging Data Analytics to Investigate the Effectiveness of Flipped Classroom Models: A Case Study of Practical Programming Teaching

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Abstract: Educators face multiple challenges when teaching programming, such as the intricate nature of programming knowledge, the choice of effective teaching methods, and the diverse abilities of learners. Traditional teaching methods often fail to address these challenges, leading to higher dropout rates and lower student grades. This paper explores a study on the effectiveness of the flipped classroom model as a strategy to enhance student engagement in a practical programming course. In addition, learning data was analyzed to examine the relationship between pre-class preparation and in-class learning outcomes. The study's results indicate that the flipped classroom model significantly enhances student engagement and performance. Students who diligently completed pre-class assignments and dedicated more time to study demonstrated improved performance in subsequent in-class exercises. The results emphasize the potential of the flipped classroom model as a successful teaching method for increasing student involvement, encouraging self-directed learning, and ultimately improving the overall educational experience in programming courses.

Keywords: Flipped classroom, Practical programming course, Learning analytics, Correlation analysis, Naive Bayes classification

1. Introduction

Teaching programming is increasingly important in today's technology-driven world, where programming skills are highly valued across various industries. However, programming is a challenging task (Sobral, 2021). Teaching programming is to develop higher-order thinking skills, including logical reasoning, algorithmic problem-solving, and computational thinking (Fessakis, Gouli and Mavroudi, 2013; Kalelioğlu, 2015). After receiving theoretical instruction in the classroom, students are encouraged to participate in practical programming sessions to familiarize themselves with programming. During these hands-on sessions, students engage in various fundamental exercises to strengthen their understanding of programming concepts and enhance their problem-solving abilities.

In this study, we implemented hands-on coding exercises using Moodle, an open-source learning management system (LMS) (Gamage, Ayres and Behrend, 2022) that allows educational institutions to deliver courses and manage online learning activities. By utilizing Moodle, instructors can create online courses to complement their offline teaching by posting study materials, pre-recorded videos, quizzes, and more. The quizzes implemented on the Moodle system mainly include multiple-choice, short-answer, and mapping questions. To provide a programming learning environment emphasizing hands-on coding, we employed the CodeRunner plugin (Lobb and Harlow, 2016) to deploy programming exercises within the Moodle system.

In previous semesters, the teaching approach involved assigning weekly exercises for students to practice both in class and at home. During classroom sessions, students would work on designated exercises under the instructor's guidance. Any unfinished exercises would be assigned as homework for further practice. However, this method posed challenges as students often lacked preparation, and it was difficult for the teacher to ensure consistent quality for all students. There were instances where the teacher had to re-teach the theory throughout the entire session before students could attempt the exercises. The excessive review of theory diminished the time available for hands-on practice, rendering the practical teaching process less effective. Implementing the flipped classroom model creates an additional learning environment that allows students to allocate more time to the subject while gathering valuable insights from their preparation at home. This approach enhances the efficiency of classroom teaching and learning.

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This study presents a new method for teaching practical programming. The proposed method is based on the fundamental idea of the flipped classroom teaching model, in which students study new content independently outside of class and use class time to engage in interactive activities such as discussions, problem-solving, and hands-on exercises (Abeysekera and Dawson, 2014). The flipped classroom is a reversed delivery model where typical lecture and homework elements are converted (Davis, 2016). Before class, students must review guidelines, watch short video lectures, complete quizzes, and participate in forum discussions (Han and Klein, 2019). Meanwhile, the class time is dedicated to exercises, projects, in-depth inquiries about the pre-watched lectures, and engaging in hands-on activities (Liu, Wang and Izadpanah, 2023). At the same time, the instructor assesses the learners' application of knowledge.

In the proposed experimental model, we introduced pre-class materials, including online resources and basic hands-on exercises, for learners to complete before attending the practical sessions. Learners were additionally assigned more difficult and complex exercises during the in-class practical sessions than at home. The outcomes obtained from this experiment were then used to evaluate the feasibility and effectiveness of the proposed teaching model.

This research examines explicitly two main areas: (1) the influence of pre-class preparation on students' preparedness and preparation in class and (2) the relationship between pre-class and in-class learning activities, utilizing learning analytics to gain a more comprehensive understanding of student engagement and performance patterns.

The subsequent sections of this paper are structured in the following manner. Section 2 summarizes related works to clarify our study's framework. Then, Section 3 describes the proposed design and implementation. The effectiveness of flipped classroom implementation in programming courses is discussed in Section 4. Section 5 presents an additional learning analytics approach that examines the relationship between pre-class and in-class activities. This approach enhances the effectiveness of the flipped classroom model in improving student performance. Sections 6 and 7 conclude our study by presenting limitations, remarks, and future directions.

2. Related Works

2.1 Challenges and Innovations in Teaching Programming

Teaching programming presents many challenges for educators, encompassing the nature and complexity of programming knowledge, the wide selection of pedagogical methods, and the heterogeneity of learner abilities (Kadar, et al., 2022). Core concepts such as iteration, language-specific constructs, and program design are abstract, making them difficult for students to grasp (Rouhani, et al., 2022). Moreover, programming technologies' dynamic and ever-evolving nature requires educators to continuously update their knowledge and instructional materials (Caviativa, et al., 2022). For instance, in web programming courses, the rapid pace of technological change and the diversity of tools and topics demand that educators frequently revise their course content and adapt their teaching methods (López-Pimentel, et al., 2021). The challenges are further complicated due to the need to address technical skills, such as algorithmic logic and programming language syntax, and non-technical skills, such as problem-solving and teamwork (Santos, et al., 2020). The diversity of students, ranging from those with no programming experience to those with extensive development backgrounds, exacerbates the difficulty of tailoring instruction to meet all learners' needs. This issue is particularly pronounced in computer science and data analytics programs, where students' varying levels of prior experience lead to disparate performance outcomes in assignments and overall course success (Ahmaderaghi, et al., 2024).

As a result, conventional teaching approaches frequently need to effectively tackle these difficulties, leading to many students dropping out and performing poorly, particularly among non-computer science students who find programming challenging (Groher, et al., 2021). The failure rates in introductory programming courses can be remarkably high, occasionally reaching as high as 60%, highlighting students' challenges in acquiring essential skills (Shahamiri, 2019). Moreover, traditional lecture-oriented teaching approaches frequently need to be more effective in capturing students' attention, resulting in diminished motivation and participation, especially in programming courses. This passive learning mode does not foster critical thinking or active involvement, essential for mastering programming (Dietrich and Evans, 2022). Research suggests that conventional lectures effectively capture the attention of only approximately 65% of students, resulting in many students needing to be more engaged (Shah, et al., 2024).

In order to tackle these problems, novel pedagogical approaches, such as problem-based learning and the incorporation of programming challenges, have demonstrated the potential to enhance student engagement and improve learning results by fostering a collaborative and competitive atmosphere (Santos, et al., 2020;

Martins, et al., 2020). However, these methods require careful implementation and continuous assessment to ensure effectiveness (Santos, et al., 2020). One practical approach is gamification, which has been shown to significantly enhance student motivation and engagement (Papadakis and Kalogiannakis, 2019). By integrating game design elements such as points, badges, avatars, and leaderboards, educators can create a dynamic and competitive learning environment that encourages active participation and sustained interest in programming courses (Papadakis, 2020). In another research, web-based applications combining automated programming assessment with gamification concepts can also provide immediate and accurate feedback, enhancing students' willingness to participate and learn from their mistakes (Hellín, et al., 2022).

To effectively teach programming, adopting a holistic approach that considers students' varying needs and the ever-changing nature of the field is necessary to incorporate innovative teaching methods to establish a stimulating and successful learning environment.

2.2 Flipped Classroom: Application in Teaching Programming

The flipped classroom model, which reverses traditional teaching by delivering instructional content outside the classroom and focusing on interactive activities during class, has gained popularity in teaching programming. This approach enhances student learning and participation via in-class activities like problem-solving, discussions, and collaborative projects. By shifting the focus from passive information reception to active knowledge application, the flipped classroom allows students to access lecture materials, such as videos or readings, before class, freeing up classroom time for more personalized and interactive learning experiences (Rivera and Flores, 2024). This method promotes a deeper understanding of the material as students arrive prepared to engage in activities that reinforce their learning.

The flipped classroom model is particularly beneficial for accommodating diverse learning styles. It allows students to learn at their own pace outside of class and review materials as needed to ensure comprehension (Sánchez-Cuervo, 2024). Technology integration is essential in this approach, providing digital tools and platforms that deliver pre-class content and facilitate in-class activities.

In programming education, the flipped classroom has been shown to enhance student engagement, understanding, and the application of complex concepts. Research indicates that this model can significantly improve students' problem-solving skills and ability to apply theoretical knowledge in practical scenarios (Zhou, 2024). The flipped classroom fosters active learning and computational thinking- skills crucial for mastering programming languages and concepts- by allowing students to engage with lecture materials at their own pace, followed by in-class activities focused on coding exercises and collaborative projects.

Despite its benefits, the implementation of the flipped classroom model presents challenges. The success of this approach heavily depends on the quality of pre-class materials and the design of in-class activities. Poorly designed materials can lead to confusion and disengagement among students, diminishing the advantages of the flipped model (Malkoc, et al., 2024). Additionally, effective implementation requires reliable access to digital resources and technological support, which can be a barrier in some educational settings. Another challenge is the need for students to be self-motivated and disciplined in engaging with pre-class materials (Jin-gang, et al., 2024). Without this intrinsic motivation, students may come to class unprepared, hindering the effectiveness of in-class activities.

Nevertheless, the flipped classroom model has shown promise in programming education, often leading to higher levels of student satisfaction and engagement, which can result in better learning outcomes and retention of programming skills. The model also fosters a collaborative learning environment, encouraging peer-to-peer learning and support, which are beneficial in programming education, where problem-solving usually involves teamwork (Kraml, 2024). Thus, despite the challenges associated with the flipped classroom model, its application in teaching programming has generally yielded positive results, providing a more interactive, student-centered learning experience. The effectiveness of this method relies on careful and thorough planning and implementation, guaranteeing that the components before and during class are carefully crafted and smoothly incorporated. This research aims to apply methods to improve participation in pre-class activities and assess the efficacy of the flipped classroom approach in teaching practical programming courses.

2.3 Learning Analytics

Educational Data Mining (EDM) and Learning Analytics (LA) are rapidly evolving fields that leverage data-driven approaches to enhance educational outcomes. These disciplines analyze educational data to improve learning processes, personalize education, and optimize educational systems.

Educational Data Mining involves applying data mining techniques to educational data to discover patterns and insights that inform educational practices. Data analysis techniques, such as classification, clustering, and association rule mining, are used to examine data from educational environments like learning management systems and online courses. For instance, Pliuskuvienė et al. (2024) highlight using EDM to identify at-risk students and tailor interventions to improve their academic performance. Similarly, Bellaj et al. examine the use of EDM to predict student success and improve curriculum design by analyzing student interaction data (Bellaj, et al., 2024).

Learning Analytics, on the other hand, focuses on measuring, collecting, analyzing, and reporting data about learners and their contexts to comprehend and enhance the learning process and the settings in which it takes place. Cerezo et al. (2024) emphasize the role of LA in providing real-time feedback to students and educators, thereby facilitating adaptive learning environments that respond to the specific needs of each learner. Liu et al. (2023) support this approach, stating that LA can assist educators in making informed decisions by visualizing learning patterns and identifying areas for improvement.

In a study focused on programming students, various techniques, including k-nearest neighbors (kNN), decision trees, logistic regression, and neural networks, were used to predict students likely to drop out. Among these techniques, kNN achieved the highest accuracy in classifying at-risk students (Pliuskuvienė, et al., 2024). Furthermore, various machine learning algorithms such as Naïve Bayes, support vector machine, random forest, and extreme gradient boost have been employed to forecast academic accomplishments. The primary objective has been to enhance data quality by eliminating noise and fine-tuning hyperparameters (Bellaj, et al., 2024). Predictive models are essential for early intervention, enabling educators to offer timely assistance to students who may be encountering difficulties.

Figure 1 illustrates a comprehensive framework that integrates innovative teaching methods and learning analytics approaches to address the intricate challenges of teaching programming. The framework delineates three fundamental obstacles in programming education: the complex nature of programming knowledge, limited student engagement, and the heterogeneity of student skills. Traditional teaching methods frequently need help effectively tackling these problems, resulting in a higher percentage of students dropping out and subpar academic performance, particularly among students with limited or no previous programming knowledge. This research highlights the significance of implementing various instructional methods to address the above-mentioned difficulties, including gamification, flipped classrooms, and problem-based learning. These methods promote an interactive and cooperative learning setting while supporting multiple learning preferences and skill levels.

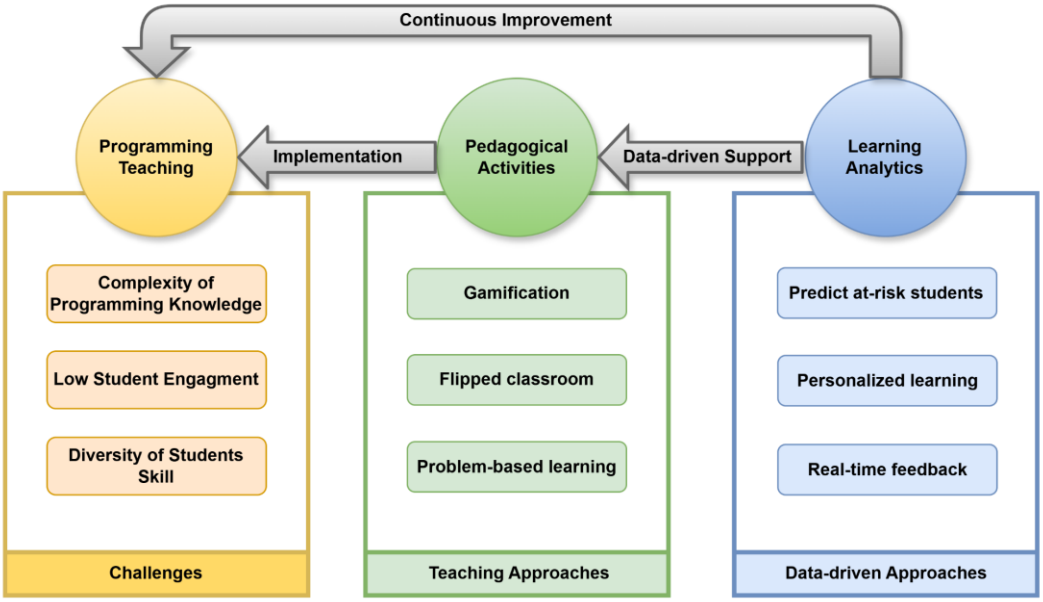

Figure 1: A framework integrating teaching methods and learning analytics for programming education

In addition, the proposed framework incorporates LA and EDM as essential elements to improve and customize the learning experience. Through the utilization of data-driven methodologies, such as predictive modeling for the identification of students at risk, personalized learning pathways, and real-time feedback mechanisms,

educators can make well-informed choices that directly influence student performance and engagement. Moreover, the support offered by learning analytics facilitates the ongoing enhancement of instructional approaches and materials, thereby enhancing the accessibility of programming education despite the ever-changing nature of programming technologies. The integrated framework promotes a continuous improvement culture in programming education, intending to improve student learning outcomes and reduce the achievement gap between students with varying prior experience and aptitude levels.

3. Methodology

3.1 Implementation of the Flipped Classroom Model

To suggest adopting the flipped classroom model in practical programming courses, we analyzed various teaching models, such as the traditional, general, and flipped classroom models, specifically for practical programming courses. This examination allowed us to identify the benefits and drawbacks associated with each approach. Table 1 provides a concise overview of the comparisons, explicitly highlighting the support provided to learners based on two specific criteria: student engagement and student self-study.

Table 1: Comparison of the traditional classroom, general flipped classroom, and flipped classroom for a practical programming course

Model vs. Criteria	Student Engagement	Student Self-Study
Traditional Classroom	May face challenges in maintaining student engagement throughout the class (Singh, et al., 2024).	Relatively low self-study as students mostly follow instructor-led activities (Estaji and Jonaidi-Jafari, 2022).
General Flipped Classroom	Besides in-class activities requiring active participation, student engagement increases through pre-class materials (White, et al., 2017).	Cultivate student self-regulation by requiring pre-class preparation and independent practice (Silverajah, et al., 2022).
Flipped Classroom for a Practical Programming Course	Encourage active student participation through hands-on coding questions and real-world projects in pre-class activities.	Develop intense student self-study and self-directed learning skills through independent coding practice and project work.

Traditional programming classes typically emphasize in-class instruction, where students receive direct guidance and knowledge from the instructor. Although this approach may accelerate the learning process, it also possesses significant limitations. For example, students who need a complete comprehension of the subject matter during class may encounter difficulties with their homework, and only those who have a high level of discipline tend to make adequate preparations for the next session. This model frequently emphasizes delivering content rather than addressing individual learners' unique abilities and learning styles (Li, et al., 2014). As a result, instructors need help keeping students actively involved in the class (Singh, et al., 2024), and more emphasis on self-directed learning leads to a low level of independent study as students mainly rely on instructor-led activities (Estaji and Jonaidi-Jafari, 2022).

On the other hand, the Flipped Classroom model, especially for practical programming courses, provides a more dynamic approach by organizing learning into two primary elements: pre-class and in-class activities. Pre-class activities transfer the obligation of learning to the students, encouraging active participation and enabling them to learn at their preferred pace. To promote independent learning and motivation, we suggest implementing pre-class assignments that gradually escalate in complexity, commencing with easy assignments and advancing to more challenging ones. Engaging in these tasks promotes student readiness before class, which is essential for enhancing the efficacy of the learning process. Programming courses often incorporate pre-class activities that involve practical coding exercises and real-world projects. These activities improve problem-solving abilities and foster a strong sense of self-study and self-directed learning by encouraging independent coding practice and project work.

In-class activities in the Flipped Classroom emphasize interactive and collaborative exercises, such as team-based learning, presentations, and quizzes, which build on the knowledge students have acquired during their pre-class preparation. We recommend dividing in-class sessions into two phases for programming education: an initial review of pre-class work, including live coding and error correction, followed by hands-on practice with more advanced exercises. The instructor should guide these sessions through active learning methods like pair programming and group discussions, making the class livelier as each student brings different perspectives and

levels of understanding (White, et al., 2017). Moreover, the Flipped Classroom cultivates student self-regulation by requiring pre-class preparation and independent practice. It encourages learners to proactively search for additional learning resources that align with their preferences and styles (Silverajah, et al., 2022).

Therefore, we propose implementing the flipped classroom model for practical programming courses, highlighting its effectiveness based on two criteria: student engagement and self-study. In helpful programming courses, student engagement is demonstrated through participation in hands-on coding exercises and real-world projects (Pears, 2010). At the same time, self-study is reflected in the student's ability to develop their skills independently. These criteria, such as participation rates and self-development, can be quantitatively assessed using data collected from Moodle.

This study integrates the Flipped Classroom model into practical programming involving two exercises: PreLab and InLab.

- **PreLab**: Before the in-class session, students must complete the exercises in the PreLab. The PreLab exercises typically consist of easy-to-moderate difficulty-level tasks, aiming to help students grasp the key concepts from the theory and facilitate self-learning.
- **InLab**: The in-class activities consist of two components. First, the PreLab exercises will be discussed and reviewed. The instructor will gather feedback from students regarding the PreLab tasks and provide general guidance to the entire class. Then, students will practice individually with the InLab exercises under the instructor's guidance. The InLab exercises will be organized from moderate to advanced difficulty and aim to enhance students' programming skills after they have been sharpened through the PreLab exercises.

Integrating PreLab and InLab activities improves student engagement and promotes more significant interaction between teachers and students. Instructors can better understand each student's capabilities by utilizing LA approaches, such as real-time predictive analytics. This implementation enables customized instructional approaches that more effectively cater to individual needs, ensuring that the pre-class and in-class components are well-aligned with learners' current comprehension and advancement. Providing individualized assistance can significantly enhance academic achievements in programming instruction.

3.2 Study Design

This study aims to incorporate the Flipped Classroom model into Programming Fundamentals courses to increase student engagement and use the learning data obtained from activities conducted before and during class. The Flipped Classroom approach positively impacts student learning engagement, particularly in pre-class activities. The influence of pre-class exercises on student performance is demonstrated by the improved academic outcomes of students who engage in active participation as opposed to those who do not. The gathered educational data can also be employed to analyze and improve instructional methodologies. A learning analytics methodology is utilized to forecast the in-class scores of students by analyzing their pre-class outcomes, thereby providing additional evidence of the efficacy of the Flipped Classroom model.

The study was conducted in the Programming Fundamentals course during the second semester of the 2021-2022 academic year. A question repository consisting of 99 questions was created to enhance the teaching of practical programming in the course. These questions cover fundamental programming topics such as Strings, Arrays, Functions, and Pointers and are distributed across four practice sessions. Using a voting process, the instructors responsible for the practical sessions categorized the questions into three difficulty levels—easy, medium, and hard. Questions rated as easy to medium were compiled into a set for Prelab activities, while those rated as medium to hard were used for Inlab exercises. The questions were delivered in an online judge format, requiring students to solve programming problems related to the course topics. Student submissions were automatically graded using test cases in CodeRunner, a plugin implemented on the Moodle LMS platform.

Figure 2 illustrates the process of the proposed approach to a programming course, divided into two phases: PreLab and InLab. In the PreLab phase, students begin by engaging with preparatory materials, including reading material like slides or books, videos, and code examples. The work on exercises classified as Easy and Medium in difficulty, with their submission, is graded by an Automated Grading System (AGS). Student's results are recorded in a system for later review by the lecturer. On the lecturers' side, they are responsible for selecting and categorizing exercises by difficulty level, utilizing Learning Analytic tools to assist in this process, like classification tools. Lecturers also review the student's results to gain insights into the student's understanding and performance.

In the InLab phase, students start by listening to a general provided by the lecturer before moving on to more challenging Medium and Hard difficulty exercises. AGS grades these submissions for exercises. On the lecturers' side, they can use Learning Analytic tools to predict the InLab scores right after the PreLab exercises closed. The prediction results help lecturers understand the distribution of scores and the student's overall ability. This analysis enhances the interaction between lecturers and students, allowing the lecturer to provide a more tailored and effective guide during the InLab session.

According to Figure 2, the evaluation needs to be conducted from two perspectives: Pedagogical Activities and Learning Analytics. From the Pedagogical Activities perspective, the evaluation can be based on the feasibility of implementing the teaching approach, the readiness of students to participate in the PreLab or the impact of the PreLab on the course as reflected in the scores. From the Learning Analytics perspective, the evaluation can be based on the prediction's feasibility or accuracy in students' exercise data.

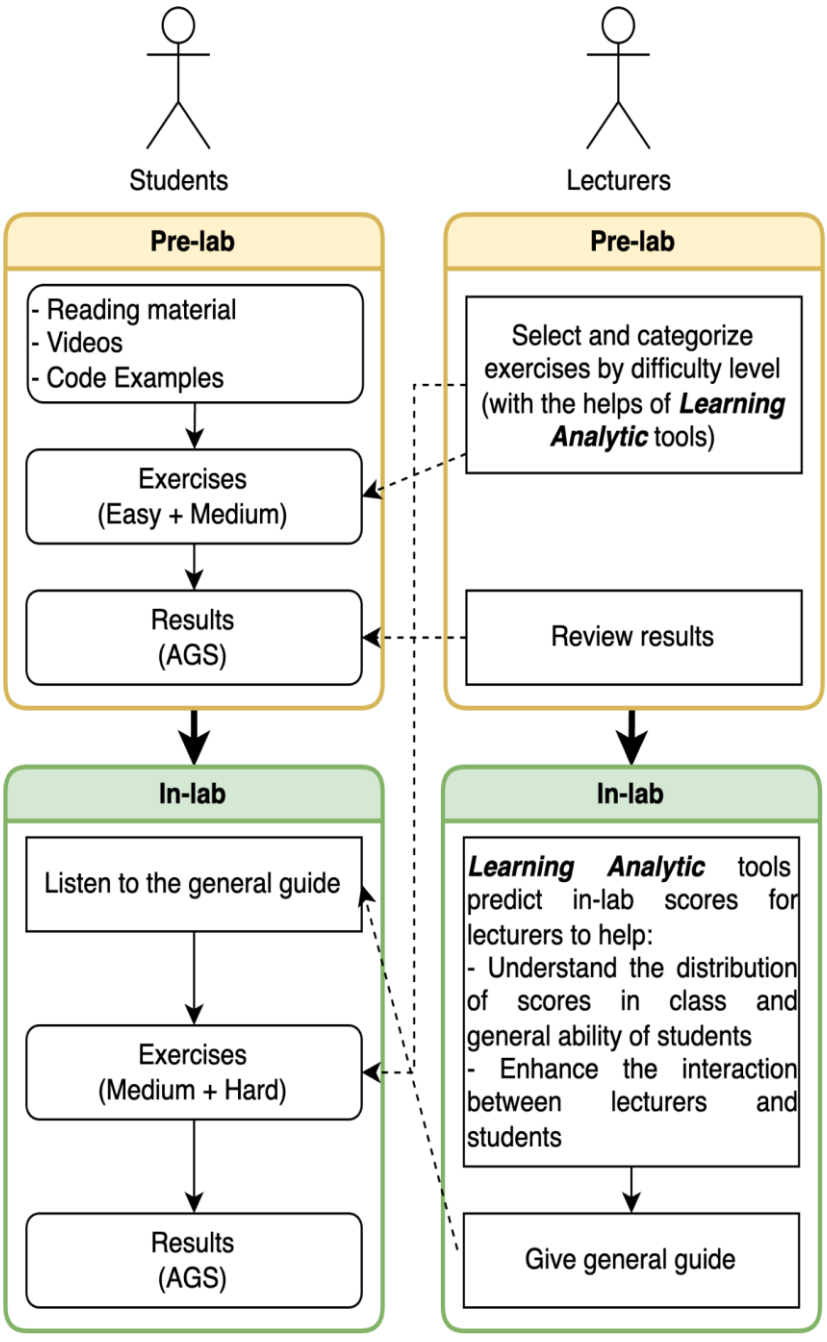

Figure 2: The process of the proposed approach for applying flipped classroom into a programming course

3.3 Data Accumulation

The proposed model was applied in the Programming Fundamentals course in the second semester of the academic year 2022-2023 at our university. The course includes four (4) PreLab and four (4) InLab lessons. This research was conducted with 786 first-year undergraduate students who participated in the course. The data collected from the Moodle system consists of attempts made by students. Based on the Moodle design, a lab exercise contains multiple questions, and each question can have multiple attempts from students. In each attempt, students submit and try numerous times until they achieve the desired result. As a result, in a lab exercise, the minimum number of attempts students must carry out to complete the lab is equal to the number of questions. For example, if PreLab 1 has ten questions, the minimum number of attempts required for students to complete the lab is 10. If the number of attempts exceeds 10, students have submitted multiple times for some questions in the lab. Students can make many attempts for each question, so the scoring for a question is based on the highest-scoring attempt. Therefore, the score of a lab exercise for each student is the average score of the questions in the lab. If a question does not have any attempts by a student, that question will be scored as 0 points.

The results of the lab exercises are compiled and presented in Table 2. Regarding the number of students participating in the practical exercises, out of a total of 786 students, PreLab 1 had the highest student interactions, followed by InLab 1 with 757 (96.43%) and 746 (95.03%) students, respectively. On the other hand, PreLab 4 had the lowest number of participations (688 students - accounting for 87.64%), followed by PreLab 2. It can also be seen that PreLab 2 achieved the highest mean score (9.63), while the lowest mean score went to InLab 1 (8.19).

Table 2: Summary of lab results

	PreLab 1	InLab 1	PreLab 2	InLab 2	PreLab 3	InLab 3	PreLab 4	InLab 4
Count	757	746	688	732	708	733	676	706
Mean	8.97	8.19	9.63	9.12	9.07	9.07	9.35	9.15
Std	2.34	2.87	1.38	2.09	2.21	2.18	1.93	2.13
Min	0	0	0	0	0	0	0	0
25%	9.40	7.77	10.0	9.75	9.60	9.58	10.0	9.88
50%	9.90	9.70	10.0	10.0	10.0	10.0	10.0	10.0
75%	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Max	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0

Additionally, Figure 3 shows each lab's score distribution, revealing a trend that students either achieve perfect scores or abandon the assignments altogether. Scores are heavily concentrated at the 10-point mark, with a significant number also clustered at 0. The remaining score categories are practically empty. This suggests a binary approach to these practical programming assignments – students strive for the highest marks or give up. Interestingly, despite not following a standard or uniform distribution, our data provides valuable insight into how students typically perform on these tasks.

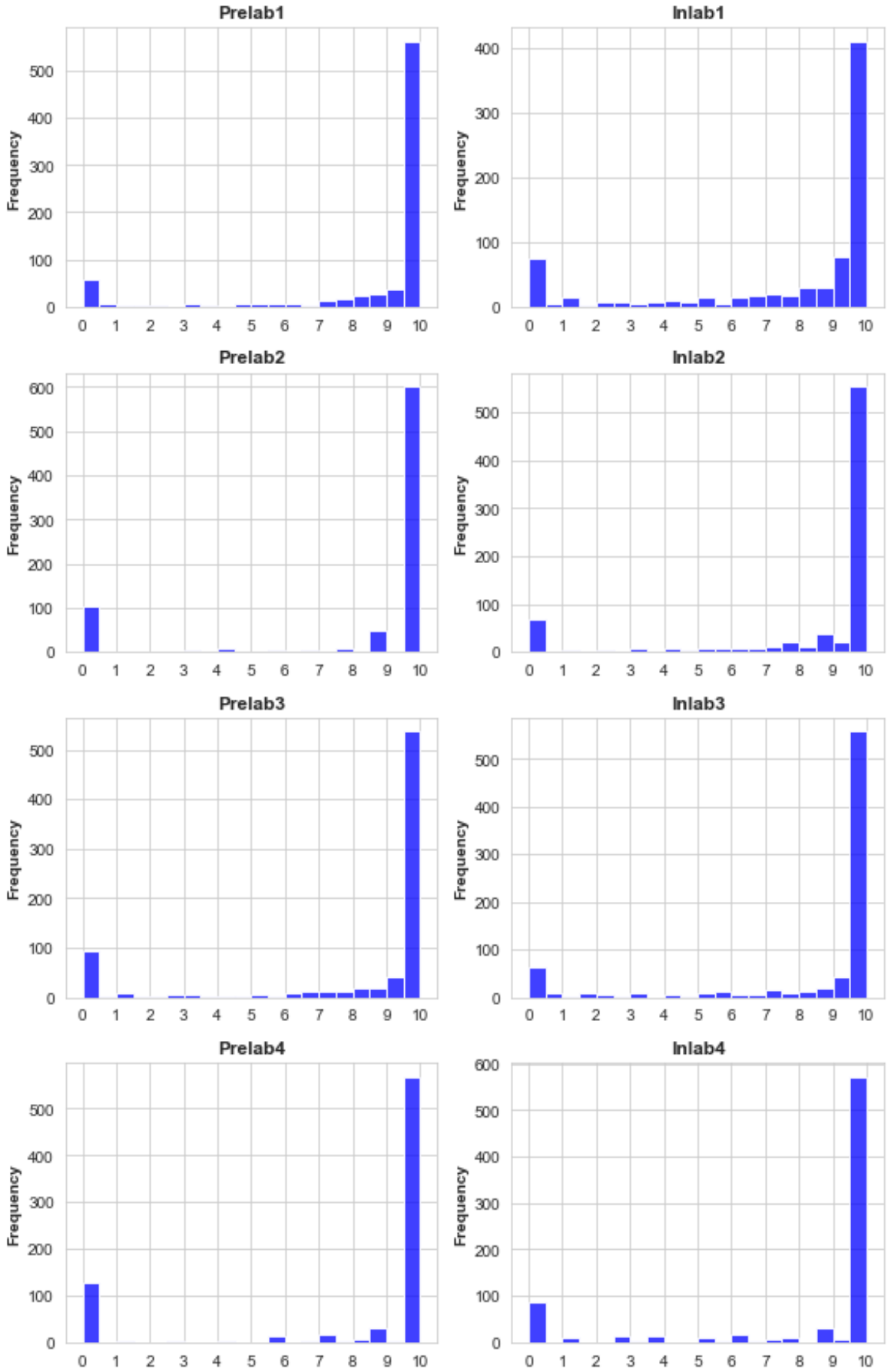

Figure 3: The lab score distribution

4. Effectiveness of the Flipped Classroom Model Implementation

4.1 Student Consensus

Consensus among most students is demonstrated by the ratio of students participating in PreLab questions to the total number of students in the course. Students only need to answer one PreLab question to be considered participating. The value of this ratio aims at 1.0, indicating a high consensus on the new learning method.

In other words, this consensus indicates the learners' engagement. The number of participants partially reflects the effectiveness of implementing this teaching approach. The experimental results obtained for PreLabs 1, 2, 3, and 4 are 0.96, 0.87, 0.90, and 0.86, respectively, which indicates that students still widely accepted the new teaching method even though it was implemented for the first time.

4.2 Ability to Measure Learners' Studying Time

Measuring the study duration of learners cannot be accurately recorded through the system. The actual study duration will be greater than the time recorded in the system. The latter is calculated from the first submission to the final submission. The average study duration t_j for assignment j and the average study duration r for a lab are determined as follows:

$$t_j = \frac{1}{n}\sum_{i=1}^{n} d_i$$

$$r = \frac{1}{T}\sum_{j=1}^{T} t_j$$

where n is the number of attempts of a student for assignment j; $d_1, d_2, \dots, d_j, \dots, d_n$ are the durations of the student's attempts for assignment j; and T is the allowed study duration for a lab.

If T is constant, a higher study duration recorded in the system reflects a higher level of learner investment. This indicates that the student spends more time and effort on the assignments or labs. Table 3 summarizes the study duration that students must allocate for each lab assignment, where the total allowed study duration is the same for all PreLabs and all InLabs.

Table 3: Student's time spent for each lab lesson

	Related PreLab	Related InLab
Lab 1	7 hours	8 hours
Lab 2	3 hours	4 hours
Lab 3	7 hours	5 hours
Lab 4	4 hours	4 hours

4.3 Ability to Collect Illustrative Data for Learner Development

This ability is related to student self-study. Using appropriate statistical data analysis tools, we can observe the development of learners over time. By examining the number of submissions for each question, comparing related questions (which may have different levels of difficulty and occur at different stages: PreLab or InLab), and using a timeline diagram, we can visualize the development of learners. Figure 4 illustrates the growth process of solving a question in an assignment for a sample student.

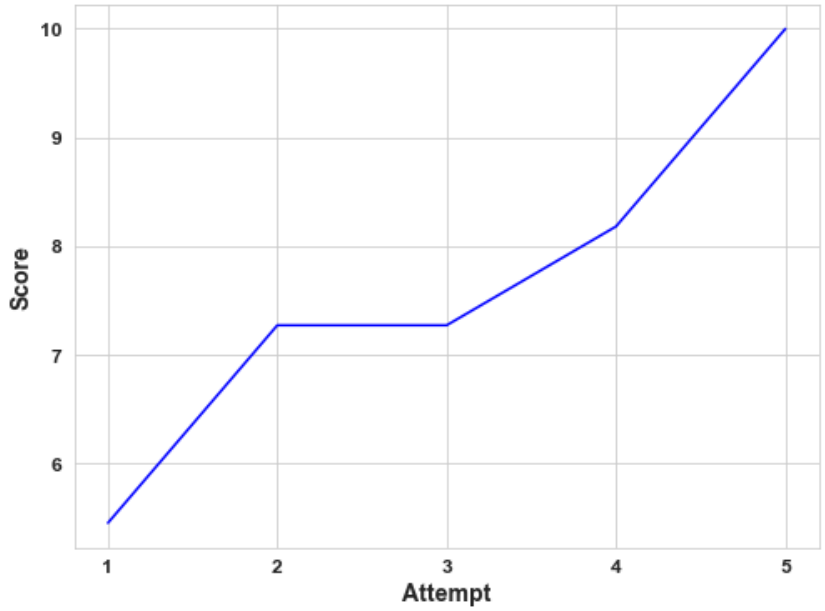

Figure 4: The growth process of a learner solving a question

We can also observe the growth index, which is the difference between the best and initial performance. Figure 5 illustrates the distribution of this growth index in a sample assignment question. The case with a value of 0 represents the group of students whose highest score corresponds to their first submission, excluding those who submitted only once. The case with a value of 10 represents the group of students who initially scored 0 but completed the question with a score of 10.

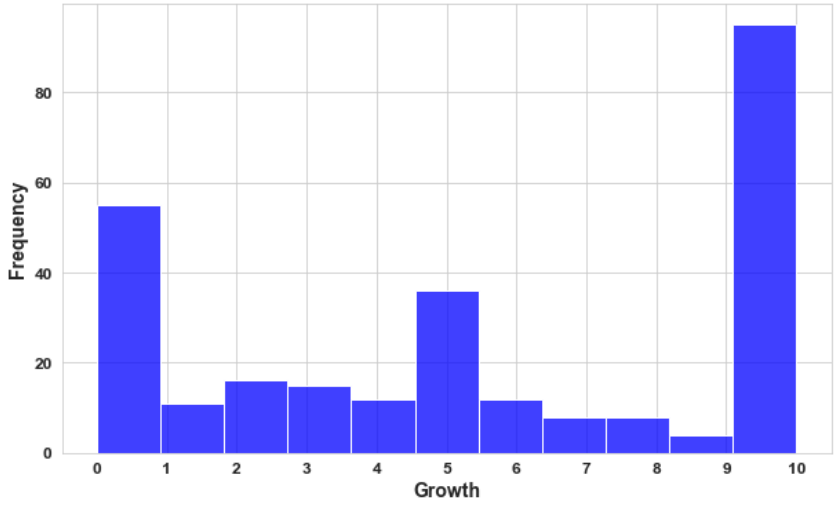

Figure 5: The histogram of growth index of a question

4.4 The Impact of Completing PreLab Before Doing InLab

We compared two groups of students based on the score distribution of their InLab assignments: (1) the first group includes students who did not complete PreLab, and (2) the second group includes students who completed PreLab. Figure 6 shows the score distributions of the InLab assignments for the two groups, in which the label of **InLab i (without PreLab i)** indicates that the students did not complete PreLab i before doing InLab i, and **InLab i (with PreLab i)** means that students completed PreLab i before doing InLab i. For example, if PreLab 1 consists of 10 questions, some students complete only one question, while others complete nine. We set a threshold to determine the completion of PreLab, where students have to complete all the questions in the PreLab assignment. With this threshold, the percentage of students in each group for each lab assignment is summarized in Table 4.

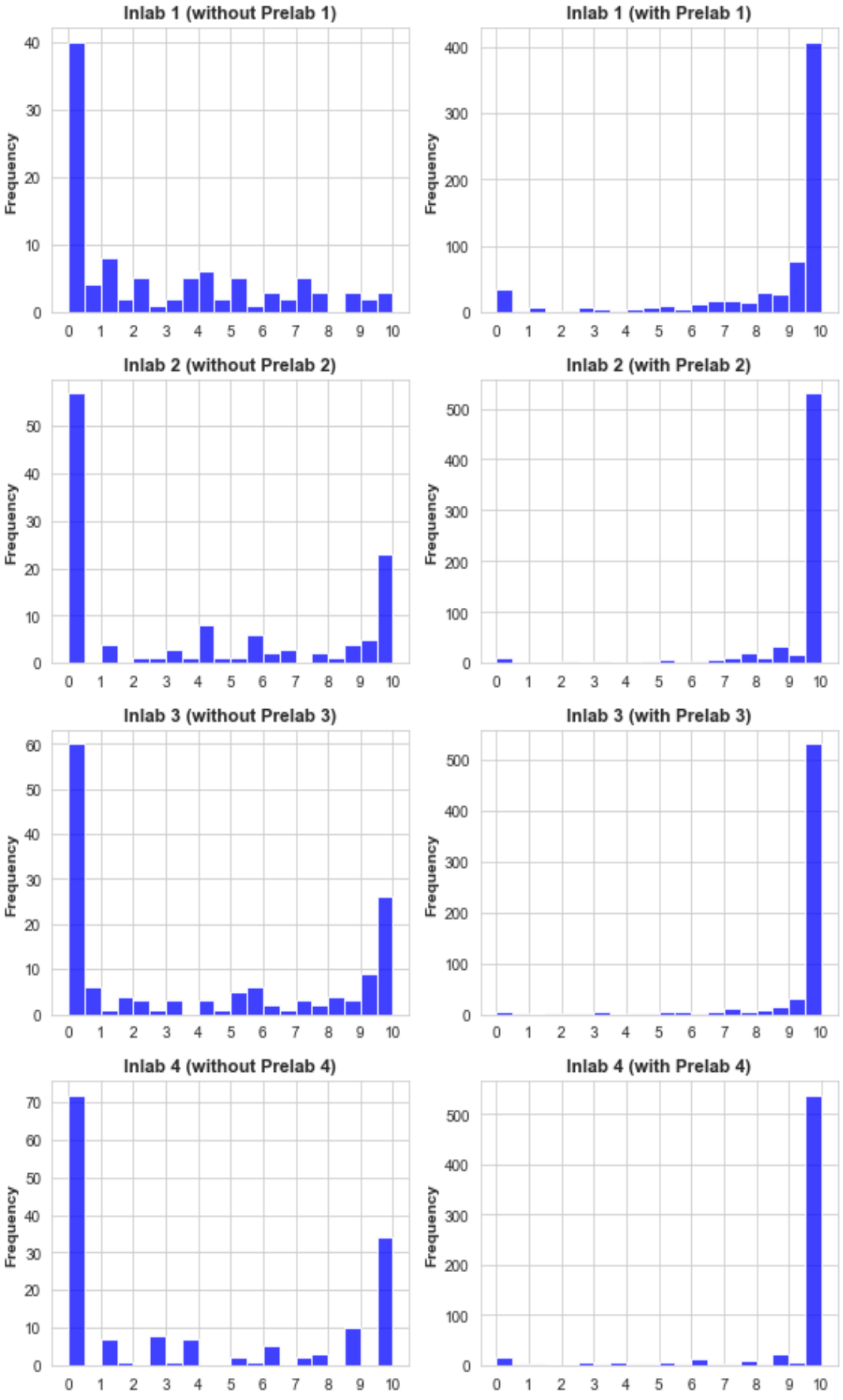

Figure 6: The score distribution of InLab assignments

Table 4: Percentage of students in each group completing each lab assignment

	% Completed	% Not Completed
PreLab 1	87%	13%
PreLab 2	84%	16%
PreLab 3	82%	18%
PreLab 4	81%	19%

As shown in Figure 6, the distributions on the left side have more students with lower scores than those on the right, which indicates a higher probability of failure for the students who did not complete PreLab. Additionally, more than 500 students achieved scores between 9.5 and 10, while the number of students with scores below 6 is low. Therefore, completing PreLab has a positive impact on the InLab results. Additionally, the score distribution of InLab assignments for students who did not complete PreLab shows instability in their performance, which is reflected in the scattered distribution of InLab scores ranging from 0 to 10 for students who did not complete PreLab. In most PreLab assignments, a significant portion of the histogram for InLab 1 (without PreLab 1) shows a score of 0.

To obtain more detailed information, as shown in Table 5, we examine the evaluation of three groups (the group of students who completed PreLab, the group of students who partially completed PreLab, and the group of students who did not do PreLab) in three cases of InLab results ("< 5", "≥ 5", and "≥ 9").

Table 5: InLab results in details

		% Students completed PreLab	% Students partially completed PreLab	% Students did not do PreLab
InLab 1	< 5	10.23 %	73.53 %	89.66 %
	≥ 5	89.77 %	26.47 %	10.34 %
	≥ 9	70.76 %	4.90%	3.45 %
InLab 2	< 5	3.92 %	61.79 %	68.37 %
	≥ 5	96.08 %	38.21 %	31.63 %
	≥ 9	82.65 %	22.76 %	21.43 %
InLab 3	< 5	3.42 %	57.34 %	75.64 %
	≥ 5	96.58 %	42.66 %	24.36 %
	≥ 9	87.71 %	24.48 %	12.82 %
InLab 4	< 5	5.21 %	62.75 %	72.73 %
	≥ 5	94.79 %	37.25 %	27.27 %
	≥ 9	85.94 %	22.22 %	17.27 %

Evaluation of groups with InLab results (≥ 5): For students who fully completed the PreLab assignments, the majority (over 89%) of students achieved a passing score (≥ 5) in all 4 InLabs, and the majority of students (over 70%) scored 9 or 10 in all 4 InLabs.

Regarding students who partially completed the PreLab assignments, only about 26.47% to 42.26% of students achieved a passing score (≥ 5) in all 4 InLabs, and only about 4.90% to 24.48% of students scored 9 or 10 in all 4 InLabs. For students who did not do the PreLab assignments, the percentage of students who achieved a passing score (≥ 5) in all 4 InLabs is low (ranging from 10.34% to 31.63%), and similarly, the percentage of students who scored 9 or 10 in all 4 InLabs ranges from 3.45% to 21.43%.

Evaluation of groups with InLab results (< 5): For students who fully completed the PreLab assignments, very few (less than 10%) students received a failing score (< 5) in all 4 InLabs. Regarding students who partially completed the PreLab assignments, over half (over 57%) of students received a failing score (< 5) in all 4 InLabs. For students who did not do the PreLab assignments, the percentage of students who failed the InLab assignments accounted for over 68.37% in all 4 InLabs.

In conclusion, the data analysis reveals the significant impact of completing PreLab exercises on students' performance in the InLab exercises. Students who fully completed PreLab demonstrated consistently higher scores in the InLab tests, while those who did not complete PreLab showed unstable and lower scores. These findings highlight the importance of engaging in PreLab exercises as a crucial step in achieving better results and improving practical skills in the course.

5. Effectiveness of Student's Performance Prediction

After using statistical methods to observe the flipped classroom's effectiveness, we continued to analyze the collected data to clarify the relationship between PreLab and InLab. Specifically, two data analysis methods—correlation coefficient measurement and Naive Bayes classification—were used in this study. Since PreLab is conducted before InLab, we will predict the outcomes of InLab based on the results of PreLab.

The process of students completing assignments during a semester is recorded in a data matrix. The columns of the data matrix represent the following fields as shown in Table 6, including **PreLab Result** (PreLab Score), **PreLab Attempts** (the number of attempts a student submitted answers for this PreLab), **PreLab Questions** (the number of questions in PreLab), **PreLab Growth** (the progress level of a learner calculated by averaging question growths). A question growth is the difference between the max score and the one achieved from the first attempt and the **InLab Result** (InLab Score).

Instead of observing each lab exercise separately, we concatenate the four data matrices for each lab exercise into a single unified data matrix. Then, we adopt the correlation analysis and the predictive effect as below.

5.1 Correlation Analysis

Table 6 displays the Pearson correlation coefficients (Benesty, et al., 2009) that examine the relationships between different factors in PreLab and InLab activities. Significantly, a robust positive correlation was found between the results of the PreLab and InLab activities (r = 0.698), indicating that students who achieved higher scores in the PreLab tasks generally excelled in the subsequent InLab tasks. This relationship can be attributed to several reasons. Firstly, PreLab activities often serve as foundational exercises that equip students with the essential knowledge and skills needed for InLab tasks. Students who actively and comprehensively participate in these pre-class activities will likely develop a more profound comprehension of the concepts, resulting in improved performance in in-class activities (Förster, et al., 2022). Furthermore, according to reference (Liu, et al., 2024), achieving success in pre-class activities can boost students' self-assurance, leading to a more optimistic attitude towards in-class assignments.

Table 6: Correlation analysis between factors of PreLab and InLab

	PreLab Result	PreLab Attempts	PreLab Questions	PreLab Growth	InLab Result
PreLab Result	1	0.739	0.885	0.221	0.698
PreLab Attempts		1	0.876	0.590	0.481
PreLab Questions			1	0.262	0.596
PreLab Growth				1	0.113
InLab Result					1

Furthermore, significant positive correlations were observed between the number of attempts made during the PreLab phase and the results obtained during the InLab phase (r = 0.481). Similarly, significant positive correlations were observed between the number of PreLab questions completed and the results obtained during

the InLab phase (r = 0.596). This suggests that more attempts and PreLab questions are associated with better performance in InLab activities. This positive correlation indicates that active engagement with PreLab materials and dedicating adequate time to learning may lead to better preparation for InLab sessions. Repetitive learning can enhance comprehension, facilitating the students' application of knowledge during the InLab sessions.

On the other hand, the correlation between the growth observed during the PreLab phase and the results obtained during the InLab phase was relatively weak (r = 0.113), suggesting a less substantial relationship. This finding implies that growth measurement should more accurately capture the factors contributing to success in InLab activities. A plausible rationale is that students who excel academically frequently obtain perfect scores on their initial try. In contrast, students with lower performance may choose to completely omit specific questions, leading to a growth value of zero, which does not offer significant insights. This suggests that a more deliberate and strategic approach to designing PreLab exercises is required. This approach should involve presenting more demanding tasks to high-achieving students and offering extra assistance to lower-achieving students. This approach is consistent with the authors' findings in (Malkoc, et al., 2024). The findings indicate that performance in PreLab activities can predict performance in subsequent InLab activities. This highlights the significance of actively participating in PreLab activities to improve learning outcomes.

5.2 Predictive Effects

These findings suggest that PreLab performance can be a predictive factor for subsequent InLab performance, emphasizing the importance of engaging with PreLab activities to enhance learning outcomes. Previous studies have used various methods for prediction. In this study, Naive Bayes Classification is utilized to examine the predictive effect of PreLab results on InLab performance. By employing the Naive Bayes Classification, we can assign categorical predictions to the InLab scores based on the PreLab results. This approach has been proven effective in different domains and has shown promising results in predicting various outcomes (Blanquero, et al., 2021; Rabie, et al., 2022; Farhana, 2021; Vishwakarma and Kesswani, 2023. Naive Bayes Classification was applied to observe the predictive effect of PreLab results on InLab performance as follows:

$$P_{InLab-Result \mid PreLab} = \frac{P_1 \times P_2 \times P_3 \times P_4 \times P_{InLab-Result}}{P_{PreLab}}$$

where

- $P_1 = P_{PreLab-Result \mid InLab-Result}$
- $P_2 = P_{PreLab-Attempts \mid InLab-Result}$
- $P_3 = P_{PreLab-Questions \mid InLab-Result}$
- $P_4 = P_{PreLab-Growth \mid InLab-Result}$

A PreLab is defined as a vector that includes PreLab results, PreLab attempts, PreLab questions, and PreLab growths. Since the predicted outcomes of the Naive Bayes Classifier are categorical, we transformed the InLab scores into five classes: Class 0 (scores from 0 to less than 4), Class 1 (scores from 0 to less than 5), Class 2 (scores from 5.5 to less than 7), Class 3 (scores from 7 to 8.5), and Class 4 (scores 8.5 and above). With a dataset size of 3144, we divided the dataset into two sets: the training set (2512 instances) and the test set (632 instances).

The Naive Bayes Classifier's classification results are presented in Table 7. More precisely, we assessed the model's performance on the test set by measuring precision, recall, and F1-score metrics. Class 0 demonstrates a moderate level of precision (0.60) and recall (0.69), leading to an F1-score of 0.64. On the other hand, Class 1 and Class 2 exhibit a precision, recall, and F1-score of 0.00, suggesting that the classifier failed to make any accurate predictions for these particular classes. Class 3 exhibits a relatively low level of precision (0.27) and recall (0.09), leading to a low F1-score of 0.14. Class 4 exhibits exceptional performance with a high level of accuracy (0.85), sensitivity (0.94), and F1-score (0.90). These findings align with the fact that Class 0 and Class 4 have the highest and second-highest levels of support in the dataset, respectively. Programming learners typically iterate on their work until they reach the highest possible score, resulting in the majority of learners' scores being categorized as either Class 0 or Class 4. The predictive model demonstrated an accuracy of 0.81 and an F1-score of 0.77, indicating a consistently dependable performance.

The results emphasize the strong correlation between PreLab performance and subsequent InLab outcomes, highlighting that actively participating in PreLab activities can significantly improve learning outcomes. The data

suggests that learners who engage in regular programming practice tend to review and improve their work until they achieve the highest scores possible. As a result, scores are clustered in Classes 0 and 4.

Table 7: Naive Bayes Classification results

Class	Precision	Recall	F1-score	Support
0	0.60	0.69	0.64	77
1	0.00	0.00	0.00	18
2	0.00	0.00	0.00	23
3	0.27	0.09	0.14	32
4	0.85	0.94	0.90	482
Accuracy				0.81
F1-score				0.77

6. Limitations

The findings of this study should be interpreted with caution due to several limitations that need to be considered.

- First, implementing the flipped classroom model in this research primarily demonstrates its feasibility in a practical setting but needs more integration with learning analytics (LA). LA support is essential for maximizing the utilization of data-driven insights to enhance the flipped classroom process, as it may restrict the comprehension of how this model impacts student engagement and self-study. Subsequent investigations should prioritize the integration of LA to offer a more all-encompassing strategy for enhancing the flipped classroom experience.
- Second, the study's use of the Naive Bayes algorithm for predicting InLab performance based on all PreLab activities collectively may not fully capture the nuances of student learning progression. A more precise method would involve making predictions in real-time, such as using PreLab 1 to predict InLab 1, PreLab 2 to predict InLab 2, and so forth. This would allow more timely and targeted interventions, potentially improving the accuracy and effectiveness of the predictions. Further research should aim to refine the predictive model to enhance its application in real-world educational settings.
- Third, this study's data collection was limited to a single semester, which restricts the ability to assess the long-term impacts of the flipped classroom model on student engagement and learning outcomes. Evaluating the effects over multiple semesters would provide a more robust understanding of the approach's sustainability and consistency. Future research should incorporate a longer duration of data collection in order to assess the long-lasting impact of this instructional approach accurately.

7. Conclusion

This paper explores the effectiveness of implementing the flipped classroom model in a practical programming course. We compared the traditional classroom model, the general flipped classroom model, and the flipped classroom model tailored explicitly for teaching practical programming regarding two critical criteria: student engagement and student performance.

The effectiveness of the flipped classroom model in the practical programming course is demonstrated in various aspects. Firstly, most students have a consensus, which is reflected in the high participation rate in pre-class activities. Secondly, measuring learners' learning time allows for assessing their investment in the new teaching method, with longer study durations indicating higher effectiveness. Thirdly, illustrative data collected from the Moodle system enables the observation of learners' development over time, aiding in assessing their self-study progress. Finally, the impact of completing pre-class activities before in-class labs is evident, with students who fully meet the pre-class assignments consistently achieving higher scores in the subsequent in-class tests.

Moreover, the data analysis revealed that students who performed well in PreLab activities had higher scores in the subsequent InLab sessions, indicating a strong positive correlation between PreLab and InLab results. Additionally, increased attempts and engagement with PreLab questions were associated with improved

performance in the InLab. Naive Bayes classification demonstrated promising predictive effects, with high accuracy and support for specific score ranges in the InLab.

In the future, we will investigate a more detailed teaching model that includes homework, tentatively called PostLab. Based on PreLab's results, clustering students into groups for practical InLab sessions could be a potential research direction.

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Behind the Screens: Evaluating the Effectiveness of Zoom in EFL Learning and Teaching in Higher Education

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Abstract: This study examines the usage of Zoom platform features and functions in managing EFL classes from the perspectives of students and their instructors. The study used a mixed-method approach. Quantitively, a questionnaire was distributed to undergraduate EFL students enrolled in advanced English courses (B2) in the first semester of the academic year 2023/2024 in a Palestinian university. The questionnaire was complemented by interviewing nine EFL instructors who have utilized the Zoom platform in their EFL classes. The quantitative data were subjected to statistical analysis whereas the interview data were analyzed thematically to obtain qualitative insights. The findings of the study revealed that Zoom features and functions significantly boost the online language learning experience in the EFL classes according to the students' views. The students highly appreciate the features of recording, raising hands, screen-sharing, mute/unmute controls, file-sharing, and chat box while learning the English language. The results also indicate that both male and female students have similar views on the efficiency of Zoom features and functions. The analysis of the qualitative data reveals that EFL instructors largely utilize Zoom features and functions in their EFL classes and appreciate the benefits of these tools. Nevertheless, the results demonstrate that the instructors encounter some challenges primarily related to technical issues. The findings provide valuable views to the field of language learning and teaching through building on the experiences of undergraduate students and instructors with the context of EFL.

Keywords: EFL classes, EFL instructors, Online teaching, Online learning, Zoom

1. Introduction

The notion of e-learning has been proposed and endorsed in most of the countries around the world. It is also considered as the latest trend in 21st-century educational methodology, which requires new knowledge and skills. In other words, it is an alternative form of delivering education through technologically facilitated tools. E-learning has significantly helped teachers in their teaching activities. The incorporation of e-learning in teaching helps make teachers' jobs easier. (Soon and Aziz, 2022).

Higher education in Palestine has experienced significant changes in the last few years (Badah et al., 2023). The sector has witnessed substantial advancements in the field of teaching English as a foreign language (EFL), especially with the increasing emphasis on online teaching (Abuhussein and Badah, 2024). Therefore, the development of technology-based management tools has become a necessary endeavor. However, this need has been magnified with the advent of the COVID-19 pandemic, leading to unprecedented interruptions and transformations across various domains of life (Shweiki et al., 2021).

Zoom has been particularly popular despite the sudden ubiquity of remote teaching using different virtual platforms (Ohnigian et al., 2021). This is due to its enormous potential for foreign language acquisition. It has been proven effective in providing educators with a useful tool for formatively assessing learning, facilitating small group interactions, engaging learners, and extending learning beyond the 'traditional' classroom (Kohnke and Moorhouse, 2022).

This platform, a free access utility, offers various built-in useful functions and tools that support the teaching and learning process. The breakout rooms, the instant message feature, the screen-sharing option, the poll feature, the diverse reactions, the recording and language interpretation functions, the file-sharing, the chat box

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options, the attendance tracking, microphone and camera controls, the Q & A feature, the waiting room and other collaborative features, such as the whiteboard along with different annotation options, are unanimously essential to the administration of online sessions. These functions can immensely facilitate communicative language learning through the use of authentic language instruction in interactive synchronous classes (Kohnke and Moorhouse, 2022).

For EFL instructors, handling an online class is a challenge. Nevertheless, this can be resolved if the right foundations are arranged appropriately and convenient tools are utilized in the teaching-learning process. Likewise, learners in a virtual classroom can explore the facilities of the internet to create meaningful and constructive learning environments (Sibanda, 2021). Moreover, boosting students' English-speaking self-efficacy to get involved in active learning activities is, therefore, key (Hartono, Widiyati and Anwar, 2023). Both EFL instructors and students entail support resources and ostensible technology requirements for this purpose. That is to develop technological competence in order to improve their ability to use digital tools to foster classroom interaction. Furthermore, teachers and learners need to be familiar with the features of various digital tools and how they can be used for teaching (Huong and Moorhouse, 2023). In this vein, Tarteer, Badah and Khlaif (2021) argue that technology plays a vital role in the educational methods that enhance effective learning when supported by ICT elements. Thus, the paper aims to investigate whether such technological tools, embedded within the Zoom platform, can impact EFL language learners. It will also help shed the light on the utilization of such tools by the instructors themselves as it will examine the extent to which these tools are implemented in their virtual English language classes.

It could be argued that prior studies either addressed Zoom platform in general or focused on breakout rooms or other features. However, there is a paucity in the studies that investigate the best practices of Zoom and the functionalities of Zoom features and their specific role within the online EFL classes. The current study, however, aims to explore the efficiency of Zoom features and functions from the perspective of both teachers and instructors. Its main objective is to evaluate the impact of Zoom functionality in learning and teaching English as a foreign language as perceived by EFL learners and instructors. By doing so, the researchers aim to determine how specific Zoom features and functions including the chat box, file sharing, recording and other tools can contribute to the online education environment. Specifically, the study seeks to identify which functions of Zoom are most appreciated by students. Besides, the study tries to provide valuable insights on the most frequently used Zoom features as viewed by the EFL instructors.

By doing so, the current research makes a meaningful contribution to the existing literature on online language education. It brings attention to how digital platforms can be used to enhance active participation in language education classrooms. Additionally, the results may be of interest to EFL teachers through revealing the EFL students' perceptions towards the most valued Zoom features.

Accordingly, the current study aims to find answers to the following three questions:

1. How do EFL undergraduate students perceive the efficiency of the usage of Zoom's different functions in improving their language learning experience in their online classes?
2. Are there any differences regarding the usage of Zoom features and functions in English language classes according to the gender?
3. To what extent do EFL instructors use Zoom platform's functions in their online classes and how effective are they from their own perspective?

The current study, therefore, endeavors to address these three questions so that the intended study objectives are met. First, it reviews related literature on the role of technology in EFL learning and the functions of Zoom in facilitating language learning, establishing the study's theoretical framework. Then, it refers back to similar studies to examine how Zoom platform is used in different settings and show the gap in the existing literature. The study, then, outlines its methodology. The findings are presented and thoroughly discussed and compared in relation to existing literature in the respective sections. Finally, the study provides a concise summary of its main conclusions, followed by pedagogical implications. Limitations of the current study and recommendations for further research are provided, too.

2. Literature Review

2.1 Role of Technology in EFL Teaching

The integration of technology in language education has witnessed a paradigm shift. As a result, the pedagogy of teaching methodology has also changed. In the contemporary era, the integration of technology, along with

its diverse tools and applications, has become increasingly salient in the educational process. This integration holds significant potential for enhancing the teaching and learning experience (Al-Ghazo, 2008), especially after the spread of COVID-19.

Even before the pandemic, educational institutions embraced synchronous learning for enhanced online education (Delello, McWhorter and Lawrence, 2019). Nowadays, online and blended learning are becoming very popular worldwide (Lee, 2021). Therefore, both teachers and students need to develop their digital skills. Huong and Moorhouse (2023) stated that "Technological competence concerns the teacher and student's ability to use digital tools to foster classroom interaction. For example, teachers and learners need to be familiar with the features of various digital tools and how they can be used for teaching" (p.2). As educators increasingly embrace online platforms, understanding the effectiveness and challenges associated with each one is significant. Therefore, teachers need to develop new digital competencies as they may not be competent to teach online (Kohnke and Moorhouse, 2022). Moreover, students' e-classroom interactional competence is not less important than teachers'. Students should learn how to interact in an online classroom (Huong and Moorhouse, 2023). In other words, instructors need to introduce to their learners the Zoom features that they will need to use during the virtual sessions like how to ask questions, how to show that they have done a task, how to interact in class, and so on (Ohnigian et al., 2021).

2.2 Effectiveness of Online Learning Environment

Some might argue that the shift to online learning implies the potential loss of real interaction, communication, and collaboration among students, impacting their sense of community. Also, Zhang (2020) claims that difficulties posed by online learning arise from students multitasking and lacking focus, encountering internet connectivity issues, and feeling awkward when speaking to a screen. It can also be argued that online teaching does not guarantee students' retention especially when students do not turn on their cameras (Querol-Julián, 2023) and that adults are reported to have shorter attention spans in online learning, approximately six to eight minutes (Ohnigian et al., 2021).

However, it is said that synchronous videoconferencing platforms like Zoom enable real-time teaching, fostering live interaction. Zoom provides a psychologically comfortable online environment, where students can form positive perceptions of their virtual learning spaces. This positive adaptation, and the combination of Zoom features which facilitate synchronous interaction similar to real-time communication promote learner engagement and facilitate effective communication, cooperation, and collaboration (Zaiarna, 2021). Moreover, online learning makes students feel less anxious and more comfortable than face-to-face learning since they are not in a direct physical contact with others (Hollister et al., 2022).

2.3 Zoom Platform's Functions and EFL Classes

The Zoom platform effectively facilitates the learning process, as the teacher, serving as the conference organizer, enables both oral and written communication by utilizing various functions provided by the system (Agapova, 2020). Zoom has gained eminence for its range of features beneficial to language education. Guzacheva (2020) mentions that Zoom has expediated the incorporation of several innovations into EFL teaching through its various features.

Zoom is a versatile application offering video, audio conferencing, chat, and webinars. Through Zoom, teachers can allow features such as the waiting room, meeting ID, meeting passcode, muting-all option, disabling students from sharing their screens, and removing participants to increase the security of the online sessions (Kohnke and Moorhouse, 2022). Teachers can also schedule or start instant meetings. During meetings, users can modify layouts, access chat messages, record, and use features like the whiteboard for drawing or writing. It also includes features, such as annotation tools, polls, breakout rooms and video and screen sharing. These functions facilitate communicative language learning through the use of authentic language instruction in interactive synchronous classes. (Kohnke and Moorhouse, 2022; Nurieva and Garaeva, 2020).

Moreover, Zoom is widely regarded as advantageous in the educational process because it experiences minimal disconnection issues. Moreover, the audio quality during online video sharing on Zoom ensures clear communication for all participants (Dharma, Asmarani and Dew, 2017).

A substantial body of research confirms that the option of recording the online classes in Zoom provides students with an enduring resource where they can retain the knowledge at their own convenience and pace (Ohnigian et al., 2021; Liu and Wang, 2023; Kohnke and Moorhouse, 2022), ridding students of the anxiety since they do not need to worry about the Internet instability (Liu and Wang, 2023). The recording tool also encourages

students' autonomy; they can choose to either watch the class offline or online, thus encouraging them to develop self-study skills (Liu and Wang, 2023).

In addition, the chat box tool in Zoom meetings could be a more student-friendly option since it allows teachers to send corrective feedback on students' work through private chat boxes, helping them to avoid feeling embarrassed about their mistakes. This is because "correcting the students' mistakes in e-learning, as the classes are recorded, might lead to the speakers' anxiety and demotivation because the language learners watch the files again" (Liu and Wang, 2023, p.6). The chat option is also helpful for students unwilling to show their confusion or weak oral skills in front of their classmates. Therefore, it grants them the comfort of messaging their questions to the teacher privately and even anonymously (Kohnke and Moorhouse, 2022). Although it is argued that the chat function can be misused by some students to chat with each other or send inappropriate content, teachers have the option of preventing student-to-student chatting and can disable the send-to-all function for a better class behavior management (Kohnke and Moorhouse, 2022).

Furthermore, the poll's function can be utilized to mitigate students' chances of feeling bored and to increase their engagement through making classes more interactive. This function can also be employed as a formative assessment tool through which teachers can check their students' understanding before moving on (Kohnke and Moorhouse, 2022). It can also be applied as a way to check students' active or actual presence to encourage students' retention (Ohnigian et al., 2021).

Another Zoom feature that is effective in EFL learning is the reactions function. According to Kohnke and Moorhouse (2020):

> *"Zoom allows students to indicate through non-verbal icons when they have a question, show agreement or indicate if they want the teacher to speed up, slow down or take a break. These icons can provide useful information regarding students' attentiveness, excitement, agreement or confusion with the language content being presented". (p.297)*

Furthermore, the screensharing function of teachers' slides and instructions fosters students' EFL writing skills since, according to Huong and Moorhouse (2023), it enables students to learn essay structures and linguistic expressions for academic writing.

There is consensus among scholars that Zoom has become one of the most preferrable virtual learning platforms (Agustina and Suharya, 2021; Lee, 2021; Hastomo and Marcela, 2021; Kohnke and Moorhouse, 2022) mainly because of its breakout rooms feature (Hartono, Widiyati and Anwar, 2023), a distinctive feature of Zoom that is not found in other platforms. This functionality enables teachers to partition students into smaller groups, allowing them to assess presentations and participant interactions in each subgroup. At the designated time, participants are impeccably returned to the main room when the session concludes. Breakout rooms allow students to participate in hands-on communicative tasks and assignments within a smaller peer group (Chandler, 2016).

Conversely, it is argued that Zoom group discussions via breakout rooms may become time-consuming since, in comparison with face-to-face interactions, it takes a longer time to implement the group activities, and it is more challenging for instructors to oversee and manage online groups (Kohnke and Moorhouse, 2022; Huong and Moorhouse, 2023). Furthermore, Cavinato et al. (2021) note that while breakout rooms offer advantages, students may struggle to share answers efficiently, resulting in slower discussions than traditional classes. Also, students' prolonged screen time might lead to fatigue, termed "Zoom fatigue" (Wiederhold, 2020, p. 437). However, the benefits of breakout rooms outweigh the downsides. Through engaging students in group activities via breakout rooms, they get the chance to communicate with peers and enhance their proficiency in the English language in a way that encourages collaborative peer learning, increases students' motivation to participate in class discussions (Huong and Moorhouse, 2023; Hartono, Widiyati and Anwar, 2023) and boosts their self-efficacy in speaking English (Chandler, 2016).

2.4 Similar Studies

Nuryanto (2021) asserts that Zoom meetings offer students features for both independent work and collaborative discussions, contributing to increased engagement and motivation. Students appreciate the efficiency of incorporating Zoom into the learning process, noting time and effort savings. The study also highlights the perceived environmental friendliness of online learning through Zoom as it reduces paper usage.

In a study carried out by Nabil, Ayubi and Ansari (2023), the findings reveal that most participants believe Zoom enhances collaborative learning and boosts interaction between students and professors. Ease and cost-

effectiveness of sharing in discussions are also highlighted as notable advantages of Zoom technology by the participants. Additionally, more than half of the participants affirm that they find the features of the Zoom program easy to comprehend for educational purposes.

Furthermore, a study that examines the benefits of Zoom, conducted by Tuncer and Karatas (2021), reveals that Zoom offers tailored features for education, aiding the transition from face-to-face to online learning. It creates a supportive virtual environment, fostering synchronous interaction, communication, collaboration, and improving foreign language skills.

Another study implemented on 36 students, who were enrolled in an English-speaking course, concludes that the Zoom breakout rooms function increases students' speaking self-efficacy through providing them with opportunities to speak and discuss given topics with their teammates, and even ask questions about unclear instructions or ideas (Hartono, Widiyati and Anwar, 2023).

In a similar study, Huong and Moorhouse (2023) surveyed the e-classroom interactional competence of approximately 243 participants in terms of using Zoom breakout rooms. It mainly aimed at investigating what technological and interactional competences students have or need in order to more efficiently engage in breakout rooms activities. The results indicate that students tend to exchange ideas and opinions with their group members about the activities given in breakout rooms rather than asking the teacher to explain any ideas about the activity. Students' responses to the open questions accredit the Zoom breakout rooms feature for its effectiveness in enhancing communication skills, teamwork and group work.

Furthermore, Lee (2021) conducted a research study on a group of 25 students who were enrolled in English communication courses in a private university in South Korea. Lee's study indicates that most students were satisfied with using Zoom breakout rooms in EFL classes.

Another study, carried out by Kim (2020) to investigate the effect of online teaching using Zoom on learners' English reading comprehension achievement, highlights that learners were satisfied with Zoom lectures since they increased their motivation towards learning, encouraged autonomous learning and students' interaction, provided easy access and offered the option to retrieve information. However, it notes that some learners are dissatisfied with Zoom due to technical problems that are related to Internet stability and audio quality.

Similarly, Vu and Bui (2021) investigated the impact of EFL students' engagement when studying English reading comprehension online through Zoom. The study targeted 44 intermediate-level students at a public university in Vietnam. These students were placed into a control group and an experimental group. Traditional teacher-centered approach was utilized in teaching the students in the control group while students in the experimental group experienced student-centered type of teaching through engaging in breakout rooms for pair work, group work and screen sharing. Afterwards, students' vocabulary and reading comprehension abilities were assessed through a post-test whose scores indicated that the experimental-group students outperformed the control-group students.

As for the studies that examined the usage of Zoom features and the gender, they are very few as evidenced in the available literature. Alfadda and Mahdi (2021), for example, explored the usage of Zoom application in language learning among undergraduate EFL students. Their study shows that the variable of gender did not influence students' acceptance of using Zoom in language learning classes. Prevalla et al. (2022) investigated the readiness of university male and female students towards using Zoom. Interestingly, their study revealed that females had higher attitude towards distance education than males.

3. Methodology

3.1 Research Design

The current study adopts a mixed-method approach to meet its main goals. The study design includes quantitative as well as qualitative data collection techniques in order to ensure a deeper understanding of the research questions. Creswell and Creswell (2017) state that this approach involves collecting both quantitative and qualitative data and then merging these datasets to derive insights or draw conclusions. They argue that qualitative data typically include open-ended information where responses are not predetermined, while quantitative data involves closed-ended responses such as those commonly found in the questionnaires. The researchers adopted this approach as it provides a comprehensive understanding of Zoom platform through capturing measurable and numerical results as well as informed and personal experiences. Whereas the quantitative data provide generalizable perceptions from the EFL students, the qualitative data generated by the interviews reveal the usage degree, challenges, and benefits of Zoom as experienced by instructors.

Together, the two methods provide a more comprehensive view and a more robust answer to the study's three questions.

3.2 Participants

3.2.1 Students

The study population consisted of all undergraduate EFL students enrolled in the advanced English course (B2) during the first semester of the academic year 2023/2024. The course is a four-credit hour course that mainly focuses on effective argument. 108 undergraduate students from different academic backgrounds responded to a questionnaire that was specifically designed for this purpose. Female participants represented 67.3 % whereas 32.7 % were males as illustrated in Figure 1. The majority of them (80.6 %) were in their first academic year. They were chosen to participate in the study since they have previously attended online EFL courses and used Zoom in their language classes. The students were selected purposefully based on their usage of the Zoom platform whereas their participation was voluntary. Table (1) shows the socio-demographical characteristics of the participants.

Table 1: Participants' Socio-demographical Characteristics

Variable	Categories	Frequency	Percentage
Gender	Males	35	68
	Females	72	32.
Academic Year	First Year	87	80.6
	Second Year	20	18.5
	Third Year	1	0.9
How long have you been using Zoom in language learning classes?	Less than 3 months	31	28.7
	3-6 months	41	38.0
	6-12 months	17	15.7
	more than 12 months	19	17.6

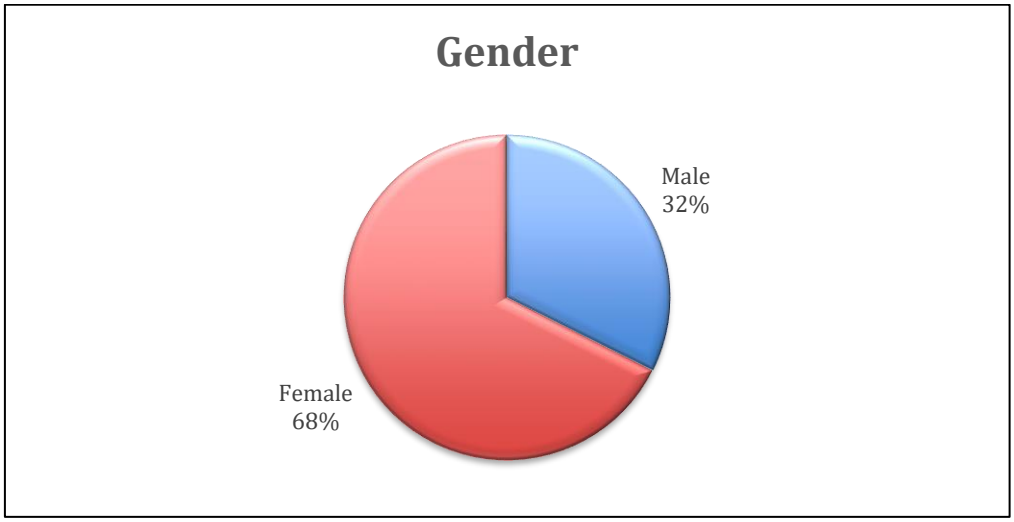

Figure 1: Gender of Participants

3.2.2 Instructors

Nine EFL instructors from the same university were interviewed to gather their insights and attitudes about the usage of Zoom tools in online EFL classes. All instructors have had the opportunity to use Zoom platform for teaching purposes. They were briefed about the research main goals. The selection criteria were based on their usage of Zoom platform features in their online classes.

3.3 Study Instruments

3.3.1 The questionnaire

A questionnaire was distributed to all undergraduate students learning English as a foreign language in a Palestinian university. The questionnaire was assessed by two experts who teach English as a foreign language in two Palestinian universities. Simultaneously, a qualified statistician evaluated the items and the scoring mechanism. This approach ensured a rigorous and comprehensive examination and thus enhanced the reliability and validity of the survey tool. The questionnaire included statements ensuring complete confidentiality for the participants' responses and that they can voluntarily respond to its items. It was developed using Google Forms and disseminated through the respective department in the university. The survey consisted of three sections: an introductory part stating the study objectives, a section generating background information such as gender, academic year, and the duration of using Zoom for language learning, and a section electing the students' attitudes towards using Zoom features and functions in EFL classes.

3.3.2 The interview

In-depth structured interviews were conducted with nine EFL instructors to gain their insights based on their personal experience in EFL classes. The interview questions, listed in Appendix A, covered key aspects about the specific Zoom features used by them, the frequency of their usage, and their impact on teaching practices. Besides, the instructors were questioned about how these features contribute to student engagement and participation in EFL classes, the challenges encountered with Zoom, and the strategies employed to overcome them. The interviews offered informative qualitative data complementing the quantitative results from student questionnaires, providing a comprehensive view of Zoom's role in EFL classes.

3.4 Data Analysis

Regarding the quantitative data, descriptive statistical analysis was employed to interpret the data gathered from the students' questionnaires. Specifically, frequency distributions, means, and standard deviations were calculated to measure the tendencies and variations among the responses. In addition, thematic analysis was applied to the data gathered from the EFL instructors' interviews, where the data were coded, categorized and further thematically organized to classify the recurring themes and patterns.

3.5 Ethical Considerations

The ethical considerations related to this study were addressed to ensure the integrity and respect of both the instructors and students involved in the study. An official approval for conducting the research at the university was granted by the head of the Department of Languages and Translation, who consulted the relevant staff at the deanship. Both group of participants were informed about the purpose of the study, and their consent was secured prior to their involvement. Confidentiality was strictly maintained, and all data were used exclusively for research purposes.

4. Results

The results are presented separately for the EFL students and their instructors in line with the research questions. The finding indicate that both groups almost have similar perceptions towards the efficiency of using Zoom features and functions in EFL classes.

R.Q.1: How do EFL undergraduate students perceive the efficiency of the usage of Zoom's different functions in improving their language learning experience in their online classes?

Overall, as shown in Table (2), the Zoom features and functions significantly boost the online language learning experience by promoting engagement and facilitating communication in the EFL classes. The table shows that students highly appreciate the features of recording, raise hand, screen-sharing, mute/unmute controls, file-sharing, and chat box while learning the English language. Other features including direct messaging, attendance tracking, annotation, non-verbal emojis/reactions, polls, Q&A, waiting room, breakout rooms, and camera option are perceived slightly less positively compared to the previous ones with high agreement.

Table 2: Means and standard deviations for perspective regarding the usage of Zoom' features and functions in English language classes

N	Sentence	Mean	SD	Degree	%
1	The recording feature has been beneficial for reviewing language class lectures.	4.29	0.93	High	85.8
2	The raise hand function has been effective in promoting participation during language classes.	4.16	0.85	High	83.2
3	The screen-sharing option has enhanced my understanding of language skills.	4.07	0.83	High	81.5
4	The mute/unmute controls have been effective in managing language classes.	3.92	0.89	High	78.3
5	The file-sharing feature has facilitated the exchange of language learning materials	3.78	0.84	High	75.5
6	The chat box has facilitated communication with my teacher and classmates during language classes.	3.71	0.96	High	74.2
7	Overall, I am satisfied with the interactive functions provided by Zoom in my language classes.	3.70	0.96	High	74.0
8	The whiteboard feature has enhanced collaborative learning experiences during my language classes, allowing for effective visual explanations and interactive discussions.	3.68	0.83	High	73.6
9	The direct message feature in the chat box has facilitated privacy with my teacher and classmates.	3.64	0.92	Medium	72.9
10	The attendance tracking feature has encouraged me to attend the language classes continuously.	3.64	0.98	Medium	72.7
11	The above-mentioned features have contributed to my commitment to attend the whole language class.	3.64	0.86	Medium	72.7
12	The annotation feature has played a significant role in my language classes by enhancing collaborative activities and providing visual explanations,	3.44	0.78	Medium	68.8
13	The use of non-verbal emojis and reactions has added a positive aspect to language class interactions	3.38	0.91	Medium	67.7
14	The poll feature has helped engage me in language learning activities	3.35	0.77	Medium	66.9
15	The Q & A feature has been effective in addressing my personal inquires that are related to language learning.	3.33	0.95	Medium	66.5
16	The waiting room feature has helped the instructor to manage student entry effectively.	3.28	1.06	Medium	65.6
17	The breakout room function has positively impacted my language learning experience	3.25	0.84	Medium	65.0
18	The camera option has facilitated the communication during language classes.	2.87	1.13	Medium	57.4
	Average	**3.62**	**0.51**	Medium	**72.4**

R.Q.2: Are there any differences regarding the usage of Zoom' features and functions in English language classes according to the gender?

The results of this question, as shown in Table (3), show that there is no statistically significant mean difference perspective regarding the usage of Zoom' features and functions in English language classes according to the gender p=0.995. Both male and female students have similar views on the efficiency of Zoom features and functions.

Table 3: Mean Difference of Perspective Regarding the Usage of Zoom' Features and Functions in English Language Classes Based on Gender

Gender	n	Mean	SD	DF	t-value	p-value
Males	35	3.62	0.53	105	0.006	0.995
Females	72	3.62	0.46			

R.Q.3: To what extent do EFL instructors use Zoom platform's functions in their online classes and how effective are they from their own perspective?

The results of this research question reveal that EFL instructors largely employ Zoom features and functions in their language classes and that they appreciate the benefits of these tools. On the other hand, the results demonstrate that the instructors encounter some challenges primarily related to technical issues. The results are presented below, and they are based on themes derived from a thematic analysis approach. Five different themes were identified from the interview questions conducted with the EFL instructors. Such thematic analysis ensures a structured and detailed representation of the qualitative data that were collected.

Theme 1: Frequency of Utilized Functions

The qualitative analysis of data reveals interesting threads from the EFL instructors' responses. The respondents indicated that they have actively utilized many functions including screen sharing, breakout rooms, chat box, raise hands, annotations, mute-participants, polls, recording, microphone, remove-participants, and reactions. It was obvious throughout the interviewing process that instructors have preferences for specific features. Arguably, this depends on their teaching styles and preferences, their students' levels, and the overall course objectives. It is also worth highlighting that screen-sharing, chat box, raise-hand, annotations and breakout rooms, respectively, are the most frequently used functions among the interviewees whereas the polls function seems to be ignored by most of the instructors interviewed. One can conclude from the instructors' answers that most instructors tend to use the basic features of Zoom when there are numerous additional functions to leverage.

Theme 2: Enhancement of Teaching

It was obvious that most of the EFL instructors particularly indicated that they have favorably utilized screen-sharing, chat box, raise-hand, annotations and breakout rooms over other tools. They claim that these features have significantly enhanced their teaching practices by allowing them to share the materials, facilitate group/pair work, assess students' work, provide visual explanations, and enhance peer learning.

One participant explains that Zoom has enhanced instructors' ability to reinforce their students' learning through sharing different types of educational content within class. To elaborate, one participant states that "It also helps when we are sharing videos. It is also helpful if I want to google something quickly and show it to them". Such options cannot be easily utilized in face-to-face settings. Participants also addressed their abilities to use features like the polls and the chat box which help them assess their students' understanding and foster their learning. Instructors also highlight how these features help maintain students' focus and attention during online classes.

Furthermore, features like breakout rooms facilitate group/pair work, granting students the chance to collaborate with their classmates for more effective learning opportunities. To illustrate, one participant indicates that breakout rooms "are excellent for group work as they help teachers design collaborative activities and help instructors broadcast voice and written messages to all during the activity".

Moreover, it is argued that some features like the chat box enhance peer learning. For instance, one participant claims that through the chat box, students "would still answer even if they made mistakes because they could all look at each other's answers and check their answer", thus utilizing peer assessment to boost their learning.

Theme 3: Student Engagement

According to the EFL instructors, Zoom features enhance students' participation and engagement by providing opportunities for interaction via the breakout rooms, chat box, and reactions features. For instance, one participant claims that the chat box maximizes the engagement of students of all mixed abilities and personality types that even "shy students who are hesitant to use the microphone to participate are active in the chat box". Furthermore, when instructors provide feedback on students' written responses in the chat box, students feel more motivated to actively participate in the discussion and become productive and self-regulated learners since they might consult further resources before they share their answers in the chat box. Chat box and reactions features are said to encourage student participation by providing various channels for them to ask questions, respond to prompts, and engage with course materials at their own convenience.

Moreover, features like breakout rooms facilitate student collaboration and engagement. For example, one participant states that "The breakout rooms function is very engaging. It helps the students interact with each other as well".

Theme 4: Effective Classroom Management

Instructors have strategically leveraged the Zoom features to manage classroom dynamics, control interruptions, and ensure a smooth session flow. Features such as waiting rooms, mute options, remove participants, polls, and raised hands have helped these instructors maintain discipline and organization as noted.

These features are effective in managing the classroom environment by regulating student entry, controlling disruptions, and maintaining order. Therefore, it was obvious that instructors have utilized various features strategically to ensure smooth session flow and minimize distractions, demonstrating effective management techniques in the online setting. One participant noted that "the option to have students raise their hands, let students open their cameras and have control over that is important to prohibit anything that might be inappropriate in one way or another". Another instructor exclaims that these features have even helped students to become self-regulated and self-disciplined" since they know that any disruptions will be addressed effectively by the instructors.

Theme 5: Challenges and Recommendations

Overall, some instructors have expressed some concerns about technical issues (e.g., internet connectivity), time-consuming features (e.g., breakout rooms, annotations), students' misuse of certain features, security issues with online exams, and students' as well as instructors' unfamiliarity with certain features. However, some instructors redressed that, with experience, they managed to address most of the above-mentioned challenges. For example, Participant four mentions that to prevent students from misusing the share-screen function, instructors can control who can share what.

Recommendations include improving cybersecurity for examinations, providing additional feedback beyond the chat box, activating new Zoom features through the university's account/subscription plan, and addressing technical issues to enhance the online teaching experience. For example, one of the participants claims that there are more updated versions of Zoom that have more beneficial features to utilize than the features available through the University's current subscription plan. Therefore, this participant has purchased the latest Zoom App saying that "it has other features like taking attendance. I can make a summary of the meeting that could be sent to students".

5. Discussion

As demonstrated by the results of the first question, Zoom was found to be useful in EFL classes as viewed by the students themselves. This positive reception suggests that Zoom functionalities are helpful in improving the efficiency and effectiveness of online language teaching and learning processes. This result is consistent with that of Souheyla (2021), which concluded that Algerian EFL students viewed Zoom as useful in their classes. Specifically, the study showed that EFL Zoom classes increase students' motivation, enhance their interaction, provide a diversity of learning materials, and integrate proper assessment.

The findings of the second question suggest that Zoom's features and functions are viewed similarly by both female and male undergraduate students in EFL classes. One female participant said that "I use all of the features" once she was asked about the type of Zoom features that she uses in her language classes. This gender neutrality shows that the design and usage of these features are universally accessible irrespective of gender. Additionally, it provides an inclusive learning environment where both males and females can equally benefit from the technological tools in the EFL classroom. Such results also indicate that the efficiency of Zoom features and functions is consistent across different demographic groups. Arguably, these implications can be advantageous for educators in designing the teaching strategies in the online learning modality, knowing that the Zoom features and functions they use are equally effective for all students. Interestingly, since gender does not affect the respondents' views, EFL researchers may focus on other factors that influence the usage and effectiveness of Zoom features including technological proficiency, age, and social backgrounds.

Considering the results of the third question, it could be argued that the instructors' responses highlight the multifaceted role of Zoom features and functions in boosting online language learning and teaching. These features and functions have the ability to facilitate curriculum delivery, enhance student engagement, and support effective class management. However, addressing issues related to the technical issues and improving certain features could optimize the online teaching process.

Most of the respondents registered a high preference toward using the screen-sharing feature mainly for sharing the textbook with their students. One respondent stated that she uses this feature for many purposes. She added, "we share screen for the videos, audio, links, Google Drive". This might, however, point to a more

traditional, teacher-oriented perception of the instructor's role as instructors tend to be the center of the learning process when sharing books and imparting knowledge. Although sharing the textbook with students on Zoom is advantageous especially when students have a limited access to the textbook, teachers can enrich this experience and demonstrate a more learner-centered learning approach through applying various techniques. That is, students can be asked to present and discuss certain activities and sections in the textbook instead of being solely presented and discussed by their instructors. In addition, instructors are advised to indulge their students in collaborative discussions and let them participate in annotating texts. Utilizing such annotations can aid teachers throughout the screen sharing process. By encouraging learners to take the lead in terms of annotating the shared material, teachers can definitely help students learn and be more involved.

Six out of the nine interviewed instructors reported using the breakout rooms feature. One of the respondents clearly mentioned that they "use breakout rooms for collaborative work". This might reflect their awareness of what Chandler (2016) reported of the breakout rooms tool as a distinctive feature of Zoom platform. Moreover, Hartono, Widiyati and Anwar (2023) claim that Zoom is the most preferred teaching platform mainly because of its breakout rooms feature. However, this utilization of the feature was considered by the majority to be a challenge. One of the respondents stated plainly, "the breakout rooms were a challenge". It seems that this could be referred partly to the reported low preference of this feature by students. Students might not prefer being obliged to participate in discussions and collaborative activities as they might favor activities that are based on self-selection. Another potential reason for struggling with the breakout rooms feature could be instructors' unfamiliarity with such features that would entail they step out of their teaching comfort zones. Some instructors might not be competent in using such features. Therefore, instructors need to enhance and continuously update their digital competencies to be able to teach online effectively (Kohnke and Moorhouse, 2022).

Some of the participants announced that they view breakout rooms as a time-consuming feature. One participant expressed doubts about the effectiveness of this function stating: "I do not use breakout rooms a lot. I'd rather listen to the students because I teach lower levels, so I do not think it would be very effective". This is consistent with results of other studies. In their study, Kohnke and Moorhouse (2022) reported that it is worth noting that Zoom group discussions via breakout rooms are time-consuming since it takes a longer time to implement the group activities and are challenging for instructors to oversee since it is harder to manage online group discussions the way teachers manage in-person discussions.

It was also clear that the interviewed instructors asserted that their utilization of Zoom features contribute pointedly to students' engagement and participation in collaborative activities and discussions. These results receive support from the studies of Nuryanto (2021) and Nabil, Ayubi and Ansari (2023). Nuryanto states that Zoom meetings offer students features for both independent work and collaborative discussions, contributing to increased engagement and motivation. Students appreciate the efficiency of incorporating Zoom into the learning process, noting time and effort savings. The study also highlights the perceived environmental friendliness of online learning through Zoom as it reduces paper usage. Similarly, Nabil, Ayubi and Ansari (2023) argue that most participants believe Zoom enhances collaborative learning and boosts interaction between students and professors. Ease and cost-effectiveness of sharing discussions were also highlighted as notable advantages of Zoom technology by the participants. Additionally, the study unveils that more than half of the participants find the features of the Zoom program easy to comprehend for educational purposes.

6. Conclusion

This study has examined the role of Zoom features and functions in the online EFL learning experience from the perspective of both students and instructors. Pedagogically, the findings suggest that incorporating these tools can enhance student engagement and learning outcomes in the EFL classroom. While the study has highlighted an important aspect of the EFL online learning environment, it is essential to acknowledge its limitations. The study was restricted to one academic semester and a particular cohort of undergraduate students and instructors in a Palestinian university. This would limit the generalizability of the results to a broader context. Accordingly, EFL researchers may broaden the scope beyond a single semester and specific university in order to comprehensively explore Zoom's effectiveness in EFL education. Besides, future research could build on the results of the current study and use qualitative methods to deeply explore the students' experiences in using Zoom platform in learning a foreign language. Finally, future research might examine the influence of EFL instructor training on using Zoom features effectively in EFL contexts.

The findings of this study offer some practical implications for online language education. First of all, the positive view of Zoom features and functions suggests that EFL instructors can encourage student participation through

integrating these tools intentionally in their EFL language classes. Besides, the challenges that were perceived by EFL instructors suggest that they need to work on mitigating them effectively to facilitate the educational process within the context of online language education.

Ethics statement: Needed approval for conducting the study was granted by the related head of the department. Besides, the participants were informed about the purpose of the study, and their consent was secured prior to their involvement.

AI statement: The participants exclusively used AI-enhanced tools to enhance the article's readability.

Declaration of Conflict of Interest

The authors have no conflicts of interest to declare.

Data Availability Statement

Data will be made available on request

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Appendix A: Interview Questions

- Please mention the functions/features of Zoom platform that you use in your online EFL classes.
- How often do you use different Zoom platforms functions to manage your online classes?
- To what extent do these functions /features enhance your teaching practices?
- To what extent do such functions /features contribute to students' retention, engagement and participation in EFL classes?
- What challenges have you encountered when using Zoom for EFL classes, and how have you addressed them?
- In your opinion, how can functions /features offered by Zoom platform be optimally used to enhance language teaching and learning?