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Heinrich Söbke and Marija Cubric

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Contents

Micro-Celebrities or Teacher Leaders? An Analysis of Spanish Educators' Behaviors on Twitter

Carlos Marcelo, Paulino Murillo, Paula Marcelo-Martínez, Carmen Yot-Domínguez and Cristina Yanes Cabrera
Faculty of Education, Universidad de Sevilla, Spain

marcelo@us.es
paulino@us.es
pmarcelo@us.es
carmenyot@us.es
yanes@us.es

Abstract: Social networking sites have become affinity spaces for teachers. Many teachers use them with different intentions and motivations, including learning. On social media platforms there are active teachers who have developed a certain leadership and recognition from many teachers. In some areas, like marketing or fashion, people with influence are called influencers. This paper investigates who they are, how their network is configured and how they perceive themselves. The questions that directed our research were: Who are the predominant Spanish teacher leaders on Twitter? What is the network structure that characterizes them? What perceptions do these teacher leaders have about their role and its impact on their professional development as teachers and others? This study has two distinct but interrelated phases. We investigated the structure and relationships among 54 Spanish teacher leaders. Using a social network analysis (SNA) approach, through the analysis of the social behavior of these teachers on the social network Twitter, we first identify educational profiles who have a high degree of centrality in the network. These are teachers who are recognized as opinion leaders by a significant proportion of their fellows. In addition to the degree of centrality that tells us how relevant a user is in a specific digital community, we identified teachers who play a key role in the circulation of information in the network studied. In some way, these teachers share common characteristics with activists in other fields. Of the 54 teachers, we selected 20 who were then interviewed. The findings demonstrate that they don't consider themselves micro-celebrities or influencers. We found a lack of identification not only with the term, but also with the image of an influencer which was understood as banal, superficial, commercial, and far from what they do in social networks.These teachers develop their identity as new digital artisans who foster a culture of collaboration and create affinity spaces that allow informal learning. Their motivation is intrinsic, through recognition and prestige among other teachers, which leads them to build a kind of constructivist leadership.

Keywords: Teacher learning, Leadership, Twitter, Social network, e-Learning

1. Introduction

The isolation conditions resulting from the COVID-19 pandemic have favored the increased use of social media by teachers. Social networks have become new spaces for meeting, exchange, dialogue, collaboration, and critique for many teachers (Lay,et al., 2020). Social networks did not explicitly emerge as environments for teacher learning and professional development. Despite this, research has shown that these networks facilitate relationships and communication between teaching professionals, while providing a space to share their practices, classroom activities, and assessment (Carpenter and Krutka, 2014). Social networking sites have enabled the configuration of affinity spaces among teachers (Gee, 2017) not only to exchange information and resources, but also to develop a sense of belonging.

Social networks are occupying an important space in the path to a teacher's professional development. Therefore, informal leadership figures have emerged from active teachers in social networks. Their leadership activity allows the generation and acquisition of learning by other teachers who participate in these social networks (Daly and Finnigan, 2010; Fischer, Fishman and Schoenebeck, 2019). Social Network Analysis (SNA) has been used to analyze the roles, leadership and influence among these active teachers. To do this, the classification of levels of betweenness centrality and closeness centrality is taken as a reference. On the one hand, betweenness centrality of a user indicates to what extent the user is positioned as an intermediary so that the information that flows within a conversation in a social network is distributed among the community. The greater the centrality of intermediation, the greater the capacity for spreading information, even outside its community of followers. On the other hand, closeness centrality is considered, which describes the connections with other users that a user presents within the social network in which conversations take place. Teachers who present a high centrality of closeness and intermediation can distribute information to other teachers more

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efficiently, so they represent figures that can be consolidated as disseminators in the network (Daly, et al., 2019; Fischer, Fishman and Schoenebeck, 2019).

The leadership roles that active teachers practice in social networks like Twitter turns them into opinion leaders (Lazarsfeld, Berelson and Gaudet, 1944). These teachers are reference and influence figures for other teachers who have spontaneously turned their practices in social networks into informal learning processes. They have a leadership capacity that has been specifically described as "a type of teacher leadership focused on improving teaching and learning" (Carpenter, et al., 2021, p. 5). They have been called education influencers, teachers with a certain leadership capable of mobilizing the actions and behaviors of other users who share a common affinity (Carpenter, Shelton and Schroeder, 2022). The term influencer is widely used in areas such as marketing or fashion. Influencers are trusted by their followers and, because of this, commercial brands have noticed the possibilities they offer to promote targeted consumption. Social influence theory, applied to the study of commercial influencers, has identified three aspects that can characterize the influencer-follower relationship: dependence, identification, and internalization (Bentley, et al., 2021; McCormick, 2016; Tafesse and Wood, 2021). But are these teachers really influencers?

2. Literature Review

In educational research, works have recently emerged focused on studying the use of social networks by teachers as a means for professional development, as well as those expressly focused on the contribution of outstanding teachers in social networks. Thus, different studies have analyzed how teachers use Facebook (Hart and Steinbrecher, 2011), Instagram (Carpenter, et al., 2020) or Twitter (Carpenter, et al., 2019). The latter, according to Luo, Freeman and Stefaniak (2020), is the main platform for creating professional networks that allow knowledge sharing. In fact, teachers value the immediate nature of Twitter communication, which allows them to overcome the isolation they may feel in performing their duties and helps them develop a sense of community for teachers. They perceive Twitter as a tool for furthering their own professional development, rather than as a means of interacting with students or families (Holmes, et al., 2013).

Recent studies have focused on analyzing how and why teachers use social networks for professional development and as spaces to establish contact with other teachers, creating opportunities for affinity and collaboration (Carpenter, et al., 2020). Social networks contribute to expanding what has been called social capital (Rehm and Notten, 2016). Through them, teachers generate interactions that can be stable or temporary, allowing them to gather resources or obtain information from other people considered relevant to their work (Fox and Wilson, 2015). Multiple studies elucidate the reasons why teachers use social networks. Among the main reasons are the following: to inquire (from other more experienced teachers), to find resources, to share resources with other teachers, to receive emotional support, to be trained, to carry out a self-assessment (training needs, reflection), and to dialogue with other teachers (Greenhow and Askari, 2017; Higueras-Rodríguez, Medina-García and Pegalajar-Palomino, 2020; Li, Zheng and Zheng, 2020; Nochumson, 2020; Staudt Willet, 2019). Furthermore, teachers recognize that social networks allow them to take advantage of their learning opportunities over traditional professional development options, feeling a greater sense of achievement from learning acquired from a community (Ross, et al., 2015).

But teachers use social networks with varying degrees of intensity and frequency (Xing and Gao, 2018). On Twitter some teachers only participate as content receivers. They are what Wise, Hausknecht and Zhao (2014) call "active listeners". Others also retweet messages that seem relevant to them. Few of them systematically and continuously feed the networks with their own proposals and content. Teachers with a higher number of followers and a constant and active presence on social networks are a minority. Antelmi, Malandrino and Scarano (2019) proposed a rule whereby 90% of the profiles that participate in conversations on a social network have a passive role, being represented as punctual or sporadic participants. Only 1% of the profiles that interact are those that the literature highlights as facilitators of information or active teachers. If we transfer this rule to according synchronous conversations on Twitter, we find that they are usually dominated by a few active members of the network, who generate a large volume of tweets (Xing and Gao, 2018).

The presence and intensity of participation of teachers on social networking sites are often related to their structural position in the network. As established by social network theory, according to Daly (2010), the position and capacity to manage the flow of information in the network will depend on the level and degree of links that a given subject has. This is related to the concept of centrality and its different types (Del Fresno García, Daly and Segado Sánchez-Cabezudo, 2016). So Daly, et al. (2019) differentiate different types of actors in social networks. Firstly, transceivers are people who actively participate with high retweeting or mentions by other members, which shows us that they are people highly valued by others within their social network. Secondly,

transcenders are those who are mentioned by many members of the network but at the same time retweet and share contributions from other members. Finally, there are traders, people who are key to the flow of information from one group to another in the network. They are people who, given their high level of participation and followers, find it easier to appear in the accounts of other users who share the same topic of interest. From the perspective of this classification, subjects who participate in a social network and can be categorized as transceivers, transcenders, or traders could be considered to have a certain level of recognition and informal leadership. They are also called influencers (Liou and Daly, 2018).

Research on educational influencers is recent and scarce. Few studies have contributed to highlighting the characteristics, identity, and motivations of teachers with a prominent role in social networks. In a recent article, Carpenter, Shelton and Schroeder (2022) proposed a framework for understanding how the role of the influencer is constructed. A framework that poses challenges between maintaining the principles of authenticity and extracting results through the monetization of their contributions. Therefore, although education may be understood as a public service in which the marketing, advertising, sales, and consumption aspects of products are secondary, some trends that contradict this idea are observed. One of the roles that they highlighted recently are the "teacherpreneurs" (Berry, 2015), teachers with leadership capacity who share educational materials, information and educational content through social networks and are recognized by others as authorities whose materials they can trust and use (Shelton and Archambault, 2018; 2020). The resources and materials generated by these teachers are very attractive to teachers looking for classroom-tested materials that are accessible and ready to use online (Carpenter and Shelton, 2022). The activity that teacherpreneurs develop is based on designing and sharing their own teaching materials and resources available to the educational community through platforms such as www.tes.com and teacherspayteachers.com. These materials are often provided free of charge, but in other cases they involve a fee. Koehler, et al. (2020) show that the average price of resources downloaded on teacherspayteachers.com is $3.73 and that only 69% of downloads were free resources. The top 1% of the teachers on the platform account for 81% of total sales. Therefore, a small minority of sales teachers receive the highest financial return for the materials they produce, while the majority do not. As literature shows, there is a differentiated treatment for all those teachers with high activity and leadership in social networks because some of them carry out their activity in social networks to pursue a lucrative goal (Carpenter et al., 2021; Gil-Quintana and Vida de León, 2021), but others do it altruistically.

In this article, we focus on determining who are the active teachers in Spain on Twitter, what are the structure of their relationships, as well as their perceptions and ideas about the leadership role they play. Specifically, the research questions that we intend to answer are as follows.

RQ1. Who are the predominant Spanish teacher leaders on Twitter? What is the network structure that characterizes them?

RQ2. What perceptions do these active teachers have about their role and its impact on their professional development as teachers and others?

3. Methods

This study has two distinct but interrelated phases. Firstly, to answer the first research question, we identified profiles with relevance on Twitter who could be classified as "educational influencers" (Marcelo and Marcelo-Martínez, 2021). To do this, we use Buzzsumo software, a marketing analytics tool that allows advanced queries to be performed on profiles and topics most consumed and shared on social networks. We started by filtering users by country (Spain) and keywords present in both the user's biography and their publications, such as "educación, soyprofe, profesor, profesora". From this analysis, we obtained a sample of 64 Spanish profiles, of which we initially selected 10. We consider those with more than 15,000 followers and more than 5,000 published tweets (Marcelo and Marcelo-Martínez, 2021). Once the most prominent teachers had been identified, we began to analyze the mentions they made on their Twitter posts. We were interested in finding people whom these teachers considered relevant and who were included in their mentions. Once the list of subjects mentioned by these ten active teachers was configured, we established as a criterion that at least four of the profiles in our sample were mentioned. This process allowed us to identify a total of 44 new teachers, which together with the initial ten profiles make up the sample of 54 subjects to be analyzed.

Of the 54 Spanish teachers selected, 38 were men and 16 women. Regarding the educational level towards which their interventions are oriented, we found 23 whose publications are mainly directed toward primary education, 10 toward secondary education and high school, 21 focus their tweets on higher and university education, and 4 of them also address conversations and content related to early childhood education.

Through the first research question, we sought to determine whether the sample configures an integrated or dispersed social network. For this, we applied the procedures of SNA. These procedures require the configuration of an adjacency matrix in which it can be observed how many mentions each teacher receives from the rest of them. To carry out this study, we used data obtained from 167,162 tweets from the 54 profiles. Once these data were downloaded, we proceeded to extract the mentions. This compilation of frequencies generated an adjacency matrix that shows the number of times each teacher was mentioned by each of the other 53. It should be noted that in this case we found some self-mentions by some of them. Once the adjacency matrix was created, we used the GEPHI 0.9.2 program (Bastian, Heymann and Jacomy, 2009) to analyze the relationships. Gephi is an open-source program that allows interactive visualization of networks and provides the tools to generate dynamic and hierarchical graphs. This software has been used because it is the tool that provides a greater and better graphic representation of the relationships established between the analyzed sample.

Secondly, to answer the second question, we invited the 54 previously identified teachers for individual interviews with the research team. There were 18 who agreed to participate in that study phase. Of these, 7 were women and 11 were men. Most of the participants were active teachers in primary education (8), secondary education (1) high school (1) and higher education (4). The rest were professionals dedicated to the education and training consulting sector (2), as well as to writing educational blogs and narratives for young people (2). Data were collected through semi structured interviews on-line. They were carried out through the ZOOM video conference application and lasted an average of one hour. One of the interviewees requested to personally answer the interview script through an audio recording.

The interviewers had a script of questions (Appendix 1) that sought to gather a variety of information about topics such as participation in social networks; the origins and evolution of each one of them; the topics that concern them and their publication process; their self-image as a person with the capacity to influence others; the way they relate to followers and other influential teachers; and the possible learning that is generated through social networks. Once all interviews were completed, two of the interviewers began to transcribe the recordings. To analyze the data, two of the interviewers developed inductively a set of themes (Appendix 2) that allowed us to classify the data. Data analysis was developed inductively as the interviews were analyzed. A system of categories inherent to the themes that emerged and were categorized by both researchers arose. We used the MAXQDA program to perform a theoretical coding based on the scripted questions and analyze the content of the answers of the teachers interviewed. MAXQDA is an intuitive software, which can be used on Windows and Mac and allows and facilitates the coding process. It facilitates the analysis of qualitative data by allowing coding, pattern extraction, etc.

4. Results

Below are the results of this study according to the two research questions and phases of empirical work.

4.1 Analysis of the Network Structure of Active Teachers in Spain

A total of 54 active teachers in Spain were identified. They were either in practice or retired teachers who had developed a high activity of publication and dissemination of educational content through the social network Twitter. Figure 1 shows their profiles. Those colored in red have been the teachers who subsequently participated in the interview.

The first research question displays an interest in a discussion surrounding the structure of communication between them. We tried to see if identified teachers could be represented as independent micro-celebrities, with limited relationships with the rest of them, or whether they relate fluidly to each other to create collaboration networks. The network analyzed is an undirected network (Hoppe and Reinelt, 2010) since each member can be mentioned individually and by any other member. Analysis with the Gephi tool allowed us to create a network of 54 nodes (profiles) and 1,607 edges (relationships between nodes) (Figure 1).

An aspect of interest when analyzing a social network relates to determining which nodes of the network play an important role in terms of the level of connections they have with the rest of them and the quality of these connections. One of the parameters that is usually analyzed in a network is its density (the ratio between possible and actual connections) (McCulloh, Armstrong and Johnson, 2013). A network will be very dense when the number of relationships between its members is very high, as close to the maximum as possible (Friedkin, 1981). The density of the network we are analyzing is high: 0.718. This value is calculated automatically once the database of profiles is uploaded into the analysis software Gephi. This high density means that interactions occur between 71.8% of all possible interactions. That is, most active teachers in Spain relate fluidly to the rest. This

result is corroborated by the fact that the diameter of the influencer network is 3. In a social network, the diameter is defined as the largest possible distance between any two nodes of the network, that is, the number of steps that must be taken from one member to the other (Wasserman and Faust, 1994). Therefore, we note that the network is very dispersed. See Figure 1.

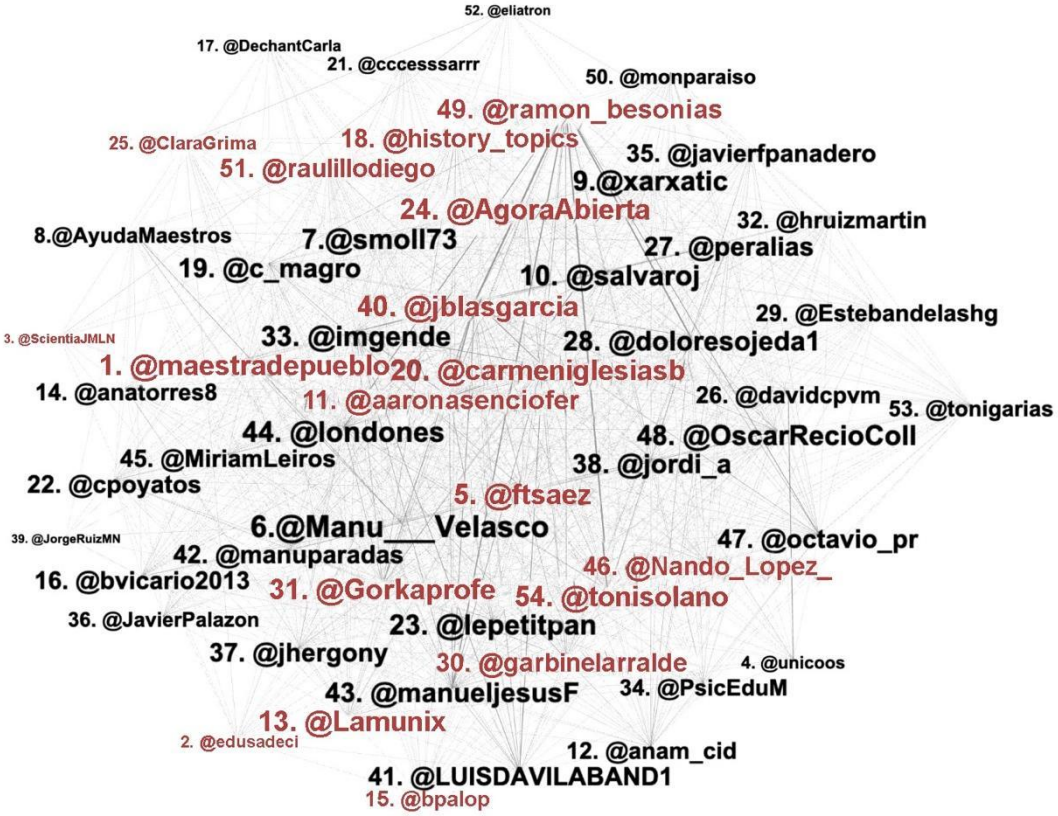

Figure 1: Representation graph of groups of educational influencers according to centrality

Together with density, it is important to analyze the centrality, as it enables the identification of the most prominent nodes in the network (Del Fresno García, Daly and Segado Sánchez-Cabezudo, 2016). The degree of centrality of a profile is an important indicator of its level of influence in the network. It can be seen in Figure 1 that there are differences in the size of the name of each profile. Through this size, the degree of their centrality in the network is represented. Thus, a teacher whose profile name appears with a larger font size shows greater centrality.

The degree of centrality of a teacher is determined by the ratio between the number of mentions this teacher makes of the others and the number of mentions that are received from others. We refer to the mentions received as in-degree centrality and those issued as out-degree. As we mentioned before, in-degree refers to the number of incoming connections, while out-degree is related to the outcoming relations and interactions (likes, follows, replies, etc). In our study we also included two important values: centrality and betweenness centrality in order to investigate the structure of the network present in these active teachers. In Table 1, we note that there is a certain balance between in-degree and out-degree centrality among active teachers studied. Thus, for 24 teachers, the difference between in and out degree is negative, which means that they make more mentions than they are mentioned (Cha et al., 2012). Furthermore, in 26 cases, the opposite is true and in 4 cases in and out degrees are balanced. However, in particular, the percentage of difference between in-degree and out-degree measures is generally low. We only found four teachers whose ratio between in- and out-degrees is greater than 25% (@anatorres8, @AyudaMaestros, @bvicario2013 y @maestradepueblo). These teachers are characterized by a more self-centered attitude, with less concern about mentioning other members of the community. To confirm that there are no significant differences between the teachers' in- and out-degree scores, we performed the Wilcoxon W test for two related samples. The significance obtained is .981, which allows us to accept the hypothesis that there are no significant differences between the contrasted scores. Most

of the teachers analyzed present a high sense of community, with the ability to recognize (through mentions) the contributions of the others in the group. See Table 1.

Table 1: In-degree, Out-degree, Centrality and Betweenness centrality

Profile	In-degree	Out-degree	Ratio in/out degree	Percentage of difference in / out degree	Centrality	Betweennes s centrality
@aaronasenciofer	39	39	,00	,00	78	33,51
@AgoraAbierta	40	34	6,00	8,11	74	16,75
@anam_cid	34	24	10,00	17,24	58	7,71
@anatorres8	11	33	-22,00	50,00	44	5,20
@AyudaMaestros	27	14	13,00	31,71	41	11,37
@bpalop	17	18	-1,00	2,86	35	13,61
@bvicario2013	13	38	-25,00	49,02	51	18,15
@c_magro	37	37	,00	,00	74	23,01
@carmeniglesiasb	42	43	-1,00	1,18	85	38,71
@cccesssarrr	17	13	4,00	13,33	30	14,48
@ClaraGrima	21	9	12,00	40,00	30	13,50
@cpoyatos	25	33	-8,00	13,79	58	15,17
@davidcpvm	24	24	,00	,00	48	29,02
@DechantCarla	9	16	-7,00	28,00	25	2,46
@doloresojeda1	40	40	,00	,00	80	41,39
@edusadeci	16	10	6,00	23,08	26	13,73
@eliatron	10	9	1,00	5,26	19	9,70
@Estebandelashg	29	33	-4,00	6,45	62	13,39
@ftsaez	46	43	3,00	3,37	89	80,35
@garbinelarralde	33	39	-6,00	8,33	72	11,48
@Gorkaprofe	36	46	-10,00	12,20	82	45,67
@history_topics	27	34	-7,00	11,48	61	14,96
@hruizmartin	29	27	2,00	3,57	56	19,37
@imgende	44	40	4,00	4,76	84	53,79
@javierfpanadero	35	26	9,00	14,75	61	72,64
@JavierPalazon	18	20	-2,00	5,26	38	5,05
@jblasgarcia	41	46	-5,00	5,75	87	57,08
@jhergony	36	29	7,00	10,77	65	25,20

Profile	In-degree	Out-degree	Ratio in/out degree	Percentage of difference in / out degree	Centrality	Betweennes s centrality
@jordi_a	37	28	9,00	13,85	65	15,28
@JorgeRuizMN	8	3	5,00	45,45	11	0,40
@Lamunix	28	40	-12,00	17,65	68	21,60
@lepetitpan	31	43	-12,00	16,22	74	40,93
@londones	41	42	-1,00	1,20	83	55,03
@LUISDAVILABAND1	21	37	-16,00	27,59	58	12,76
@maestradepueblo	43	14	29,00	50,88	57	36,21
@Manu___Velasco	42	48	-6,00	6,67	90	115,36
@manueljesusF	37	40	-3,00	3,90	77	24,61
@manuparadas	26	35	-9,00	14,75	61	10,25
@MiriamLeiros	34	28	6,00	9,68	62	6,02
@monparaiso	19	27	-8,00	17,39	46	11,10
@Nando_Lopez_	39	18	21,00	36,84	57	29,41
@octavio_pr	40	30	10,00	14,29	70	19,28
@OscarRecioColl	39	30	9,00	13,04	69	14,72
@peralias	34	42	-8,00	10,53	76	28,10
@PsicEduM	31	20	11,00	21,57	51	4,77
@ramon_besonias	39	33	6,00	8,33	72	22,39
@raulillodiego	35	32	3,00	4,48	67	18,21
@salvaroj	28	42	-14,00	20,00	70	29,79
@ScientiaJMLN	8	5	3,00	23,08	13	1,29
@smoll73	29	42	-13,00	18,31	71	37,45
@tonigarias	24	29	-5,00	-9,43	53	9,97
@tonisolano	46	39	7,00	8,24	85	38,64
@unicoos	14	12	2,00	7,69	26	4,48
@xarxatic	38	31	7,00	10,14	69	34,52

4.2 Perceptions of Spanish Teacher Leaders on Twitter

As we have previously mentioned, 18 of the total active teachers of the first phase were interviewed. In Figure 1, we have highlighted with a different color the handles of the teachers who participated in the interviews. The analysis of the content of the interviews aims to answer the second research question.

4.2.1 Neither micro-celebrities nor influencers

The interviewees are not only not considered micro-celebrities, but also influencers. They do not identify with the term "influencer," just as they do not identify with the terms "micro-celebrities" (Carpenter, et al., 2021) or "teacherpreneurs" (Shelton and Archambault, 2020). They recognize it as a pejorative connotation due to its commercial, pecuniary, and even superficial or unprofessional perception. First, they do not perceive themselves as influencers simply because they have attracted followers and recognition on social networks, given that they understand participation on these social networks as a contribution to a network of professionals where they offer what they have and encourage collaboration. "If we understand an influencer as someone who has an opinion and wants everyone to follow him because his opinion is selling a product, selling the methodology, etc. Then I am not interested in influencing anyone at all" (Int.05). Second, they do not consider themselves influencers because they want to keep their feet on the ground: "One of the things I have learned is that to participate in networks you have to be humble, you need to know how to behave, you have to be aware of where you are. That humility is fundamental, that humility of not thinking you are more than anyone, because I am still a teacher"(Int.03). Third, rejection of the influencer label is related to the fact that it is a term external to the teaching profession.

The term influencer, as we can see, does not represent them. But this does not mean that they do not exert some influence on other teachers. They develop what Lambert (2002) calls constructivist leadership, who considers that the role of leadership should be to involve people in the process of creating the conditions for learning. These conditions occur through dialogue and the reciprocal construction of knowledge (Rodesiler, 2017). From Lambert's point of view, constructivist leadership requires dialogue and reciprocity. The capacity for reciprocity is the result of time spent in dialogue and in interacting with others and sharing ideas. This dialogue process is often initiated by participating teachers as they commit to sharing ideas and resources. In this process, the interviewees assume that their activity gives them some visibility in the networks: "In general, I don't complain about the visibility I have" (Int. 09) "I always create the content that I share. And this is what gives you visibility" (Int. 05). They also recognize that their publications have an impact because they encourage people to talk about them, to pay attention to certain educational issues, to apply ideas, and to reuse resources: "I see on social networks what issues concern me and those are the ones I post about, and that is what gets someone to talk about it. And that serves to get someone to talk about them" (Int. 17).

They consider that their interventions in the network are useful to make people think and bring about change and improvement: "To think that I can turn that into a few sentences that make someone think and maybe change some things in their classroom that could be better or be misaligned with what is known" (Int. 07). It should be noted that they are concerned about the responsibility required by their role in social networking sites and how careful they are with what they say. "Of course, we have influence on what we can say. So if we have it, we must measure it very well" (Int. 04) "... That is, I have an impact due to my work and that makes me feel responsible. That is to say, I try to be very careful of what I say" (Int. 13).

As we can see, the teachers that were interviewed develop what Lambert (2002) calls acts of leadership (as opposed to assuming leadership roles). These acts of leadership are based on a sense of honesty and responsibility with respect to the trust others have placed in them. They do not feel like leaders but recognize their leadership capacity. This is what Lambert means when he states: "The redistribution of power requires that formal leaders construct and interpret themselves as they construct meaning and knowledge with others. Their sense of personal identity allows for courage and risk, low-ego needs, and a sense of possibilities" (Lambert, 2002, p. 60).

4.2.2 The new "digital artisans"

Michael Huberman (1993) proposed the idea of teachers as independent artisans, understanding that some teachers act as if they were experts in "bricolage". He stated: "A subject who creates or repairs learning activities of various kinds with a particular style and signature. Adapting instructional materials on the fly that he has brought, that he has been given, or that he has been able to find" (Huberman, 1993, p. 15). This image of the teacher suggests a professional who, like the sculptor or painter, carpenter, or watchmaker, "works alone" and needs solitude to do his or her job well. In some ways, teachers acting as independent artisans do so to protect themselves from work settings that are not very inclusive or collaborative. Teachers, as artisans, do not always develop their skills in solitude. Talbert and McLaughlin (2002) suggest that the idea of craft communities can work when they are understood as groups of teachers who collaboratively develop solutions and knowledge, working with their own means and resources. Almost thirty years have passed since Huberman's proposal, and we recovered it to conceptualize the work and personal approach assumed by the teachers we interviewed.

These are teachers who have gradually achieved a certain notoriety by sharing their ideas, opinions, and resources with others online. The teachers we interviewed can be considered independent digital artisans: "Every network begins in solitude" (Int. 14). They are people who feel they have "something to say" and build their discourse around their personal preferences and interests, concerns and experiences: "According to my interests, I write based on those interests" (Int. 06). They freely decide on the topics to be addressed. These may be linked to the content of the topics themselves, for example, mathematics, or they may deal with their teaching: "What I try to do is to disseminate mathematics, looking for an excuse of what is going on around us" (Int. 02). They may also be cross-cutting themes (technology, strategies to facilitate learning, etc.).

They are inspired, up to date, and find the foundation for their content through reading: "I am a big reader. I have always started 3 or 4 books and read them at the same time. In these readings, we open up new fields. The more I read, the more doubts arise, and I realize how little I know" (Int. 06). Through their own social networks, they can easily follow what is published on the topics they are working on or those that are most significant to them. They make their ideas, opinions, resources, experiences, etc. available to others, knowing that there are some who listen.

As digital artisans, they generally do not plan their posts. In the cases where they do, it is usually because they are addressing their students and discussing topics that they are working on or are planning to work on with them. They also do not follow a work method: "I do not program the entries or think about them and store them beforehand. I discuss current events or what happens to me at school or what I read" (Int. 12). They justify an unsystematic, unorganized action, attending to their own conceptions of how and for what purpose social networks should be used by education professionals.

4.2.3 Creators of affinity spaces

The dynamics of dialogue and exchanges that occur in social networks generate collective spaces of encounter that can be understood as "affinity spaces" (Gee, 2005). In these spaces, people find other people or topics related to their interests (Rosenberg, et al., 2016). This affinity space is configured as a learning opportunity for teachers outside of the confines of formal training (Gee, 2017). Affinity spaces have a more open and somewhat diffuse connotation to the concept of communities of practice popularized by Wenger (2000), since a community of practice has goals and objectives that have a higher level of formality, as well as norms of interaction among community members.

Interviewees have created affinity spaces with their followers and with other educational influencers (Marcelo and Marcelo-Martínez, 2021). They have earned the credibility of their followers by sharing reflections, information, experiences, etc. in social networks. They are on social networks expressly for this purpose, stating: "I see it as an exchange of information or experiences. An exchange with the people who follow me" (Int. 10). This is a relevant achievement if we consider them to be clear about their objectives. Their main purpose is to generate learning opportunities for their followers; also, to build their own learning through the interactions and exchanges that take place. "It gives me a sense of being in tune with many teachers who want to share and want to train and continue training to transform education" (Int. 15).

The vast majority of the followers of the interviewees are teachers at all levels of education. Through their statements, the number of "followers" seems irrelevant: "I don't want to fall into this clientelism" (Int. 13). But they understand that followers provide a means for them to reach out to others. They are like multiplying agents, replicating and disseminating their posts, although sometimes they have some doubts, as this teacher did: "Being an influencer and all this, at certain times it has been a big thing for me, because I used to say: I am not doing anything for this, I am just learning and being curious" (Int. 17).

These platforms have provided them with access to an affinity space that connects them to countless people, as well as to a vast amount of information. "It has put me in contact with many very curious teachers of all kinds. They all contribute in some way" (Int. 18). Around them, they have built their own contact networks, with known and anonymous professionals, who nourish them with content that becomes fertilizer for their activity, as well as a source of learning and employment opportunities. Undoubtedly, networks have become a source of learning for them. "It is a learning space that I would find it very difficult to do without today. For me, if the little blue bird closes tomorrow, I would be upset" (Int. 11).

Interaction with users and followers in social networks often occurs as responses to comments on publications, intervening in debates, responding to a request or direct consultation, etc. There is a general perception that it is insufficient and that there is little interaction with them, although they would like to do it more often. Interaction occurs spontaneously from feedback and questions received, and debates generated about the

publications. They interact when time is available and as long as comments, questions, etc. are formulated with respect. Occasionally, personalized contact is maintained through private messages. "What is clear is that if you want something, you immediately resort to private messages, something that was hardly used before" (Int. 08).

4.2.4 Recognition and learning as rewards

Hashim and Carpenter (2019) proposed a model to analyze teachers' motivations to become involved, engaged, and motivated to use social networks. This participation, when it becomes very active, as is the case for participating teachers, requires time and consistency. Using utility-based theory, these authors differentiated between individual and social motives. Individual motives are related to the need for professional development and learning that teachers themselves perceive (self-efficacy). From these motives, they understand that participation in social networks can support their learning. Another motivation for teachers to use social networks is related to social aspects. With the emergence of social networking sites, the boundaries between school and the outside world have become porous, allowing teachers to develop a sense of identity and professional reputation both inside and outside of their schools.

We identified both motives in the teachers interviewed. Thus, they are satisfied and recognize different benefits of their participation in social networking sites, both on a professional and personal level. They especially emphasize the feeling of being valued by other professionals, which affects them on an emotional level and has an impact on their self-concept and self-esteem. For this reason, the recognition that most satisfies them derives from the words of gratitude of their followers.

Participation in social networks has changed them: "You ask me if I'm the same as I was 6 years ago and the same as I am now, and it has nothing to do with me as a teacher, because I've evolved" (Int. 01). Social networks have facilitated learning and professional development and have allowed them to have a greater professional projection: "Some of the training requested from me relates to the impact that my content had... I would not have succeeded if I had not been on social networks" (Int. 15), "As a result of this, they called me to give training courses, to publish on websites" (Int. 18), "When I started looking for work and projects as a freelancer, they opened many doors for me" (Int. 06).

In addition to positioning themselves as referents for specific professional approaches, as this teacher states: "My greatest satisfaction is being able to write several books and meet many people, participating in several projects... I have also learned a lot from other accounts through my participation in networks" (Int. 12).

5. Conclusions and Discussion

This study emerged from the extensive use that teachers in Spain are making of the social network Twitter for their own development and learning and the emergence in it of leading teachers that plays a key role in their learning. Within it, we researched the network structure and relationships among 54 active teachers. Using a SNA approach, we first identify teachers who have a high degree of centrality in the network. In addition, we identified influencers who play a key role in the circulation of information in the network studied. As we have analyzed, the network of 54 teachers is horizontally self-organized, with some groups having common characteristics but interacting with the rest of the groups, and where teachers of all educational levels are equally mixed.

Micro-celebrities or teacher leaders? We have conducted the analysis of a group of teachers who are creating new forms of interaction and who have developed informal interactions that allow them to voice their opinions with the ability to generate and share ideas and resources (Fait, 2018). These education professionals don't perceive themselves with the term "influencers". They assume a type of informal leadership (Ross, 2019) gained from the trust and recognition that their own peers have been giving them through social networks. This leadership is built on individuality, initiative, and motivation to share and exchange with other teachers. They are artisan teachers who have found a niche in the digital space to expand their possibilities of interacting with other teachers. Taking into consideration the article recently published by Carpenter, Shelton and Schroeder (2022), we find that Spanish teacher leaders opt more for autonomy and the ideal of contributing to the professional development of their colleagues than for receiving remuneration. They do not consider themselves neither influencers nor micro-celebrities. However, they share the tensions to which Carpenter, Shelton and Schroeder (2022) referred; on the one hand, being leaders among teachers, but at the same time not wanting to stand out due to a professional culture that does not reward the visibility of teachers (Patton and Parker, 2017).

The denial of leadership is something we have found informally when interviewing some of these teachers The analyzed teachers operate as opinion leaders to the extent that they not only redistribute information but also generate their own information, either because they design content or because they find first-hand information based on their position in the network (Walter and Brüggemann, 2020). Therefore, we can assume that digital social networks allow the establishment of new informal leadership among teachers (Daly, et al., 2019). Through them, opportunities are created so that, by sharing their experiences, ideas, conceptions, and reflections, teachers can develop personal or professional learning (Greenhalgh, Rosenberg and Wolf, 2016).

These proactive teachers share some characteristics identified by Gerbaudo (2017) when analyzing the social movements Occupy Wall Street, Indignados, and UK Uncut. According to this author, these movements were characterized by three "technolibertarian" principles: transparency (tendency to open up, to open-source), horizontality (rejection of formal hierarchies) and denial of leadership (tendency to assume that leadership is something to be avoided). The principle of transparency was observed throughout the interviews in the teachers' insistence on the idea of sharing their opinions and resources altruistically. As we have stated, they do not identify with the term influencer and assume the idea that they are often mere transmitters of ideas to promote the development and learning of other teachers. We see the principle of transparency not only in relation to the accessibility of resources and materials, but that it also has to do with the horizontal manner in which teachers build knowledge among themselves. This knowledge allows teachers to "learn in practice (by doing), through meaning (learning is intentional), through learning in participation with others, and through identity (learning and changing who we are)" (Lieberman and Mace, 2010, p. 80). These teachers are far from the concept of a "teacherpreneur" that has become popular in recent times (Koehler, et al., 2020; Shelton and Archambault, 2020).

Spanish teachers assume the principle of horizontality in teacher learning and professional development processes. Learning can take place at any time anywhere. Therefore, along with formal professional development activities, due to the contribution of the type of teacher interviewed, informal activities have multiplied, such as conversing with other teachers and carrying out independent activities such as searching the internet for teaching resources (Jones and Dexter, 2014). Teachers are accessing the internet to expand their development opportunities through social media platforms (Prestridge, 2019). Social networks enable the establishment of meaningful relationships among teachers. Through them, social learning is generated, as teachers share their experiences, ideas, conceptions, and reflections. For teachers who are active, learning through social networks turns out to be a process that becomes part of their work and continues outside school hours (van den Beemt, et al., 2018). Social networks make it possible to expand what has been called social capital (Rehm and Notten, 2016). Through them, interactions that can be stable or temporary are generated, which allow teachers to gather resources or obtain information from other people that are considered relevant (Fox and Wilson, 2015). The teachers we have interviewed provide teachers who follow them with new ways of learning and professional development (Nykvist and Mukherjee, 2016).

Agents responsible for teacher learning should be aware of how social networks are contributing to learning and professional development, in line with what is evidenced here. The results presented invite reflection on the consideration that social networks deserve for extending the opportunities for interaction and collaboration. This form of professional development can perfectly complement others of a formal nature such as training through e-learning courses. While it is true that the real penetration of social networks in the practice of teachers must be considered. A line of research could be opened to consider what the current situation is in Latin American countries such as Brazil, Uruguay or Chile.

This study has some limitations. First, the selection of teachers was made based on the number of followers. The additional criteria could have been considered for their selection. Second, we have analyzed the point of view of the wrongly named "influencers", but we have yet to know the perceptions of the subjects themselves, which give meaning to the work of these proactive teachers. What do the teachers who follow them learn? Why do they follow them? What applications and transformations, both personal and classroom-related, are produced as a consequence of participation in social networks and participation in a virtual affinity space? Do students perceive the effects of their teachers' participation in social networks? These are questions that remain unanswered and should provide options for further studies.

Disclosure Statement

The authors report that there are no competing interests to declare.

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Appendix 1: Interview Script

Project: HOW DO TEACHERS LEARN IN A CONNECTED SOCIETY?

How Do Teachers Learn in a Connected Society? with Reference: PGC2018-096474-B-I00

Teacher individual interview script

QUESTIONS
1. Some biographical information We would like to know some general questions about your professional career and background on social networks.

Tell us briefly about the studies you have done and your professional experience. Are you currently teaching? If not, what is your current profession? Since when do you dedicate yourself to it?

We are also interested in knowing in which social networks you participate? Do you have a low participation profile in any of them? In which do you post more? In the latter, how many followers do you have? Do you pay attention to whether they increase? Do you follow any strategy to increase them?

2. Beginnings, the reasons that led you to become an active person on social networks.

When did you start on social networks? What was the first time you joined? What vital moment did it coincide with (after your studies, before, when you started working...)? Did someone or something motivate you to do it? Did you receive help or advice?

3. Know the process you have followed, as well as the factors and variables that have intervened in your interest in the digital world.

Explain to us the process you followed to become a highly followed person through social networks: how did you achieve it?

What problems have you found in the course of positioning yourself? What facilities? What have you learned along the way? What satisfactions have you found since you started?

Have you had any colleague or person in your immediate environment who has advised or advised you during the course?

Have you been guided by any reference? Do you follow any model?

4. Your own perception of your role as an active teacher in social networks.

Who would you say is following you? Do you know the profile of your followers? What do you think they are looking for in you?

Do you consider yourself a person with influence in the social networks in which you interact?

What do you think the interest in following you is due to? What do you think your followers like about your user profile?

5. Format in which you usually present the publications

Your posts, in what format do you usually present them (text, image, video, text and image...)? What leads you to opt for one or the other?

What type of format do you consider most appropriate to motivate followers?

6. Most relevant content that you address in your publications

What do you publish about? Does the content that you usually introduce in your publications revolve around the same topic or is it varied? What are you most attracted to or what motivates you the most? We would like you to talk to us specifically about the content that you usually introduce on a more regular basis.

What leads you to select the content you publish on social networks? Based on what do you select?

Are you specialized in a specific topic?

7. Interaction with your followers on social networks

Next, we would like you to tell us about some aspects related to the process that you usually follow in your interventions on social networks. First of all, we would like you to explain the procedure or procedures that you usually use.

Do you have a specific method to manage your interventions (think about them, organize them, etc.) that you use with a certain consistency?

Do you write on the go or do you always plan your interventions prior to publication?

Explain to us in a concrete way the procedure you follow to prepare a certain publication.

Do you prepare and/or publish more than one publication at a time?

Do you encourage interactions? Do you frequently allude to those who follow you?

How do you usually react to the participation of those who follow you?

8. General perception and degree of satisfaction in relation to your participation in social networks as a person with influence

Nearing the end of our interview, we would like you to make an overall assessment of your practice as a teacher with influence on social networks. In this sense, what difficulties do you usually find in the publication-response process? How do you value the feedback you usually receive?

What does your participation in social networks bring you personally and professionally?

What repercussions do your posts on social media have on your professional life?

What do you think your participation in social networks can contribute to your follower's learning?

Do you think that interaction through social networks is a learning opportunity? If so, can you tell us its advantages over more traditional learning sources?

Now we would like to know if you receive any kind of recognition and from whom, if so.

Finally, what recommendations would you make to someone who is starting this type of experience?

Appendix 2: Category System

1. **Who am I?:** In this dimension we include personal data, age, gender, academic level where he teaches, social networks in which he participates, number of followers he has, etc. studies completed, academic trajectory
2. **How did I get here?:** In this dimension we include the process of becoming an active teacher: how it starts, who it starts with, if they start with a blog and how they evolve. If they have participated in other networks before. Previous or parallel experiences of contact with other teachers in reality are also included: courses, seminars, conferences.
3. **What do I do? How do I build my discourse?:** In this dimension we describe the process of creating content on social networks (on a blog, Twitter account or another social network). Not only the content they publish but how they publish it. Whether they build intended or spontaneous publications. If they post text, images, videos, etc. Also which area of the curriculum do you specifically address? What topics does it touch on? Problems found. What times of the day do I choose to post, do I do it on the fly or do I plan daily at a specific time?
4. **How do I relate with others? Those who follow me and those whom I follow:** In this dimension we analyze the relationships they maintain with other tweeters. If they are people they follow and if these relationships are maintained beyond the network. If they know their followers or have any relationship with them and if they interact with their followers and how do they do it.
5. **How do I perceive myself?** This is a dimension of identity. Basically answering the question of whether they consider themselves as influencers. Why do you think they follow you (what do they think they contribute, what distinguishes them from others).
6. **What do I get from this?** In this dimension we are interested in knowing what they learn, how it motivates them or what results they perceive from their work in the network. If by being "influencers" they have become more visible by participating in webinars, conferences, workshops.
7. **What is important to me?:** This dimension is related to the values that the interviewees express in the interviews: collaboration, respect, sharing, etc.
8. **How do I learn and how do others learn?** In this dimension we are interested in the opinion on the possibilities of networks to promote one's own learning and that of other teachers. What has changed in your personal and professional life by intervening in networks so intensely?

Mapping Research Themes and Future Directions in Learning Style Detection Research: A Bibliometric and Content Analysis

Adi Wijaya[1,2], Noor Akhmad Setiawan[1] and Mohd Ibrahim Shapiai[3]
[1]Department of Electrical and Information Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia
[2]Department of Health Information Management, Universitas Indonesia Maju, Jakarta, Indonesia
[3]Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia

noorwewe@ugm.ac.id (corresponding author)

Abstract: This study aims to provide a comprehensive overview of the current state and potential future research in learning style detection. With the increasing number and diversity of research in this area, a quantitative approach is necessary to map out current themes and identify potential areas for future research. To achieve this goal, a bibliometric and content analysis will be conducted to map out the existing research and identify emerging topics and directions for future research. The study analyzes 1074 bibliographic sources from Scopus and visualizes the results of the bibliometric analysis through co-occurrence and thematic map analysis using VOSviewer and BibliometriX software. Content analysis is then conducted based on the results of the co-occurrence analysis. The findings reveal a significant increase in publications and citations in the field, with popular research topics including classification, adaptive learning, and MOOCs, and the most frequently used learning style models being Felder-Silverman, VARK, and Kolb. Emerging research topics include the use of EEG signals, online learning, and feature extraction. Future research may focus on classification, intelligent tutoring systems, MOOCs, online learning, adaptive learning, and deep learning. This study provides valuable insights into the current and future research trends in learning style detection, which can support the development of adaptive e-learning systems, intelligent tutoring systems, and MOOCs. By identifying popular research topics and emerging areas of study, this research can guide the design and implementation of effective online learning environments. Additionally, the study advances the field of e-learning knowledge by providing a comprehensive overview of the most frequently used learning style models and potential research areas. It sheds light on the ongoing development of learning style detection research and the potential for future advancements in the field, ultimately contributing to the growth and improvement of e-learning practices.

Keywords: Learning style detection, Bibliometric analysis, EEG, VOSviewer, BibliometriX

1. Introduction

Learning styles are a way to understand how different people approach learning (Goštautaitė and Sakalauskas, 2022) and how they prefer to receive and process information (Pashler et al., 2008). They are developed over time through long-term learning experiences (De Bello, 1990) and can influence an individual's learning preferences (Grey, Williams and Rebuschat, 2015). Understanding an individual's learning style can tailor learning strategies, content, and resources to their specific needs, leading to improved learning efficiency and engagement (Hmedna, El Mezouary and Baz, 2020). Hence, accurately identifying learners' learning styles is essential for personalized teaching and has significant research and practical value for implementing modern education methods (Li and Zhou, 2018).

Research on learning style detection has been increasing and is often related to classification based on learning style models. Currently, there are several learning style models being used, including Kolb, Felder-Silverman, VARK, and others. Felder-Silverman is the most commonly used model (Guabassi et al., 2019; Rasheed and Wahid, 2021a). There are two approaches to detecting learning styles: explicit recognition and implicit recognition (Zhang et al., 2021a). The explicit approach predominantly involves the administration of questionnaires to individuals for assessing their learning style preferences (Rajkumar and Ganapathy, 2020; Wouters and van der Meulen, 2020; Marosan et al., 2022). On the other hand, the implicit approach encompasses a diverse range of modalities, such as analyzing learning behavior patterns (Rasheed and Wahid, 2021b; Yousef et al., 2021), monitoring eye movements during learning tasks (Guabassi et al., 2019; Mu et al., 2019), utilizing facial image analysis (Gambo et al., 2018), and employing Electroencephalogram (EEG) technology to measure brain activity (Anoor et al., 2020; Zhang et al., 2021b). These methodologies are constantly developing and have been extensively embraced by researchers in the ever-changing field of learning style detection.

Reference this paper: Wijaya, A., Setiawan, N.A. and Shapiai, M.I. 2023. Mapping Research Themes and Future Directions in Learning Style Detection Research: A Bibliometric and Content Analysis, The Electronic Journal of e-Learning, 21(4), pp 274-285, available online at www.ejel.org

As the research landscape on learning style detection continues to expand in terms of both quantity and diversity, there is a pressing need to comprehensively assess the current state of research in this field and identify potential avenues for future investigations. To achieve this, a quantitative approach, specifically bibliometric analysis, has been recognized as a suitable method (Ellegaard and Wallin, 2015; Kent Baker et al., 2020; Noman et al., 2022). However, despite its relevance and utility, the application of bibliometric analysis to study learning style detection has remained relatively scarce, prompting the necessity for more focused attention in this area.

The primary objective of our study is to employ a bibliometric analysis to meticulously map the existing themes and topics of research in learning style detection and discern the emergence of new research areas. Additionally, we aim to chart the future trajectory and potential directions for research in this domain. To achieve these objectives, we have formulated three specific research questions (RQs):

RQ1. What are the prevalent research themes and topics within the field of learning style detection?

RQ2. What novel research topics are currently emerging in the study of learning style detection?

RQ3. What is the future work and direction in the learning style detection study?

By addressing these RQs, our research endeavors to offer an explicit and comprehensive depiction of the current status and evolution of learning style detection research. Furthermore, through the integration of bibliometric analysis and content elaboration, we seek to identify potential areas for future research and provide valuable insights for researchers and practitioners in the field of learning style detection. The fusion of these methods allows for a more profound understanding of the existing body of knowledge and opens up avenues for further exploration in this vital area of study (Kent Baker et al., 2020).

2. Methods

2.1 Bibliography Data Collection

We decided to only use the Scopus database for our literature search because it is known to be the most comprehensive and to minimize variations in data and field tags that could occur if we used multiple databases. Additionally, the Scopus database has a larger number of publications and more citations (Zhu and Liu, 2020; Pranckutė, 2021), which we believe would provide sufficient data to understand the scientific landscape, research hotspots, and other relevant information (Zakaria et al., 2022). In this study, several steps were taken in data collection. Figure 1 shows the data collection steps from determining the topic to the bibliography data included in the bibliometric analysis.

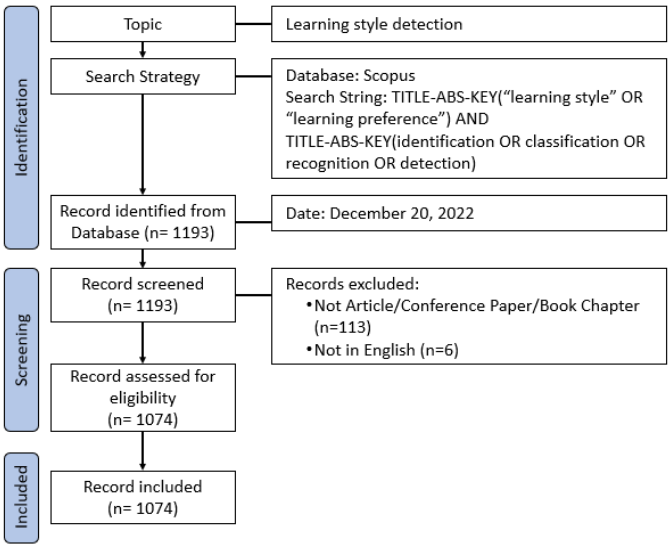

Figure 1: Search strategy adapted from the PRISMA flow diagram (Page et al., 2021)

As depicted in Figure 1, the data collection steps undertaken in this research follow and are adapted from the PRISMA flow diagram (Page et al., 2020). The data used is sourced from Scopus, which was obtained on December 20, 2022. The search terms used consist of two blocks, namely, related to the learning style and detection. This search is based on the title, keywords, and abstract containing both search terms. In terms of

publication time, this research is only limited to the maximum year 2022. Other filters used are document type, which consists of journal articles, conference proceedings, and book chapters. In terms of language, data that is pulled is limited to papers written in English. Finally, a total of 1074 bibliography data was successfully pulled from Scopus, which was then processed using two applications, namely VOSviewer (van Eck and Waltman, 2021) and BibliometriX (Aria and Cuccurullo, 2017). All the software tools can be downloaded and used for free and are effective at conducting bibliometric analysis (Moral-Muñoz et al., 2020).

Bibliometric analysis often deals with vast amounts of data, frequently consisting of hundreds, if not thousands, of papers within a particular research field (Donthu et al., 2021). In such cases, the application of bibliometric analysis becomes relevant and justifiable due to the scale and complexity of the dataset. Notably, bibliometric analysis typically does not involve study selection and quality assessment steps as commonly seen in systematic reviews. Instead, the focus is primarily on selecting appropriate databases, designing an effective search strategy, and implementing relevant filters tailored to the research objectives (Zupic and Čater, 2015; Donthu et al., 2021). By following these guidelines, bibliometric analysis provides valuable insights into research trends, collaborations, and the impact of publications within a given field, making it a powerful and insightful tool in academic research.

2.2 Bibliometric and Content Analysis

In this study, bibliometric analysis is used to map out the current conditions and research mapping for the future (Ellegaard and Wallin, 2015; Li, Wu and Wu, 2017). Meanwhile, to elaborate and extract the future work and direction, a content analysis is carried out, which is a continuation of the cluster analysis obtained from the bibliometric analysis. Figure 2 shows the research structure used in this study. From Figure 2, three groups of analysis are carried out to answer the RQs. The descriptive analysis presents descriptive-quantitative results of the bibliography data, co-occurrence, and thematic map, are analysis of bibliometric analysis, and full-text review is a technique for content analysis. Bibliometric analysis has been shown to be an effective way of evaluating academic output and providing an objective reflection of a research topic (Haddad, 2017; Giménez-Espert and Prado-Gascó, 2019).

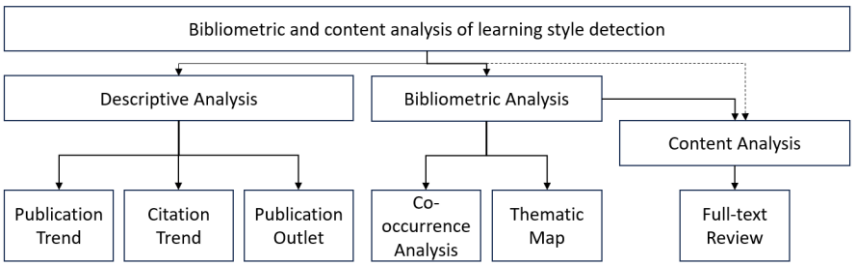

Figure 2: Research structure to answer RQs as adopted from (Kent Baker et al., 2020)

In the context of content analysis, Figure 2 serves as a crucial reference for selecting pertinent papers, guided by the co-occurrence analysis-derived mapping. This mapping provides a structured framework for identifying and retrieving full-text papers from each cluster, enabling a comprehensive investigation to address the third research question pertaining to the future direction of learning style detection research. The paper selection process is thoughtfully guided by trending and influential topics, considering key factors such as occurrence, average publication year, and citations as depicted in the VOSviewer output. A comprehensive account of the content analysis methodology employed can be found in Section 3.4.

3. Results and Discussion

In this research, bibliometric analysis is used to reveal the current state of research related to learning style detection. To start, descriptive results will be presented to provide a quantitative overview of the current state of research on learning style detection. Subsequently, the results of network analysis modelling produced from co-occurrence analysis and the thematic map will be presented to answer the research questions.

3.1 Descriptive Results

The publication chart over time is a valuable tool to assess the growth and prevalence of a specific research topic. Figure 3 depicts the progression of publications on learning style detection throughout the years. The research on this topic initiated in 1918, with no recorded publications until 1970. From 1970 onwards, it

gradually gained momentum and steadily increased until the early 2000s. Notably, in 2006, there was a significant surge in publications, signalling a pivotal point in the field's development.

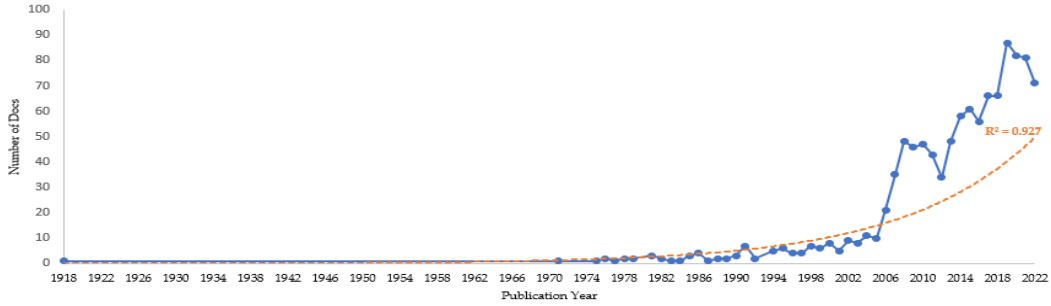

Figure 3: Publishing over time with a blue dotted-line represents the number of documents, while the orange dashed-line represents an exponential trend line

Furthermore, a trending line with an exponential trend was fitted to the data, yielding an impressive R-squared value of 0.927. This exponential trend line clearly illustrates the substantial and sustained interest in learning style detection research since 2006 until the present day. The remarkable increase in publications during this period indicates a persistent and noteworthy trend, underscoring the high level of attention and interest the topic has garnered within the academic community. The upsurge in publications on learning style detection from 2006 onwards reflects the growing significance and relevance of this area of study, paving the way for continued advancements and contributions to the field.

Aside from the publications chart over time, the number of citations per year chart is a significant measure of a research's popularity and impact on subsequent research. Figure 4 shows the number of citations chart from year to year. Along with the increase in publications in 2006, the number of citations also increased starting in 2006 and continued to rise in the following years. The increase in the number of citations follows a polynomial trend. In general, the number of citations increases in conjunction with the number of publications.

Additionally, it is important to consider information about the publication outlets related to learning style detection research. In this study, three types of documents were selected: journal articles, conference proceedings, and book chapters. Among these document types, journal articles were the most prevalent. Thus, the publication outlet graph presented in Figure 5 reflects this, with journals being the most common outlet. In Figure 5, in addition to showing the number of documents for each outlet, the average publication year is also represented by the colour bar. Where light green to yellow means a relatively young average publication year, and dark green means an older average publication year. From Figure 5, several journals can be seen as the choice for researchers.

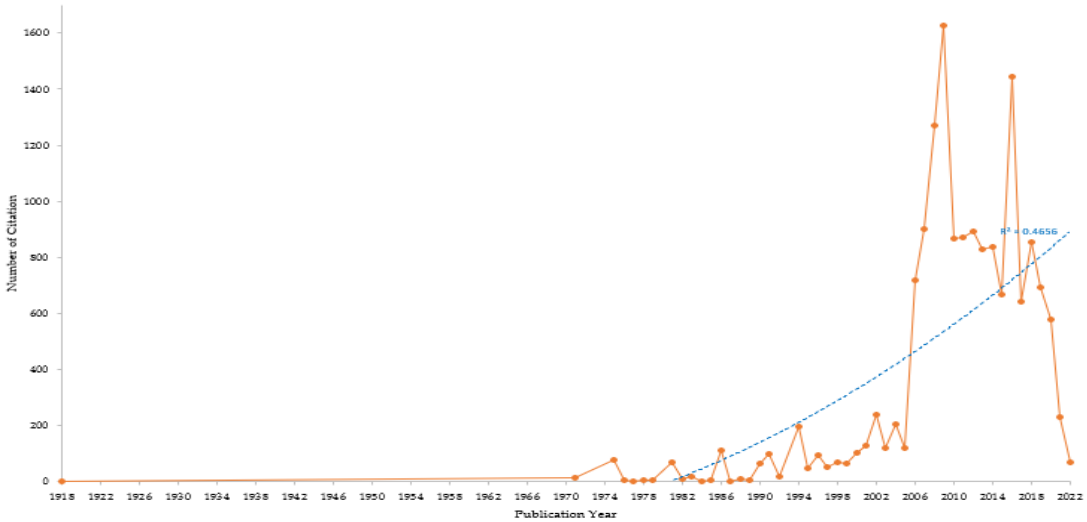

Figure 4: Citation over time with an orange dotted-line represents the number of citations, while the blue dashed-line represents a polynomial trend line

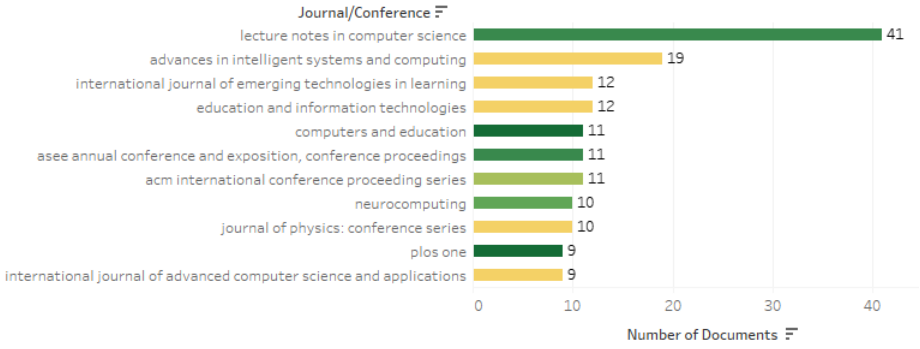

Figure 5: Top 11 Journal or Conference Proceedings that are outlets for publication

The data presented in Figure 5 illustrates the distribution of research publications in the field of learning style detection across various source types. Notably, Book Chapters in Lecture Notes in Computer Science garnered the highest number of papers, with 41 publications. Additionally, Journals such as Advances in Intelligent Systems and Computing, International Journal of Emerging Technology in Learning, Education and Information Technologies, and Computers and Education each contributed 19, 12, 12, and 11 papers, respectively. The ASEE Annual Conference and Exposition, along with the ACM International Conference Proceedings Series, contributed 11 publications each to the Conference Proceedings. Furthermore, the Journal Neurocomputing and Conference Proceedings in Journal of Physics: Conference Series both contained 10 papers. Lastly, PLOS One and International Journal of Advanced Computer Science and Applications accounted for 9 papers each. These insightful findings shed light on the diverse and prominent sources where learning style detection research is disseminated, providing valuable information for researchers and academicians in the field.

3.2 Main Research Themes and Topics

To answer RQ1 regarding the current state of research related to learning style detection, the visualization generated from VOSviewer can be used. The visualization from co-occurrence analysis maps how research topics are related, their popularity, and the clusters of topics that are created. Therefore, co-occurrence analysis can investigate the main themes and topics or crucial concepts of publications (Shafin et al., 2022). The co-occurrence analysis yields a network visualization in Figure 6, which reveals the presence of three distinct clusters of themes.

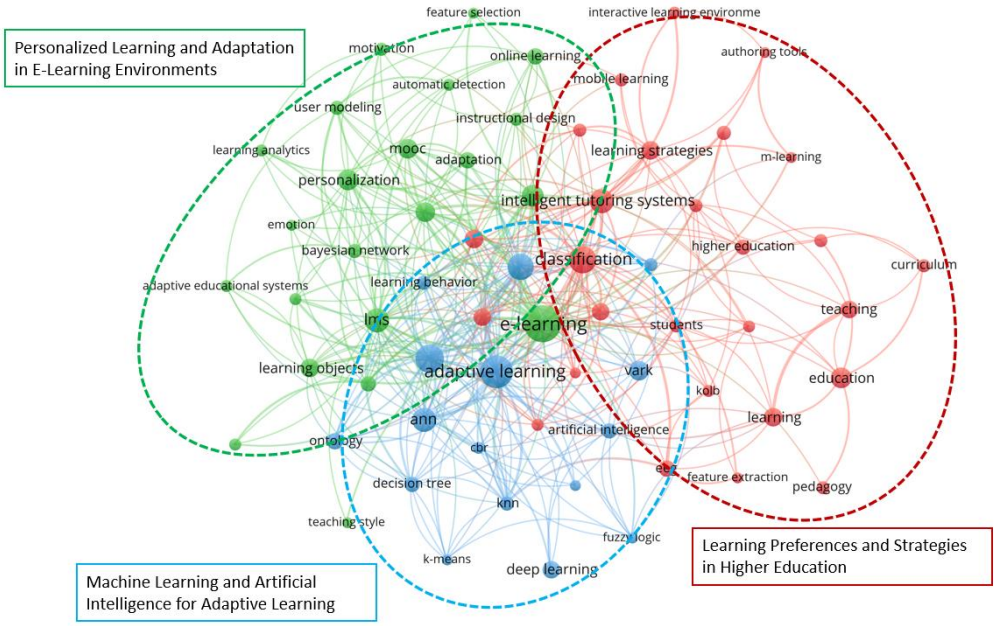

Figure 6: Network visualization from Co-occurrence analysis that results in 3 clusters

Each cluster is represented by a different color, with the red, green, and blue cluster corresponding to cluster 1, 2, and 3, respectively. The red cluster focuses on the learning preferences and strategies of higher education students using data mining and cluster analysis techniques. The green cluster's research theme is on personalized learning in e-learning environments using technologies such as educational data analysis and adaptive learning models. Meanwhile, the blue cluster deals with the use of the latest technologies such as machine learning, deep learning, and artificial intelligence to create adaptive learning environments, with the development of adaptive learning models and the identification of student learning styles accurately.

Cluster 1, represented by red, is focused on the research theme of learning preferences and strategies in higher education. Within this cluster, the most popular topics are classification and intelligent tutoring systems (Anoor et al., 2020; Mishra, Agarwal and Kolekar, 2021). These research topics aim to classify different learning styles using various modalities, such as mobile learning (Bunyakul, Wiwatwattana and Panjaburee, 2022) and blended learning (Shailaja and Sridaran, 2014), as well as intelligent tutoring systems. The research conducted using EEG signal modalities, as demonstrated by previous studies (Zhang et al., 2021c; 2021a), also falls into this cluster due to its close relation to the classification of learning styles. By exploring these topics, researchers can gain insight into the different strategies and preferences that students have for learning in higher education, which can help improve the effectiveness of teaching and learning.

Cluster 2, denoted by the color green, is dedicated to the research topic of personalized learning and adaptation in electronic learning environments. The cluster focuses on popular research topics of MOOCs and personalized learning. Studies within this cluster investigate the implementation of learning style detection on MOOCs platforms (Hmedna, El Mezouary and Baz, 2020; Rajkumar and Ganapathy, 2020) and efforts to personalize learning on the MOOC platform by considering student learning styles (Gambo and Shakir, 2021; Lin, Wang and Lan, 2022). This research is significant for enhancing the efficacy of e-learning environments by utilizing personalized learning to enhance students' efficiency and effectiveness in their learning process.

In cluster 3, denoted by the color blue, the research theme centers around machine learning and artificial intelligence in the context of adaptive learning. This cluster primarily focuses on adaptive learning approaches utilizing diverse machine learning algorithms, such as decision tree (Dutsinma and Temdee, 2020), k-means (Yusoff, Najib Bin Fathi and ., 2018), knn (Shekapure and Patil, 2019), and deep learning (Zhang et al., 2021c). These algorithms play a crucial role in analyzing student data and delivering personalized learning experiences tailored to the unique needs of individual learners. Leveraging machine learning and artificial intelligence techniques empowers researchers to enhance the effectiveness of adaptive learning, consequently facilitating more efficient attainment of students' learning objectives.

In addition, the field of education has conducted extensive research on learning style models such as Kolb, VARK, and Felder-Silverman. These models play a crucial role in identifying an individual's preferred learning method, and understanding these preferences can assist in developing effective teaching strategies. Figure 7 illustrates how these models are connected to various research topics, with Felder-Silverman being the most extensively researched (Zhang et al., 2021a). Machine learning plays a significant role in both VARK and Felder-Silverman, while Kolb has a lesser connection to it. However, all three models have ties to e-learning and classification research topics.

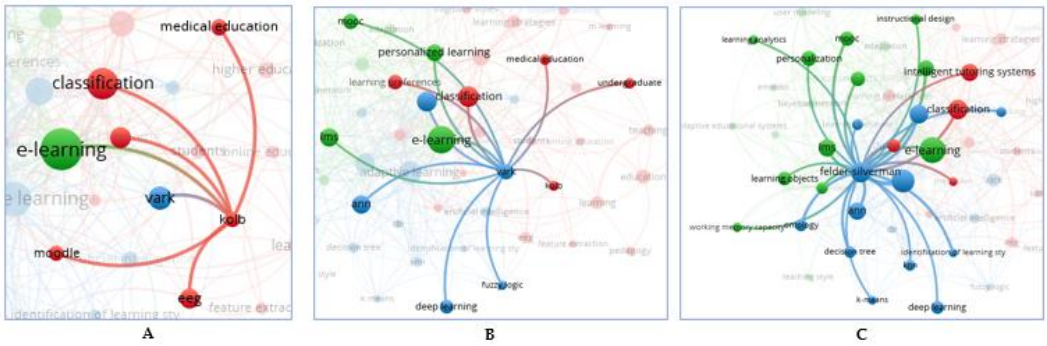

Figure 7: Three major learning style models (A=kolb, B=VARK, C=Felder-Silverman)

3.3 Emerging Topics

To answer RQ2 related to emerging topics in learning style detection research, the thematic map generated by BibliometriX can be used. This thematic map was first introduced by Cobo et al. (Cobo et al., 2011) using a strategic diagram approach with four quadrants. Each quadrant indicates a group of themes, namely motor theme, niche theme, emerging/declining theme, and basic theme in quadrants 1, 2, 3, and 4, respectively.

A strategic diagram in Figure 8 presents a thematic map of research topics related to learning style detection. Quadrant 3 shows which research topics are emerging or declining. The four topics in this quadrant are EEG, Kolb, online education, and feature extraction. However, it is not clear from this thematic map whether a research topic is emerging or declining. To confirm this, the output from a co-occurrence analysis using VOSviewer on an overlay visualization, shown in Figure 9, can be used. The overlay visualization displays the relationship between occurrence and publication year.

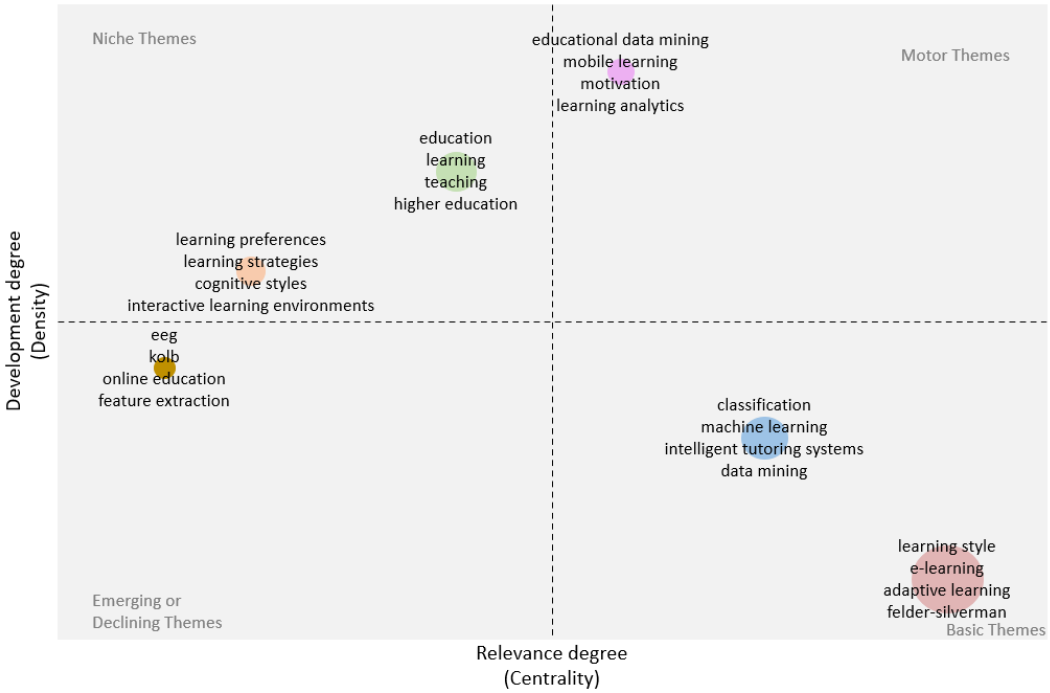

Figure 8: Strategic diagram presenting 4 quadrants with their respective labels

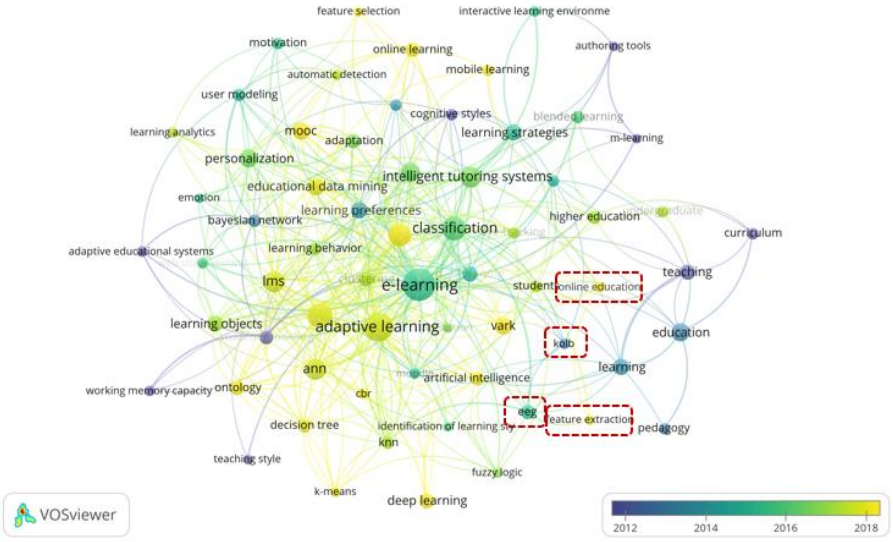

Figure 9: Overlay visualization between occurrence and average publication year with green to yellow indicating novel/emerging topics and the color blue indicating old/decreasing topics

Figure 9 shows the average publication year for each research topic through the colour of its node. Green to yellow signifies a novel publication year, while green to blue means an old publication year. Research topics with green to yellow node colours are considered emerging, while those with colours close to blue are considered declining. EEG, online learning, and feature extraction have green to yellow colours, indicating they are emerging topics. Kolb, on the other hand, has a colour close to blue, indicating it is a declining topic. To further support these findings, the number of publications and citations for each of these research topics can be mapped, as shown in Figure 10.

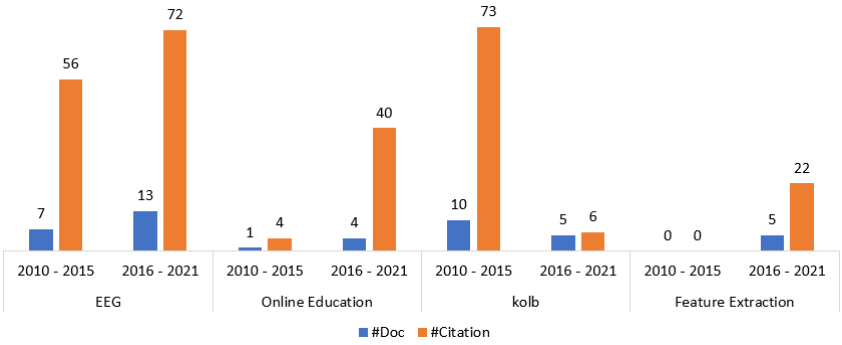

Figure 10: Chart of the number of documents (#Doc) and citations (#Citation) from the four topics in quadrant 3 to confirm whether these topics are emerging or declining from a comparison of two periods

Figure 10 shows the number of publications and citations for four research topics during two time periods: 2010-2015 and 2016-2021. These time periods were chosen to see if the number of publications and citations increased or decreased over a significant period. EEG, online learning, and feature extraction saw increases in both the number of publications and citations during the two time periods. Kolb, on the other hand, saw decreases in both the number of publications and citations. This aligns with the findings from the overlay visualization in Figure 9. As a result, it can be concluded that EEG, online learning, and feature extraction are emerging research topics in the field of learning style detection.

3.4 Future Works and Directions

In this study, a mapping of future work and direction was conducted to answer RQ3. To answer this RQ3, two analyses were conducted: a co-occurrence analysis with an overlay visualization and a content analysis. The overlay visualization will provide an overview of which research topics are currently developing and have a significant influence on learning style detection studies. Meanwhile, content analysis is used to explore potential future work. Figures 11 and 12 present the two overlay visualizations.

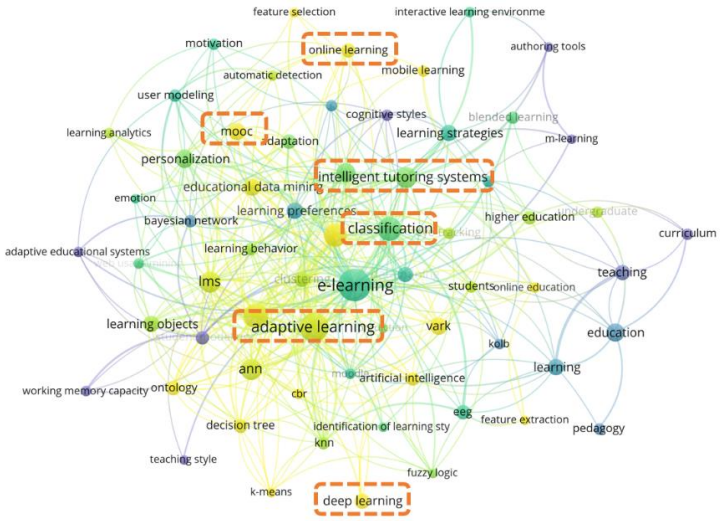

Figure 11: Overlay visualization for novel/old topics

Overlay visualizations based on publication time and the number of citations is presented in Figures 11 and 12. Based on the examination of these visualizations, six research themes that have garnered significant attention and citations in recent years are identified, namely classification, intelligent tutoring systems, MOOCs, online learning, adaptive learning, and deep learning. Given their popularity and influence in the field, these topics hold great potential for further exploration and serve as potential directions for future research.

Further investigation is required to address various issues related to the classification topic. Among these issues is the development of an e-learning system that is tailored to individual learning styles (Azzi et al., 2020). Furthermore, it is crucial to generalize the observed patterns of learning styles in diverse learners (Rasheed and Wahid, 2021a). To tackle these potential areas of future research, the classification results should be implemented in an e-learning system to enhance its adaptivity and tested with a larger sample size to enable generalization. Other potential areas of future work relate to intelligent tutoring systems, where personalized course elements based on predicted learning styles need to be developed (Mishra, Agarwal and Kolekar, 2021). Furthermore, there is a need for improved measures to monitor the accuracy of predicting learning styles in tutoring systems (Mishra, Agarwal and Kolekar, 2021). It is crucial to enhance the specificity of the tutoring system and improve the accuracy of evaluating learning style predictions.

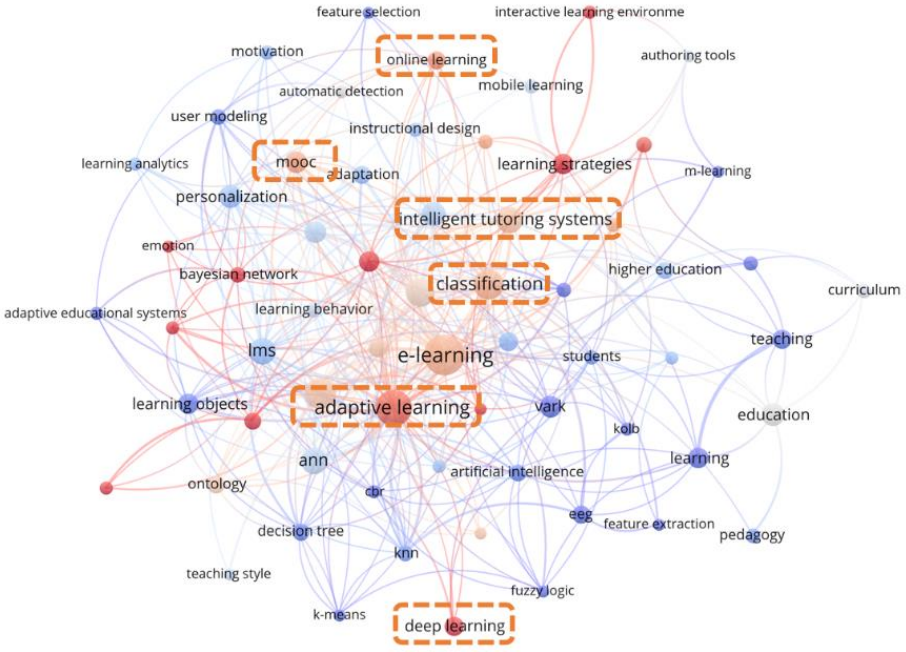

Figure 12: Overlay visualization for high/low citation

Numerous avenues for prospective investigation exist within the domain of MOOCs. One example is to the adoption of a learning analytics system, as discussed by Hmedna et al. (Hmedna, El Mezouary and Baz, 2020), which aims to enhance teachers' ability to enhance their students' academic outcomes. There is a pressing need for extensive study on MOOCs (Rajkumar and Ganapathy, 2020). Additionally, it is crucial to investigate novel approaches to enhance the precision of identifying pedagogical strategies that prove effective in the context of online learning (Li and Zhou, 2018). In order to delve deeper into the subject matter of online learning, it is important to conduct supplementary experiments involving students and their experiences inside a controlled laboratory environment (Yousef et al., 2021). It is also advisable to create instructional videos to provide a better understanding of online learning for students (Mu et al., 2019).

Adaptive learning presents potential avenues for future research, influencing the trajectory of forthcoming studies on learning style detection. A deeper exploration of learning behaviors is imperative to enhance accuracy and gain comprehensive insights into diverse learning styles (Zhang et al., 2020). Furthermore, further research is warranted concerning students' characteristics, encompassing their learning objectives, knowledge, and motivation, to facilitate a more profound comprehension and refinement of detection precision (Marosan et al., 2022). Additionally, continual investigations into the learning environment remain crucial (Wouters and van der Meulen, 2020).

In summary, the potential for future work in the field of learning style detection includes further design and implementation of adaptive e-learning systems, personalization of course elements based on learning style predictions, better metrics for evaluating learning style predictions in tutoring systems, implementation of analytics systems for MOOCs, more experimentation and instructional videos for online learning, investigation of learning behaviors and student characteristics in adaptive learning, and exploration of deep learning techniques (Gambo et al., 2018) and EEG-based datasets for detection (Zhang et al., 2021c).

The findings of this study hold significant practical implications for the advancement of e-learning. Through the identification of popular research topics and emerging areas in learning style detection, this research can offer valuable guidance for the design and implementation of adaptive e-learning systems, intelligent tutoring systems, and MOOCs. By incorporating frequently utilized learning style models like Felder-Silverman, VARK, and Kolb, e-learning designers can tailor course elements to match individual learning style predictions, thereby enhancing personalization. Additionally, the study emphasizes the importance of ongoing exploration of the learning environment and a deeper investigation into student characteristics to enhance the accuracy of learning style detection. The potential for future research in learning style detection, such as the exploration of deep learning techniques and EEG-based datasets for detection, can advance e-learning development and lead to more effective online learning environments. Therefore, the implications of this study have practical significance for e-learning practitioners and developers.

4. Conclusion

This study employed a rigorous bibliometric analysis to comprehensively map and evaluate the current state of learning style detection research. Additionally, a content analysis, guided by the insights from the bibliometric analysis, was undertaken to discern future research directions and avenues for exploration. Through co-occurrence analysis and thematic map analysis, the study successfully elucidated various research topics currently under development, encompassing areas such as classification, intelligent tutoring systems, MOOCs, online learning, adaptive learning, and deep learning. Furthermore, emerging research topics, exemplified by the utilization of EEG signals for classification purposes, were also identified, indicating the evolving nature of the field.

While learning style research has witnessed continuous development over time, several potential research directions warrant attention in the future. Firstly, the need for broader generalization necessitates an increase in the number of respondents and the utilization of diverse methodologies to ensure robust findings. Secondly, there is a pressing demand to enhance the accuracy of detection models, both from methodological and algorithmic perspectives, to yield more reliable and precise outcomes. In addition, using EEG signals to determine learning styles has shown promise due to the wide range of tasks for which EEG may be applied in many areas.

In conclusion, this study has shed light on the current landscape of learning style detection research while providing valuable insights into promising areas for future exploration. By continuing to address these research gaps and advancing methodological approaches, researchers can contribute to the ongoing growth and significance of learning style detection research, ultimately fostering more effective and personalized learning experiences for diverse learners (Narudin, Nasir and Fuad, 2021).

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Predisposition of In-Service Teachers to Use Game-Based Pedagogy

Sonia Palha[1] and Ljerka Jukić Matić[2]
[1]Faculty of Education, Amsterdam University of Applied Sciences, The Netherlands
[2]Department of Mathematics, University of Osijek, Croatia

s.abrantes.garcez.palha@hva.nl
ljukic@mathos.hr

Abstract. Digital game-based learning (DGBL) can be regarded as a promising teaching pedagogy to prepare students for challenges of the 21st century. However, the incorporation of digital games into K-12 curricula remains limited. Research suggests that a comprehensive understanding of barriers and motivational factors that teachers face when implementing DGBL is needed to ensure that teachers can receive the support required. To delineate suggestions for tailored curricula on game-based pedagogy in teacher education programs, we conducted a study to gain insight into in-service teachers' perception of DGBL in relation to their previous experience in teaching with DGBL. To achieve our goal, we examined the factors that impede and promote the implementation of DGBL among in-service teachers who are presently pursuing master's level education programs, having in mind that this group of teachers is different from pre-service teachers. Data was collected using an online survey with open- and closed-ended questions. The sample consisted of in-service teachers (n=37) who were enrolled in a master's course in math education. The data analysis conducted was of a qualitative nature. One significant finding derived from this study is that the level of pedagogical experience in utilizing games as a teaching tool appears to be a crucial factor in understanding the inclination of in-service teachers towards game-based pedagogy. Pedagogical factors were mentioned by teachers at all stages of experience with DGBL, and differences were observed between teachers at different stages. For instance, in-service teachers with experience with DGBL (intermediate and advanced stages) were concerned about being able to maintain focus on the math concepts, the need to adapt the game lesson to students, and the ways to evaluate student learning less experienced teachers were essentially concerned about ways to control the classroom during DGBL and whether the pupils would receive adequate practice in this learning mode. Differences were also noted for other factors between teachers at different stages. Advanced stage teachers did have concerns about game appropriateness for the intended learning; teachers with less experience were concerned about the lack of games (technical factors). Dealing with an existing curriculum and high workload were common aspects for teachers with no or some experience but only teachers with some experience mentioned obstacles related to school organization (structural factors). Teachers with few and some experience referred to the lack of knowledge and competence (personal factors) and that pupils would not take the lessons with games seriously (social factors). This research supports DGBL-practice (i) by adding new knowledge on the factors that can support or constrain the integration of DGBL and its implications for the development of curricula on game-based pedagogy; (ii) by providing suggestions to design and implement meaningful curricula on digital game-based pedagogy for teaching education and training programs.

Keywords: Game-based pedagogy, Digital game-based learning (DGBL), Teacher education, In-service teachers, Teachers' perceptions of DGBL, 21st Century

1. Introduction

Digital game-based learning (DGBL) is a pedagogical approach employed in educational contexts, wherein digital games are utilized to effectively attain specific learning outcomes. These outcomes encompass knowledge acquisition, skill cultivation, and attitude formation (Hussein et al., 2022). Currently, many teachers employ digital games and incorporate game elements within their instructional practices. According to An and Cao (2016), digital games have the potential to enhance the cultivation of higher-order thinking abilities and 21st-century skills while also increasing the overall enjoyment of the learning process. Digital games can facilitate experiential learning and the acquisition of practical skills that can be applied in real-life situations. This surpasses the conventional instructional methods that tend to prioritize rote memorization (An and Bonk, 2009; Siew, 2018). From this standpoint, DGBL can be perceived as a potentially effective instructional approach aimed at equipping students with the necessary skills and knowledge to tackle the complexities and demands of the contemporary era.

Teachers' attitudes toward new teaching methods such as DGBL contribute to their subsequent implementation and influence students' learning motivation (Martín-del-Pozo, García-Valcárcel, & Hernández Martín, 2019) Games and DGBL can only be effective in K-12 education if teachers and students view them as valuable teaching and learning tools (Bourgonjon et al., 2010). So far, the incorporation of digital games into K-12 curricula remains limited (Hébert and Jensen, 2019; Takeuchi and Vaala, 2014). In some cases, teachers use informal means to acquire knowledge on ways to teach with digital games, for example through trial and error or seeking ideas from peers (Takeuchi and Vaala, 2014). Professional development opportunities that guide teachers in the systematic use of games for teaching, learning, and assessment are lacking (Jukić Matić, Karavakou and Grizioti,

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2023; Martin-del-Pozo et al., 2019; Spiteri and Chang Rundgren, 2020). Further, in cases in which professional development initiatives consider game use, they rarely address pedagogy for teaching with DGBL (Hébert and Jensen, 2019). From a pedagogical perspective, this poses a considerable problem because teachers play a key role in designing and delivering learning content that supports DGBL, including customizing content to meet different learners' needs.

Teacher education in game-based pedagogy is burgeoning. Teacher education programs and higher education can play a more active role in its growth (Nousiainen et al., 2018), such as through developing game-based pedagogy curricula or by using DGBL in teaching (Foster and Shah, 2020). Equipping teachers with specific knowledge regarding the pedagogical activities involved in teaching with games is necessary because it requires knowledge and competence that is not intuitive for most teachers (Nousiainen et al., 2018). To develop curricula and professional development opportunities that can be effectively applied in higher education, a more in-depth understanding of in-service teachers' needs is required, along with the pedagogical knowledge and skills necessary for effective DGBL use. Hébert and Jensen (2019) note that a comprehensive understanding of barriers that teachers face when implementing DGBL is 'important for ensuring not only that the benefits of DGBL are translated into practice, but that teachers receive the support required to make DGBL a possibility within their classrooms' (p. 308). In this perspective, for teacher education and training programs to design meaningful curricula for game-based pedagogy that meets (prospective) teachers' needs, it is essential to understand what these needs are.

The aim of this research is to gain insight into in-service teachers' perception of DGBL in relation to their previous experience teaching with DGBL. The hypothesis in this study is that in-service teachers with less or more DGBL experience will view DGBL implementation differently and will have different concerns regarding aspects of the learning environment. Understanding the concerns and the factors that encourage and hinder them can provide valuable input for developing a meaningful curriculum. Thus, the following research questions were formulated:

RQ1: What factors hinder and encourage in-service teachers with different game-based pedagogical experiences to adopt DGBL?

RQ2: How can this knowledge be used for the development of game-based pedagogy curricula in teacher education?

2. Theoretical Background

2.1 Teacher's Predisposition to use DGBL in Practice

DGBL in mathematics education is the use of digital games within the context of learning mathematics (Byun and Joung, 2018). DGBL can also be defined in a broader way, as an approach in which educational objectives and tasks are integrated into gaming activities with the aim of motivating students to learn in an enjoyable and interactive learning environment (Hussein et al., 2022; Prensky, 2001). In this study, DGBL was used in the broader sense as this better fits the way it is used in secondary mathematics education.

Teachers' perceptions and motivational factors regarding the integration of DGBL into their instruction have been examined in relatively few studies (Hayak and Avidov-Ungar, 2020). Several factors influence a teacher's predisposition to use DGBL. Its perceived usefulness is a significant determinant of teachers' attitudes toward it. Specifically, when teachers perceive DGBL to be highly useful, their attitudes toward digital games tend to be more positive (Sánchez-Mena, Martí-Parreño, & Aldás-Manzano, 2017). The limited availability of curriculum-aligned games is an obstacle that teachers identify as impeding DGBL implementation in the classroom (Takeuchi and Vaala, 2014). Other factors that hinder digital game adoption include rigid curricula, fixed class schedules, and short lesson duration (An and Cao, 2016; Baek, 2008; Kaimara et al., 2021). The lack of financial resources is also a barrier for DGBL; teachers are unable to afford high-quality educational games and appropriate classroom technology (Baek, 2008; Jukić Matić, Karavakou and Grizioti, 2023; Kaimara et al., 2021). Despite that many students own smartphones, not all educational games are compatible with them.

A teacher's personal beliefs and experience can be both a motivating and a demotivating factor in using DGBL. The teachers' anxiety can be a barrier to DGBL adoption. According to a literature review, teachers are concerned about students becoming addicted to gaming through classroom game use and about the violence in digital games (Baek, 2008; Easterling, 2021; Ince and Demirbilek, 2013). This relates to the perceived negative side effects of classroom gaming that could lead to excessive competition and a lack of classroom control.

Teachers' pedagogical experiences have also influenced their DGBL use. Hayak and Avidov-Ungar (2020) found that teachers with more teaching experience (in the advanced career stage) implemented DGBL using more

meaningful methods and inquiry-based, collaborative learning as well as the flipped classroom strategy. Teachers with less teaching experience (in their early careers) used DGBL in a more limited way, as a pedagogical tool to help students internalize and review the material. In contrast, Hsu et al. (2017) found that teachers with less than 10 years of experience were more proficient in integrating DGBL in their instruction, were more motivated to do so, and had a better understanding of DGBL-related content and pedagogy than their more experienced counterparts. These contradictory outcomes may be partially attributed to educational policy's role as an influential variable. In countries where educational policies are aligned with aspirations for fostering innovation in schools in general and digital games in particular, there exists a well-defined set of objectives for attaining digital proficiency that are widely recognized and supported by key stakeholders. This suggests that teacher education colleges and universities are already providing training on incorporating technology into educational practices, including digital games (Avidov-Ungar and Hayak, 2023). With no policy, implementation is likely only carried out by experienced and/or enthusiastic teachers, leaving beginning teachers to struggle with enforcing classroom discipline.

2.2 Five Categories of Factors

Hayak and Avidov-Ungar (2020) examined teachers' perceptions regarding the integration of DGBL in their instruction, and five categories of factors emerged from their data: pedagogical, structural, personal, technical, and social (Figure 1).

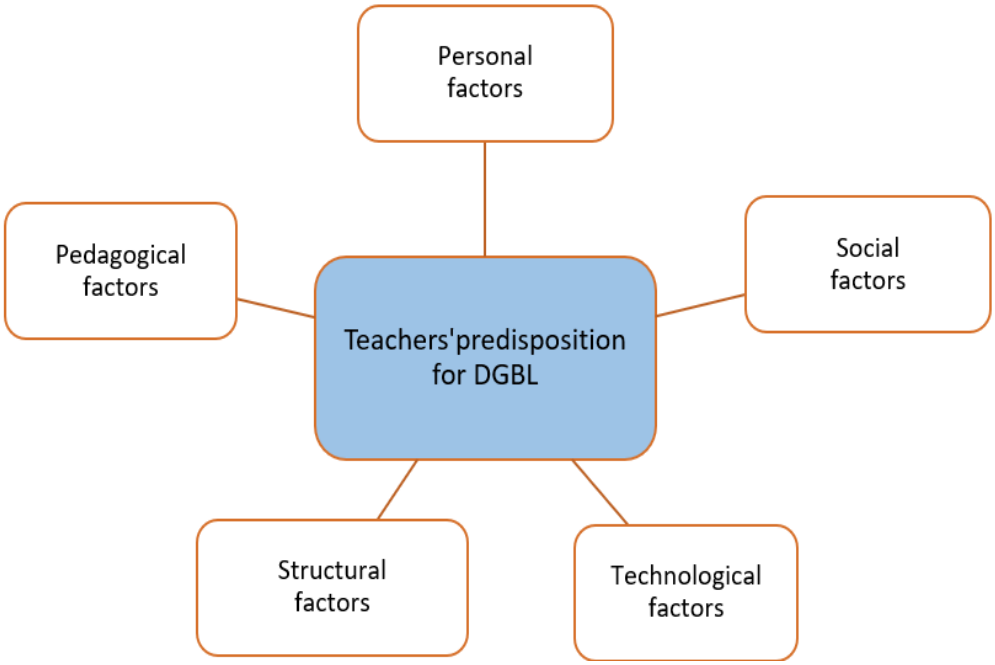

Figure 1: Factors that influence teachers' perceptions regarding the integration of DGBL in their instruction

Pedagogical factors refer to issues of discipline in the classroom, such as establishing 'control' and 'position', aspects related to adapting DGBL to particular students and the subject being taught, preparation time, and the need to search for games.

Structural factors concern the development of a compulsory curriculum, support from the school's management for DGBL integration, and availability of resources for managing integration.

Personal factors relate to the perceptual challenges that teachers experience in integrating DGBL into instruction. It can be experienced as a perceptual barrier; for example, they might need to leave their comfort zone as a teacher and change their teaching approach. It can also be perceived as an agreeable change and an opportunity for professional development. Some teachers in Hayak and Avidov-Ungar's (2020) study noted that they were enthusiastic and experienced self-efficacy when developing new digital games and sharing them with their colleagues.

Technical factors refer to technical difficulties and challenges, such as with logistical planning and technical know-how to properly operate the necessary equipment.

Social factors relate to whether pupils find DGBL interesting and relatable to their world.

We adapted the five categories proposed by Hayak and Avidov-Ungar (2020) as analytical lenses to examine in-service teachers' predisposition for integrating DGBL into their teaching. In Hayak and Avidov-Ungar's (2020) study, the teachers were all practicing DGBL and were in primary education, while in this study, some were not practicing DGBL, and all participants were in secondary education; despite the differences in the target group, the data could be organized in a meaningful way using these five themes.

2.3 Game-Based Pedagogy in Teacher Education

Implementing DGBL in mathematics teaching is also dependent on teachers' understanding of how games can be utilized in the classroom setting. Nousiainen et al. (2018) investigated how primary teachers successfully integrated game-based pedagogy and found that four areas of pedagogical competencies are required for its implementation: pedagogical, technological, collaborative, and creative. *Pedagogical* competencies include curriculum-based planning, tutoring during gameplay, and assessment. *Technological* competencies are concerned with overcoming technological challenges and analysing technological tools, including games. The *collaborative* area covers teachers' ability and readiness to share and communicate content, ideas, practices, and technological know-how. *Creative* competencies include the teacher's ability to take a playful stance, explore, and improvise as well as their creative approach toward their own professional growth. These areas of competence could be addressed in teacher education and regarding teachers' predisposition for integrating DGBL. For example, in-service teachers who face technological concerns should develop competence in the technological area.

Few studies have focused on developing and investigating teacher education programs for teaching with games (Foster and Shah, 2020). These studies show that exploring games and game-playing experiences can help pre-service and in-service teachers better understand the affordances of using games and identify and understand the practical issues in integrating games into the school context. From a design perspective, in-service teachers are a largely diverse group, and some teachers have no experience using DGBL, while others have considerable experience. Given that people are not blank slates and that learning comprises a process of construction in which people build on their previous knowledge, the development of curriculum for game-based pedagogy should consider teachers' previous knowledge of the area.

3. Materials and Methods

3.1 Context and Research Strategy

This study is part of broader research in which in-service teachers' use of game-based pedagogical activities, their predisposition to engage in these activities, and the role they see for teacher education in game-based pedagogy were examined. The research is part of the 'Game-Based Pedagogy in Teacher Education' project, which aims to develop a curriculum for game-based pedagogy at the–Amsterdam University of Applied Sciences, also seeking to develop knowledge in this new pedagogical area in teacher education. This paper reports on the research aspects relating to teachers' predisposition for DGBL and its implications for the development of curricula on game-based pedagogy. An online survey including open- and closed-ended questions was conducted. By using open-ended questions and qualitative analysis procedures, this study aimed to develop a deeper understanding of practicing teachers' actual knowledge, competence, and needs for education on game-based pedagogy. When using the qualitative inquiry approach, the intent is not to generalize findings to a given population but to develop an in-depth understanding of a central phenomenon; thus, the researcher purposefully selects individuals to form the study sample (Creswell, 2002), as in this study.

3.2 Participants

The phenomena examined in this study are teachers' predisposition for game-based pedagogy and the role that teacher education can play therein. Thereby, in-service teachers participating in a master's course on math teaching constituted the study sample because these teachers are acquainted with two contexts important for this study: school practice and the teacher education program. When teaching at school, they have direct or indirect exposure to DGBL and the possibility to apply it. The participants were in-service teachers from three teacher education institutes in The Netherlands and one in Croatia.

The Dutch participants were associated with universities that were involved in a collaborative initiative focused on a joint game-based pedagogy project. Furthermore, a collaborative effort between AUAS and the University of Osijek was undertaken with the aim of implementing digital game-based learning. These collaborative efforts provided valuable insight into the commonalities and disparities among the participants in both institutional and national contexts. Hence, given the shared focus on digital games and the utilization of DGBL as an instructional

strategy, it was considered suitable to collect data from the students enrolled in these educational institutions. On one hand, this phenomenon exemplified the potential for data collection while simultaneously posing a constraint on the sample size.

In both countries, it is possible to teach mathematics in middle school with a bachelor's degree. However, to be able to teach mathematics in high school, one must have a master's degree, which the participants had decided to pursue because it would increase their future employment opportunities. The participants provided informed consent. They were informed by the course teacher educator about the research purpose and invited to answer the questionnaire during the lesson or on their own time. The participants could complete the questionnaire anytime between May and August 2022, and participation was anonymous and voluntary. A total of N_1= 30 Dutch students were provided with a survey link, and among this population, n_1= 22, actively engaged in the survey. Similarly, in Croatia, a total of N_2 = 20 students were given access to the survey, and n_2 = 15 took part. A total of n = 37 responses were collected.

3.3 Data analysis

The online questionnaire consisted of 12 open- and closed-ended items. The closed-ended questions were followed by open questions for which the participants could explain or describe their answer. In the first section of the questionnaire, participants were asked to provide background information (*Where do you study? How many years of experience do you have as a teacher? To what extent do you have experience with the use of games and gamification in your teaching practice?*). In the second section, they were asked for information about their teaching experience with games (e.g. *Can you name three aspects that make the efficient use of games and gamification in teaching practice difficult?*). The third section focused on the role of teacher education. The results reported in this study were based on participants' answers to questions in the second section. Responses to items in the first section were used to determine participants' stage of experience with game-based pedagogy. Participants were categorized into three groups based on their level of experience in using games. They were posed the question 'To what extent do you have experience with the use of games and gamification in your teaching practice?' They could respond on a five-point Likert-type scale (1=not at all to 5=a lot). Participants' answers were clustered into three groups: beginners (no experience; participants who selected Option 1), intermediate (some experience; participants who selected Options 2 or 3), and advanced (more experience; participants who selected Options 4 or 5). This resulted in 11 beginner, 20 intermediate, and six advanced. Considering the questionnaire's anonymous nature, the ability to authenticate the data's accuracy was limited. However, notably, the responses provided by the participants for the open questions were coherent with their assigned expertise levels, thereby suggesting the reliability of the acquired data. Furthermore, given that the survey was completed voluntarily by participants who wanted it to participate, the responses were deemed valid.

The data collected through open-ended questions were analysed in two phases. In the first phase, the data were subjected to thematic coding analysis (Gibbs, 2018) guided by the first research question. This analytical procedure is used to identify text passages that express equal or similar meaning, combine these passages into categories, and define themes that emerged. In the second phase, the five factor categories (pedagogical, personal, structural, technological, and social) defined by Hayak and Avidov-Ungar (2020) were used as an analytical lens, clustering the codes emerging from the first stage in a meaningful and manageable way. Analyses in both phases were performed by two researchers and this paper's authors. The first author is the main researcher of the larger study; the second is the teacher of the course on math teaching in Croatia. Differences in coding were discussed, and when needed, the codes were adapted or changed from a particular category and/or the data were classified with a different code.

4. Results

Results from the thematic analysis revealed 14 hindering and 11 encouraging factors, which were assigned to one of the five aforementioned categories. We examined the hindering and encouraging factors the teachers mentioned at each of the three stages. The results of the analysis are presented in the ensuing sections. For each group, the hindering factors are described, followed by the encouraging factors. An overview of these results is presented in Table 1.

Table 1: Factors that hinder and encourage teachers with few, some or much experience with DGBL

Categories	Beginners (N=11) (-) Hindering factors (n=9) (+) Encouraging factors (n=3)	Intermediate (N=20) (-) Hindering factors (n=19) (+) Encouraging factors (n=18)	Advanced (N=6) (-) Hindering factors (n=5) (+) Encouraging factors (n=3)
Pedagogical	(-) Less control over the classroom (-) Poor learning quality (learning objectives out of sight) (-) More preparation time (-) Difficulty in using active learning (+) Learn about math	(-) Less control over the classroom (-) Poor learning quality (extracting the math out of the game) (-) More preparation time (-) Difficulty in using active learning (+) Learn about math (+) Facilitates learning (active learning) (+) New ways to teaching/learning math (+) Learning other skills	(-) More effort (-) Poor learning quality (keeping pupils focus on the math) (-) Evaluating learning (+) Discovery learning (+) Facilitates learning (+) Know more about pupils' learning
Structural	(-) Predefined curriculum (-) Full/inadequate program (-) High workload	(-) Predefined curriculum (-) Full/inadequate program (-) High workload (-) School organization	
Personal	(-) Feeling unprepared (-) Few knowledge and/or competence (+) Interest (to learn about it)	(-) Few knowledge and/or competence (+) Interest (to learn about it) (+) New knowledge (+) Belief (that is important)	
Technical	(-) Lack of appropriate games (-) Dependence of devices/internet	(-) Lack of appropriate games (-) Dependence of devices/internet (+) Knowing new games (+) Attention for both digital and physical games	(-) Dependence of devices/internet
Social	(-) Pupils engagement (not seriously) (+) Pupils engagement (fun)	(-) Pupils engagement (not seriously) (+) Pupils engagement (fun, motivation (+) Sharing with other teachers	

4.1 Beginner Stage

Beginner teachers have *pedagogical concerns* (n = 5), such as difficulty in classroom management, poor learning quality, and need more preparation time: 'It causes a lot of noise during the lesson; it also takes a lot of preparation, and it is more difficult to keep pedagogical control' (S016). Concerns with learning quality were related to difficulty meeting the learning objectives and supporting pupils' learning: 'I don't see how the use of a game form can guarantee that students practice enough' (S014). Two teachers (S014 and S006) referred to finding it difficult to 'use active learning' and 'guide pupils in their activities'.

Teachers' *personal concerns* (n = 4) involved doubts about having competence and knowledge to implement DGBL. One teacher explains that they feel unprepared for such teaching: 'Feels pretty unguided since I don't know how it works. Can't really prepare myself for it' (S006). Some teachers noted *structural concerns* (n = 3), such as the need to adhere to an existing curriculum and lesson materials, high workload, and school restrictions. One teacher stated that DGBL might not be achievable in every school due to the lack of basic values: 'So, be aware that it is not possible in many schools; you need a certain order, safety, trust, and stable foundation' (S004). Two teachers referred to the lack of appropriate games and computer-related problems *(technical concerns)*: 'I don't know where to find material for it, and making material myself takes a lot of time' (S014). One teacher referred to pupils' engagement *(social concerns)*: 'Students get angry because they want to get a passing grade and don't tread side paths. It can also cause a ruckus in the classroom or even unsafe situations' (S004). Few teachers mentioned encouraging factors (3 out of 11), sharing that DGBL should be about math (*pedagogical factors,* n = 2) and noting that it engages pupils and is fun (*social factors,* n = 2): 'Many students find it fun, want to win competitively (...)' (S005). One teacher mentioned finding the topic interesting and wanting to develop knowledge on it (*personal factors*, n = 1): 'There are so many amazing games. If you can use this in the lessons, it would be a lot of fun! (…) I think it would be great fun to learn more about this' (S017).

4.2 Intermediate Stage

A total of 19 of the 20 intermediate teachers mentioned hindering factors. These teachers have *pedagogical concerns* associated with difficulties in classroom management and the need to adjust the pedagogy. They were more specific in their concerns than beginners, relating to their actual experience teaching with DGBL. Teachers mentioned difficulty in extracting learning from the game: 'The students could focus too much on the game and forget the learning outcomes' (S104). One teacher (S002) referred to finding it difficult to 'ensure discipline in the learning process to do things through planning and make a clear distinction between "having fun" and "school" in this process'. Furthermore, one teacher (S115) expressed negative views regarding using games in the classroom: 'In the classes I teach, I tried this form of teaching, but it did not prove to be successful in those classes, so I switched to other forms of teaching'.

Teachers' *structural concerns* were related to the workload, the need to adhere to school organizational rules (e.g. lesson duration), and managing a full program. Teachers' *technical concerns* included the lack of games connected with the mathematical content that students are learning and the lack of devices/internet connection. They also mentioned the need for technical support to ensure that the digital games used in the lessons work efficiently. They experienced a lack of competence and felt that they did not have adequate theoretical knowledge about how to implement DGBL (*personal concerns)*: 'This is the result of trying out in my teaching practice; it is not based on a theoretical background' (S019). *Social concerns* referred to pupils not taking lessons with games seriously.

Encouraging factors were mentioned by 18 of the 20 teachers. *Personal factors* included teachers' interest in game-based learning (broader than DGBL) and their view that it is important to be aware of and have knowledge about it: 'Game-based learning is motivating for students. It seems interesting to me to learn more from this' (S019); 'Unknown implies unloved. I think it's important to let everyone come into contact with it' (S009). *Pedagogical factors* included game-based learning (broader than DGBL) as a pedagogy that enhances other skills important for pupils' future and other assessment approaches: '(...) I, as a teacher, also get feedback on how much and to what extent they have mastered the learning content' (S113). It can thus be determined that the pupils are active learners. *Social factors* primarily involved stimulating pupils' engagement:

> *I support games in mathematics teaching. They are always interesting and stimulating for students (….). The students really like this form of work because they work together and discuss a certain problem, and what I really liked as a teacher is that the weaker students participate much more than usual, while the other students help them, and at the same time, a positive atmosphere develops in the class. (S113)*

Technical factors concerned knowing about more games and paying particular attention to digital and physical games. One teacher suggested creating a database to share games for their teaching practice.

4.3 Advanced Stage

Five of the six teachers at the advanced stage mentioned hindering factors. Similar to the teachers in the intermediate stage, their concerns are related to their game-based pedagogical experience. The *pedagogical factors* they referred to included having to make more effort to adapt the game lessons for students (i.e. the lessons require a greater investment of energy) and difficulty evaluating students' learning: 'Students could form misconceptions about the subject to be learned through the game without my realizing it or being able to easily address it (as a teacher)' (S011). Teachers at the advanced level did not mention hindering factors related to the structural and personal dimensions. *Technical factors* concerned the lack of good quality games and the lack of devices/internet connection. *Social factors* referred to difficulty with pupils' engagement in learning (e.g. children's boredom due to the excessive use of video games). Encouraging factors were mentioned by three teachers and were all of a *pedagogical* nature. Teachers emphasized the way DGBL facilitates learning by allowing students to play a more active role in their learning and that this makes the lessons more interesting and motivating: 'By going through different types of quizzes/games over a period of a few months, you can see what interests and motivates children and what doesn't' (S108).

5. Discussion

5.1 What hinders and encourages in-service teachers to use DGBL?

A main finding from this study is that pedagogical experience teaching with games is a key variable when examining in-service teachers' predisposition for game-based pedagogy. Notably, despite the variations among the countries from which the participants come, there exists a shared concern and preference among the participants. Teachers at all stages of experience with DGBL mentioned pedagogical factors, and differences were observed between teachers at different stages; differences were also noted for other factors between teachers at different stages. Several obstacles mentioned have also been reported in other research (e.g. Marklund and Taylor, 2016; Watson and Yang, 2016). These results support these previous studies and complement them with insight into the differences and commonalities among teachers at different stages of teaching experience with DGBL, which, to the best of the authors' knowledge, has not been systematically explored previously.

Regarding pedagogical factors, in-service teachers with DGBL experience (intermediate and advanced stages) were concerned about being able to maintain focus on the math concepts, the need to adapt the game lesson to students, and the ways to evaluate student learning; these are particularities of the game-learning process typically related to game-based pedagogy (Kangas et al., 2017). In contrast, in-service teachers with no experience did not mention these aspects and were essentially concerned about ways to control the classroom and whether pupils would receive adequate practice in this learning mode. These findings are similar to those of An and Cao (2016), who found that distractions caused by games and focusing on playing the games (rather than learning from them) were among teachers' major concerns when using digital games in the classroom. The findings also showed that these concerns decreased after teachers were involved in a game design experience, which can be considered a form of game-based pedagogy (Nousiainen et al., 2018). In this study, the differences in pedagogical concerns among the teachers at different stages are because pedagogical competence can be developed during the process of teaching with games. Therefore, teachers with experience (intermediate and advanced stages) have already overcome these obstacles and are facing new ones. However, the results also showed that a previous negative experience teaching with games (such as the case of S115) can prevent teachers using DGBL in future practice. These results support and complement the findings of Watson and Yang (2016), who only reported the positive effect of previous experience teaching with games.

Preference for traditional teaching methods and stereotypical perceptions about the value of digital games (Kaimara, Fokides and Oikonomou, 2021) were reported by very few teachers. Some encouraging aspects from the pedagogical perspective were mentioned by the teachers, emphasizing the value of DGBL as an innovative pedagogical approach, namely, one in which pupils are active learners, learn skills other than the main math content, and engage in new ways to learn math and teachers learn more about pupils' learning.

Technical concerns such as a lack of devices and internet connection were mentioned by teachers at all stages. Lack of information and communications technology (ICT) infrastructure and training have also been noted in other studies as concerns among educators in DGBL implementation (Baek, 2008; Hayak and Avidov-Ungar, 2020; Ince and Demirbilek, 2013). Teachers with no or some experience (beginner and intermediate stages) also

had concerns regarding the lack of appropriate games, another factor mentioned in previous research as an aspect that hinders teachers' use of games in the classroom (Baek, 2008). Teachers from Ince and Demirbilek's (2013) study mentioned the inability to judge game appropriateness to match curricular needs as a hindering factor. Advanced stage teachers did not mention the lack of games as an issue; however, they had concerns regarding game appropriateness for the intended learning, particularly that pupils would develop misconceptions in their learning. A notable finding regarded the suggestion to use analog games, which was interpreted as an encouraging factor to implement DGBL. Even with many schools actively using computers today, teachers seemingly find it important to also conduct lesson activities without computers (as students already spend substantial time on the computer).

Structural concerns such as adherence to an existing curriculum (program too full or inappropriate), high workload, and school constraints have also been mentioned in other studies (Hayak and Avidov-Ungar, 2020; Marklund and Taylor, 2016). Contrary to the findings of Kaimara, Fokides and Oikonomou (2021) and Baek (2008), none of the in-service teachers in this study mentioned a lack of financial resources. Dealing with an existing curriculum and high workload were common aspects for teachers with no or some experience (beginner and intermediate stages), but only teachers with some experience (intermediate stage) mentioned obstacles related to school organization and the difficulty of integrating a game with the traditional teaching approach. The difference among teachers at different stages can be explained by an important fact: only when experimenting with teaching with games in their own school setting will they be able to discover the constraints likely to emerge in their workplace. Similarly, teachers may need to experience teaching with DGBL to determine whether the pre-defined curriculum will become an obstacle.

No teacher mentioned encouraging aspects regarding structural factors (school organization, curriculum). This was puzzling, as in the past decades, substantial investments have been made in innovating schools, renovating the curriculum, and equipping schools with technological novelties and resources. In a prior study in which game-based learning was successfully implemented (Nousiainen et al., 2018), the teachers and headmasters together created 'school-specific plans for applying GBP to address particular pedagogical goals, interests and challenges' (p. 74). It is surprising that, in this study, none of the teachers mentioned any of these aspects as encouraging factors and that structural factors were only considered obstacles. On one hand, this result may be influenced by the data collection method; it would be interesting to examine this aspect in more detail in future research using different methodologies, such as through interviews. On the other hand, the lack of encouraging structural factors may be linked to educational policies in both countries. If educational policy endorsed digital games as an innovative and effective approach to teaching and learning, it is likely that support from schools and school principals regarding the integration of digital games into teaching and learning would be available and mentioned by teachers.

Teachers at the beginner and intermediate stages mentioned personal factors. They referred to the lack of knowledge and competence as hindering factors. Only beginners reported feeling unprepared. One teacher at the intermediate stage reported feeling a lack of creativity. Lack of knowledge and competence aligns with Nousiainen et al.'s (2018) results, which also refer to creativity as a helpful competence for overcoming obstacles in the process of game-based learning. Therefore, it is not surprising that only one teacher who had experience teaching with DGBL reported experiencing the lack (or presence) of creativity.

Social factors were related to pupils' engagement (beginner and intermediate stages) and sharing with other teachers (only the intermediate stage). Few in-service teachers referred to sharing and collaborating with other teachers. This is consistent with Nousisainen et al.'s (2018) findings: 'Teachers still have much to learn regarding mutual sharing of practices and ideas' (p. 74). The authors state that collaboration within and outside the school might be necessary to introduce game-based pedagogy into school culture and make it a sustainable practice.

5.2 Development of Game-Based Pedagogy Curricula in Teacher Education

The above results suggest that the obstacles that teachers describe are possible symptoms of a deeper problem. Their views that DGBL takes more preparation time and effort, leaves them with less control over the class, and could lead to poor learning quality (pedagogical concerns) are likely related to the fact that the pedagogy involved in DGBL is more learner-centred and different from that practiced by teachers. In this case, they need to adjust their classroom pedagogy. The need to adjust the pedagogy was reported by teachers at all three stages. However, this was implicit at the beginner stage and more explicit at later stages because the teachers could refer to concrete experiences in their teaching.

An overly full/inappropriate program and school constraints (structural concerns) do not facilitate pedagogy adjustment; intermediate-stage teachers, in particular, reported experiencing this problem. Through their individual experiences, teachers at the advanced level may have manoeuvred through these challenges associated with school organization and curriculum management. The concerns noted by advanced-stage teachers were connected to practical DGBL use, which involved a lack of resources (technological aspects) and the integration of gameplay (pedagogical factor). If a pedagogy change is needed for DGBL to advance, then higher education and teacher education programs should play a more active role in this process, a finding echoed in earlier studies examining teachers' competences regarding game-based pedagogy and advocating a comprehensive approach to developing teachers' competence (Bado, 2022; Foster, Shah and Duvall, 2015);

Our results align with findings from these studies that suggest the need for a more comprehensive approach to game-based learning in teacher education that guides in-service teachers in examining game-related pedagogy. Foster and Shah (2020) note that game-playing experiences and exploring games can help prospective teachers better understand the affordances of using games or identify practical issues related to their integration into the school context. However, this might not be sufficient, as some studies have shown that participating teachers remain unsure of how to incorporate games into the classroom. The results suggest that previous experience teaching with games can be a key variable to consider when designing curriculum for game-based pedagogy. For example, one can use the knowledge of teachers at different stages to set up different teacher profiles to better connect the instruction with teachers' specific needs. Moreover, differences in participants' views can be intentionally used in a collaborative assignment to trigger critical reflection and challenge beliefs. In some cases, a concern factor for teachers at one stage is an encouraging factor for teachers at another stage (e.g. active or discovery learning). Knowledge of differences in perspectives can be exploited by course developers or teacher educators.

5.3 Suggestions for Tailored Curricula on Game-Based Pedagogy

Playing and exploring the learning aspect of games

Teachers with no experience have more doubts regarding DGBL's educational value, feel more unprepared to teach with games, and worry about being unable to manage the classroom. For these teachers, knowledge of the particularities and processes in DGBL can be too far from their zone of proximal development. More adequate tasks for these teachers could involve playing and exploring the learning aspect of games. However, Sanchez-Mena et al. (2017) caution that perceived ease of use has little effect on teachers' attitudes toward digital games. Thus, teacher training programs should encourage teachers to utilize digital games not because they are easy to use in the classroom but because they can be a helpful resource to employ.

Designing games and instruction for learning by making games

Involving teachers in designing their own games can help develop a more positive attitude and self-efficacy regarding the use of digital games in the classroom (An and Cao, 2016). The utilization of a framework that supports the development of a game from the perspective of both a game designer and an educator is recommended in this process. Tahir and Inge Wang (2019) introduced a comprehensive framework that offers robustness in its application for the analysis, design, and evaluation of learning games.

Read, discuss, and reflect on particular pedagogical activities for DGBL (and opportunities to apply this knowledge at work)

Teachers with some or a great deal of experience express concerns regarding the particularities of the game-based learning process (Kangas et al., 2017) such as planning, gameplay, and evaluation. Therefore, suitable learning activities for these teachers could address knowledge regarding particular pedagogical activities and opportunities to apply this knowledge in their practice as well as opportunities to develop/reflect on game-related areas of competences, such as the pedagogical, collaborative, technological, and creative areas (Nousiainen et al., 2018). Sometimes, a concern factor for beginners is an encouraging factor for advanced teachers. This is the case for 'active or discovery learning'. A course designer can build on this information by creating collaborative course assignments that encourage participants to explore, discuss, and experiment with different game examples, such as games with specific learning goals, with broad learning goals, for practicing a single mathematical skill, and games that involve complex learning goals. The exchange of experiences and ideas on these matters among teachers at different levels can trigger critical reflection of one's own and others' views on DGBL and, consequently, lead to a change of attitude or view on game-based pedagogy.

Prepare, experiment with, and discuss lessons with DGBL

Typical concerns from more experienced teachers such as being able to maintain focus on the math concepts, extract the math from the game activity, and adapt the game lesson to students cannot be properly addressed in lecture form due their practical nature. More adequate for this aim are course assignments in which participants need to prepare, experiment with, and discuss lessons with DGBL, preferably in the context of their own practice and school. The planning and discussion elements of the assignment can be carried out in a collaborative setting involving the three stages and exploiting the variety in participants' DGBL experience. Beginners and some intermediate teachers may find the experimentation part of the assignment too challenging and could be given the alternative assignment of collaborating with other teacher or observing a more experienced teacher conducting the experiment. Moreover, the use of modelling assignments is a suitable way to address the implementation of DGBL in practice (Foster and Shah, 2020). Modelling assignments refer to the situation in which the course leader or one of the participants tries to conduct a lesson with DGBL in an exemplary way while the other participants participate in the activity as students.

Exchange and reflection in heterogeneous learning teams: Overcoming structural obstacles

Teachers with some experience struggle with obstacles of a structural nature and may need some support in developing specific competences, such as adapting the game goals to the learning goals in the pre-defined curriculum or implementing DGBL within the established structure of their own school organization. Support can be provided in the form of learning teams in which teachers with few experience can learn how to overcome structural obstacles from teachers with more experience. This activity can be extended to the technical, personal, pedagogical, and social factors as well.

6. Conclusion

A novel undertaking in this study is the investigation of in-service teachers' perception of game-based pedagogy in relation to their previous experience in teaching with DGBL. A main finding of this study is that pedagogical experience seems to be a key variable when examining in-service teachers' predisposition for game-based pedagogy. Pedagogical, structural, personal, technical, and social factors differ given the teacher's experience stage and necessitate careful consideration when developing supportive curriculum for in-service teachers in the context of DGBL. Gaining an in-depth understanding of how to support in-service teachers in developing game literacy is essential for DGBL to progress (Foster and Shah, 2020; Hanghøj, 2013; Marklund and Taylor, 2016). Higher education can play a much more active role in its development: 1) through the application of game-based pedagogy in multiple courses and 2) by creating specific courses related to game-based pedagogy and examining what and how in-service teachers learn as well as the extent to which this impacts their work in the classroom. Five concrete suggestions can be derived for the application of game-based pedagogy for teacher educators and curriculum developers that exploit the knowledge of in-service teachers' predisposition for DGBL:

- Playing and exploring the learning aspect of games
- Designing games and instruction for learning by making games
- Read, discuss, and reflect on particular pedagogical activities for DGBL
- Prepare, experiment with, and discuss lessons with DGBL
- Exchange and reflection in heterogeneous learning teams: overcoming structural obstacles

Further research should develop and investigate specific content and assignments connecting or extending the suggestions above as well as how in-service teachers develop game-based pedagogical competence in relation to them.

Some limitations of this study must be acknowledged. First, purposive sampling and a small sample size limit the generalizability of the findings to all in-service teachers. Additionally, caution must be exercised with conclusions regarding the teachers at the advanced stage, as there were only six in this group. Second, the data collection was limited to a questionnaire. While this enabled the collection of data in a relatively short time and with little cost, while providing a considerable number and variety of responses, further research is recommended complementing the questionnaire with other methods (e.g. interviews) that could provide deeper insight into the reasons behind the responses obtained in this study.

Further research could employ different techniques for data collection, such as conducting in-depth interviews. The proposed approach would enhance a more holistic comprehension of the diverse stages and provide insight into teachers' viewpoints concerning said stages. Additionally, further research should investigate the time-based evolution of these stages and identify the primary factors that contribute to this progression. It would be

valuable to investigate the activities employed by teachers at various stages. Based on the aforementioned findings, the support that teachers require for the implementation of DGBL can be explored more deeply.

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The Antecedents of Mobile-Assisted Language Learning Applications Continuance Intention

Ferdinand Hanif Faozi and Putu Wuri Handayani
Faculty of Computer Science Universitas Indonesia, Indonesia

ferdinand.hanif@ui.ac.id
putu.wuri@cs.ui.ac.id

Abstract: The purpose of the research is to analyze the factors that influence the continuance intention to use Mobile-Assisted Language Learning (MALL) applications in the context of language courses in Indonesia. The study aims to understand the key factors that contribute to users' intention to continue using MALL applications, particularly in the context of the COVID-19 pandemic and the shift towards online and remote language learning. The research used the expectation-confirmation model and self-determination theory. Moreover, the research utilized a mixed-methods approach to achieve its objectives. A quantitative approach was employed, involving a survey with 445 respondents who had experience using MALL applications. The survey data was then analyzed using covariance-based structural equation modeling. Additionally, qualitative research was conducted through interviews with 17 respondents to gain a deeper understanding of rejected hypotheses and gather qualitative insights. The most important results of the research include identifying the factors that influence the continuance intention to use MALL applications. The study found that users' perceived usefulness of the application, their satisfaction with its usage, and their self-regulation ability significantly influence their intention to continue using MALL. These findings highlight the importance of these factors in shaping users' decision to persist with MALL applications for language learning. By understanding the factors that influence users' intention to continue using MALL, educational institutions and application providers can improve their offerings and tailor them to meet the needs and expectations of learners. This research advances the e-learning area by shedding light on the factors that influence the continuance intention to use MALL applications. By uncovering the importance of perceived usefulness, satisfaction, and self-regulation ability, the study contributes to the understanding of user behavior and decision-making in the context of e-learning. The findings can inform the design and implementation of MALL applications, leading to more engaging and effective language learning experiences in online and remote settings. This research contributes to the advancement of e-learning practices by providing evidence-based insights into the factors that drive user intention and adoption of technology in language learning.

Keywords: Mobile assisted language learning, Expectation-confirmation model, Self-regulation skills, Self-determination theory, Continue intention to use, Indonesia

1. Introduction

Since the COVID-19 pandemic, informal learning mode, such as foreign language learning, has been carried out online. Mobile-Assisted Language Learning (MALL) is defined as language learning carried out through mobile technology. The primary key components of MALL are flexibility in learning time and location, continuity of learning on different devices, easy accessibility of information, and adaptability to learning habits (Loewen et al., 2019). Examples of popular MALL applications are Duolingo, Busuu, Babbel, Rosetta Stone, Memrise, and others. Users-wise, by the end of 2020, Duolingo had reached 42 million users, an increase of 40% from the previous year, which touched 30 million users (Business of Apps, 2022). However, the overall retention of language learning applications is lower than in other categories, such as books, casual gaming, and news (Business of Apps, 2020). BBC (2020) described that one of the biggest challenges for users to learn a new language is motivation and self-control. In addition, retention is closely related to individual goals and expectations (BBC, 2020).

Using MALL, some features allow users to easily access learning resources without time or place restrictions (Chung, Hwang, Lai, 2019; Hamidi & Chavoshi, 2018). Implementing this kind of education technology may lead to psychological comfort learning (Al-Otaibi, AlAmer, Al-Khalifa, 2016). In several previous studies, there are also findings that the use of MALL can add benefits to several skills lines, such as vocabulary, reading skills, writing skills, listening skills, and pronunciation skills (Hao et al., 2019; Lin, 2014; Hwang et al., 2014; Hwang & Chen, 2013; Shih, Lee, Cheng, 2015; Loewen et al. 2019).

The use of MALL also has several limitations, such as user devices that are not certainly capable, thus affecting the quality of functionality and connectivity of learning services by MALL (Sarrab, Elbasir, Alnaeli, 2016; Ünal & Güngör, 2021). In addition, there are pedagogical limitations, such as the flow of the learning process that has not adapted to the way students learn independently (Cheon et al., 2012; Ünal & Güngör, 2021). Psychologically, the pedagogical limitation of using MALL is the continuity or persistence of users who have not been good

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(Loewen et al., 2019). Because, in the context of MALL, the persistence of MALL users is as important as the technological advances used (Loewen et al. 2019). Persistence in this context is how the user's perception and behavior remain good in the activity, even though it is faced with some distractions and difficulties (Wolters, 2004). This problem can be seen in the Duolingo application where the user's course completion rate is below 1%. (Duolingo – Golden Owl Hall of Fame, 2020). Course completion rate is a number obtained from the comparison of the number of users who take and complete the course with the total number of users who take the course (Duolingo – Golden Owl Hall of Fame, 2020). The definition of "completion" refers to completion of the overall course structure (Duolingo – Golden Owl Hall of Fame, 2020). In Duolingo, the highest course completion rate was obtained from the Ukrainian language program with 0.23% and Danish with 0.22%. (Duolingo – Golden Owl Hall of Fame, 2020). As a comparison, this number is still quite far when compared to the course completion rate in the Computer Assisted Language Learning with an open course format, which has a number of 2.9% to 4.4% (Friðriksdóttir & Arnbjörnsdóttir, 2015).

To the best of our knowledge, not many studies specifically discuss MALL, more discussing aspects of learning activities (Wang et al., 2022; Lai et al., 2022). In fact, according to Statista (2022) and Business of Apps (2022), the use of MALL has had high growth in the last few years. Further, there has been no research involving self-determination theory as an influencing factor of users' satisfaction along with their motivation (Wang et al., 2022; Lai et al., 2021; Wang & Lin, 2022), and self-regulation factors from individuals as external factors (Wang et al. et al., 2021; Wang & Lin, 2022). Thus, this study will analyse the factors that influence the continuance use of MALL. This study will adopt the expectation-confirmation model (ECM) and self-determination theory (SDT). This research can be resourceful for mobile language learning application developers and other actors in the field of language education in developing their applications.

2. Literature Review

2.1 Expectation Confirmation Model

ECM is widely used to study Information System continuance intention (Li & Fang, 2019; Wang & Lin, 2022). The ECM is widely used for several field studies, such as mobile learning (Wang & Lin, 2022), MALL (Ünal & Güngör, 2021), massive open online courses (Daneji, Ayub, Khambari, 2019; Dai et al., 2020), and online learning (Clow, 2013; Wang et al., 2022). ECM is used to study user's satisfaction and behavior in the post-information system use (Bhattacherjee, 2001). ECM believes several aspects are closely related to the continuance use of users, such as the degree of confirmation, the degree of perceived usefulness, and the degree of user satisfaction (Bhattacherjee, 2001; Li & Fang, 2019; Wang & Lin, 2022). Previous studies showed the usage of ECM and concluded that confirmation as an exogenous variable has significantly influenced the level of user satisfaction and perceived usefulness (Li & Fang, 2019; Wang & Lin, 2022). Furthermore, user satisfaction and perceived usefulness in application usage can affect the continuance use intention of application users (Bhattacherjee, 2001; Li & Fang, 2019; Wang & Lin, 2022).

2.2 Self-Determination Theory

SDT is a theory that discusses motivation and human well-being, which has the main objective of explaining how and why there can be an ongoing motivation and behavior that occurs (Ryan & Deci, 2017; McEown & Oga-Baldwin, 2019). SDT is associated closely with basic psychological needs as their component (Ryan & Deci, 2017). Basic psychological needs refer to human psychological needs that influence human self-development as an individual with their external world and the inner world, crucially (Ryan & Deci, 2011). Specifically, it covers three aspects, autonomy, competence, and relatedness (Ryan & Deci, 2017). Autonomy is an individual's need to experience independently and take actions that are carried out voluntarily (Ryan & Deci, 2017). Autonomous behavior is reflected through volunteerism or support from within and an interest that drives the behavior (Ryan & Lynch, 1989; Ryan & Deci, 2017). The second aspect is competence, the need for an individual to feel the mastery of skills and carry out activities effectively (Ryan & Deci, 2017). The need for competence is closely related to perceived effort, curiosity, and one's epistemic motivation (Ryan & Deci, 2017). The third aspect is relatedness, which covers the need for an individual to be interrelated and have a sense of ownership (Ryan & Deci, 2017). This type of fulfillment is perceived when a person feels they could perform the contribution exchange with another party (Ryan & Deci, 2017).

2.3 Research Hypothesis

We modified the ECM and SDT as our proposed conceptual model. ECM has also been used in several studies related to the use of applications for learning contexts, such as the research of Luo, Lin, Yang (2021), Ünal dan Güngör (2021), and Wang and Lin (2021). ECM is used in this study to analyze the factors that influence MALL

continuance intention while SDT is used to determine the factors that influence motivation and satisfaction with MALL. Perceived autonomy, perceived competence, and perceived relatedness are the components of basic psychological needs to represent SDT (Ryan & Deci, 2017). Those variables are used to see the learning application from the user's inner side. Self-regulation skills or perceived behavioral control were involved in this study because it has been used in the research of Lai et al. (2021), Ünal & Güngör (2021), Lung-Guang (2019), and Li (2019). These factors describe the ability of users to control their actions (Lai et al., 2021; Ünal & Güngör, 2021; Lung-Guang, 2019; Li, 2019) and are used to represent the consistency and persistence of users in carrying out learning actions (Lai et al. al., 2021; Ünal & Güngör, 2021; Lung-Guang, 2019; Li, 2019). Therefore, this research model has nine variables and 14 potential causal relationships (hypotheses) (Figure 1). The preparation of hypotheses is carried out by referring to studies related to learning applications. This study uses the two-tail hypothesis because not many studies have investigated MALL to the best of our knowledge; thus, we could not define the directional research hypothesis (one-tail).

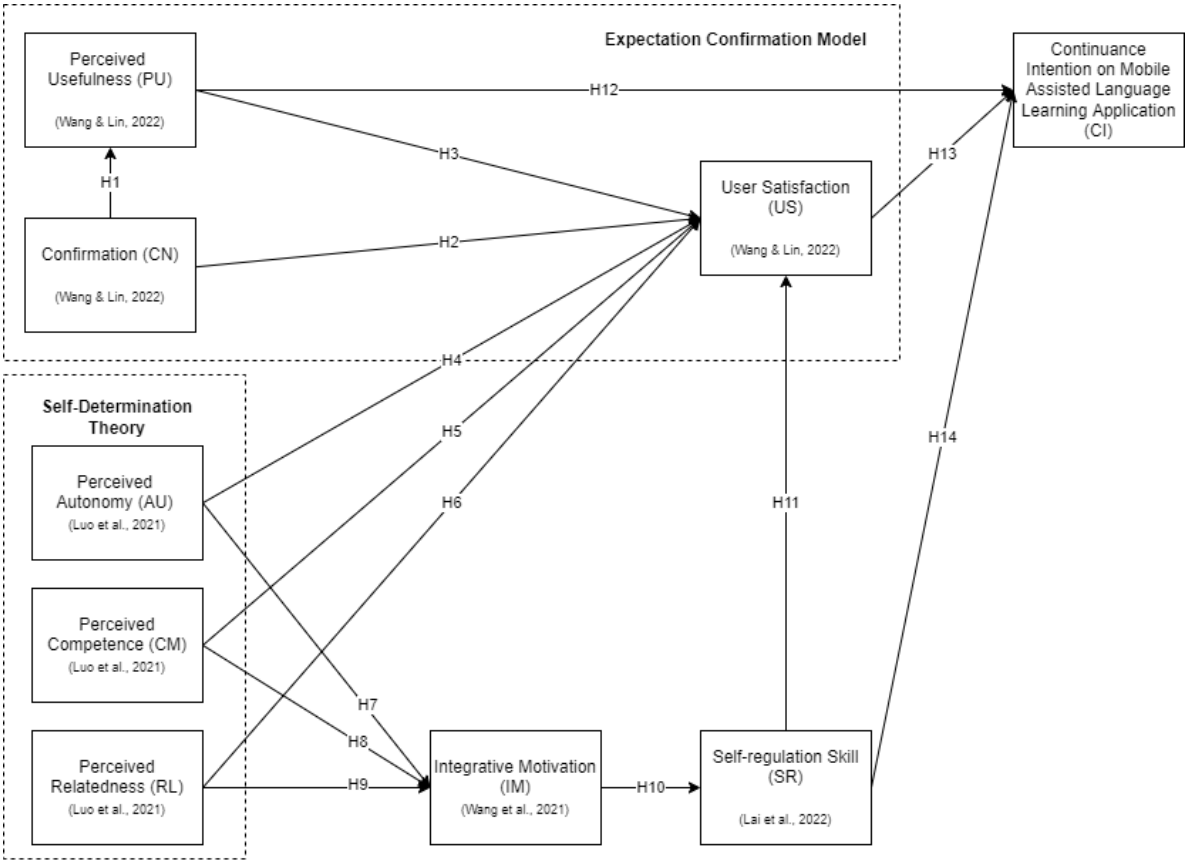

Figure 1: Proposed Conceptual Model

Confirmation is the level of user confirmation of their expectations (Bhattacherjee, 2001). In this study, confirmation is defined as the degree of user awareness regarding fulfilling the expectation in using MALL. Perceived usefulness in the Bhattacherjee model (2001) is defined as the users' perceived value or usefulness degree. Perceived usefulness is defined in this study as the degree of user confidence that MALL can improve their learning performance. Wang and Lin (2021) found that confirmation from users can affect the level of perceived usefulness of users. Their study found that users who realize the achievement of expectations using the application feel that the application will be helpful for the user. Similar results were shown in several previous studies with various contexts, such as massive open online course applications (Luo, Lin, Yang, 2021; Dai et al., 2020) and Duolingo applications (Ünal & Güngör, 2021). Thus, we propose the following hypothesis:

H1: Confirmation influences perceived usefulness on the use of MALL.

Wang and Lin (2021) and Ünal and Güngör (2021) mention an association between confirmation and user satisfaction. Both studies found that users' awareness of applications' expectations met influenced the satisfaction tendency with the applications used. Other studies on applying for massive open online courses

(Luo, Lin, Yang, 2021; Dai et al., 2020) have confirmed this relationship. Therefore, we suggest the following hypothesis:

H2: Confirmation influences user satisfaction on the use of MALL.

Wang and Lin (2021) mention a relationship between perceived usefulness and user satisfaction. Wang and Lin (2021) also found that users who feel the application's usefulness tend to be satisfied with the application used. Similar findings were also shown in several previous studies with various contexts, such as massive open online course applications (Luo, Lin, Yang, 2021; Dai et al., 2020) and Duolingo applications (Ünal & Güngör, 2021). Hence, we develop the following hypothesis:

H3: Perceived usefulness influences user satisfaction on the use of MALL.

Several previous studies found that each component of these basic psychological needs may influence user satisfaction, one of which is the autonomy component. Research conducted by Abuhassna et al. (2021) in the context of e-learning and Abuhassna et al. (2020) in the context of massive open online courses shows that the flexibility of learning activities can affect user satisfaction in using the learning application. In addition, the study of Akbari, Pilot and Simons (2015), in the context of language learning through social media, Facebook, suggests that if users feel freedom and unimpeded during the learning process, especially in exploring new information or knowledge, user satisfaction in learning with the media will surely increase or reached. Then, we propose the following hypothesis:

H4: Perceived autonomy influences user satisfaction on the use of MALL.

In a study conducted by Akbari, Pilot and Simons (2015), in the context of language learning through social media, Facebook suggests that the competence felt by students can increase user satisfaction in learning to use the media. The growth of competence felt by students while learning to use the media can create a sense of satisfaction in users (Akbari, Pilot, Simons, 2015). The sense of satisfaction felt by users is obtained because users are happy to receive feedback from the learning (Akbari, Pilot, Simons, 2015). This finding is also in line with Tseng et al. (2022) who stated that the awareness about the growth of proficiency and perceived usefulness made users feel satisfied with the online learning platform.

H5: Perceived competence influences user satisfaction on the use of MALL.

Research conducted by Abuhassna et al. (2021) in the context of e-learning and Abuhassna et al. (2020) in the context of massive open online courses indicates that users' sense of connection with the learning platform may affect user satisfaction in their application usage. Research by Akbari, Pilot and Simons (2015) within the context of language learning through Facebook also suggests that users who feel connected to learning media, especially in exploring new information or knowledge, will increase user satisfaction in learning through the media. Therefore, we suggest the following hypothesis:

H6: Perceived relatedness influences user satisfaction on the use of MALL.

Luo, Lin and Yang (2021) show that there is a wide range of applications for learning that users feel can increase student motivation intrinsically. With the freedom to learn, users are increasingly motivated to use the application because it can give the impression of better learning opportunities. These findings are also in line with research conducted by Aditia, Dahlan and Ilfiandra (2021) in the context of the online learning environment and Holzer et al. (2021) regarding online and self-regulated learning. Then, we define the following hypothesis:

H7: Perceived autonomy influences integrative motivation on the use of MALL.

Furthermore, Luo, Lin and Yang (2021), in the context of the massive open online course application, show a perceived competency growth as the result of learning activities through the application may grow students' intrinsic motivation. The growth of competence motivates users to learn because applications provide user needs or the user's way of learning properly (Luo, Lin, Yang, 2021). Research conducted by Aditia, Dahlan and Ilfiandra (2021) in the context of an online learning environment and Holzer et al. (2021) regarding online and self-regulated learning also showed the same results. Thus, we suggest the following hypothesis:

H8: Perceived competence influences integrative motivation on the use of MALL.

Luo, Lin and Yang (2021) prove that the user's sense of attachment to the application can increase student motivation intrinsically. This sense of attachment shows in the application's forms that can understand the user's input. In addition, a sense of attachment is also shown by the sense that the application can contribute to users,

and users can contribute to the application. The results of this study are also in line with Aditia, Dahlan and Ilfiandra (2021) and Holzer et al. (2021). Based on this analysis, this study added the following hypothesis:

H9: Perceived relatedness influences integrative motivation on the use of MALL.

Bai and Wang (2021), in high school students in Hong Kong, stated that there is motivation in the form of a growth mindset, and learning interest may influence the independent learning process, especially in the initiative, managing feedback received, and revising knowledge aspects. In addition, the motivation of students' mindsets to develop is one of the predictors of self-control in independent learning activities. In addition, Alotumi (2021) states that students who have intrinsic interests tend to be more enthusiastic and actively participate in learning activities. In addition, Tabak and Nguyen (2013) suggest that intrinsic motivation can indirectly affect self-control and tend to have more attention on the learning that is carried out. Then, we added the following hypothesis:

H10: Integrative motivation influences self-regulation skill in the use of MALL.

Self-regulation ability is one of the most influential factors in independent learning activities outside technology (Lung-Guang, 2019). Self-regulation skill is an individual's ability to consciously exercise complete control over an action so that it can take place consistently (Zimmerman & Schunk, 2011). In this study, the self-regulation skill variable is defined as the user's ability to control their actions on something entirely so that it is always consistent and persistent. Li (2019) found that one's self-regulation ability when using massive open online courses influences user satisfaction in learning activities. In addition, Mirhosseini, Lavasani and Hejazi (2018) also show that the self-regulation ability of students can increase their satisfaction with learning activities and their self-efficacy. The justification for these results is that students whose self-regulation abilities will generally focus on strategies for how applications are utilized according to their needs (Mirhosseini, Lavasani, Hejazi, 2018; Li, 2019). Using the perceived strategy, students feel a good satisfaction degree while using the application (Mirhosseini, Lavasani, Hejazi, 2018; Li, 2019). Both studies are also in line with the findings obtained by Hamdan et al. (2021). Hence, we propose the following hypothesis:

H11: Self-regulation skill influences user satisfaction on the use of MALL.

Perceived usefulness in Bhattacherjee (2001) is defined as the usefulness that is believed to be achieved by the user. In the context of this study, the perceived usefulness variable represents the degree of user confidence that MALL can improve their learning performance. Continuance intention from Bhattacharjee (2001) is defined as the user's intention to keep choosing or using something. In the context of this study, continuance intention is defined as the user's intention to continue using the MALL application. The relationship between the two variables is supported by Wang and Lin (2021), with the context of using mobile learning applications. Similar results were also evident in several previous studies with various contexts, such as the massive open online course application (Luo, Lin, Yang, 2021; Dai et al., 2020; Joo et al., 2018) and the Duolingo mobile language learning application (Ünal & Güngör, 2021). Thus, we define the following hypothesis:

H12: Perceived usefulness influences continuance intention on the use of MALL.

User satisfaction variable from Bhattacherjee (2001) is known as the level of user satisfaction that is known to come from interactions with related matters. This study defines user satisfaction as the degree of user satisfaction with MALL based on direct experience. Continuance intention from Bhattacharjee (2001) is defined as the user's intention to keep choosing or using something. In the context of this study, continuance intention is defined as the user's intention to continue using MALL. The use of these two variables is supported by research by Wang and Lin (2021), with the context of using mobile learning applications. Similar results were also evident in several previous studies with various contexts, such as the massive open online course application (Luo, Lin, Yang, 2021; Dai et al., 2020; Joo et al., 2018) and the mobile language learning application Duolingo (Ünal & Güngör, 2021). Therefore, we suggest the following hypothesis:

H13: User satisfaction influences continuance intention on the use of MALL.

Self-regulation skill is an individual's ability to consciously perform complete control over an action so that it can take place consistently (Zimmerman & Schunk, 2011). The relationship between self-regulation skills and continuance intention is supported by Ünal and Güngör (2021) and Lung-Guang (2019). In addition, Lai et al. (2021) state that self-regulation ability affects a person's actual behavior in learning activities. We added the following hypothesis:

H14: Self-regulation skill influences continuance intention on the use of MALL.

3. Methodology

3.1 Data Collection

The object of this research is a mobile language learning application found on the Play Store or App Store for the Indonesian area. This research was conducted with a mixed-method approach, using online questionnaires and interviews with respondents who have used the MALL application at least once. Online interviews were conducted to confirm the rejected hypothesis. After compiling the online questionnaire, we conducted a readability test to ensure that the questionnaire could be understood well. The readability test was carried out for seven days, from January 26, 2022, to February 1, 2022. The readability test was carried out on nine respondents using Zoom. The output of this readability test is an improvement in grammar and wording so that it is easier for respondents to understand. After the readability test, a pilot study was conducted on 30 respondents to test the validity of the questionnaire. The result shows the Cronbach Alpha (CA) value of 0.784, which has met the requirements for a CA value above 0.7.

Online questionnaire link was distributed through social media, such as Twitter, Instagram, and instant messaging applications like LINE and Whatsapp. In the research questionnaire, respondents also filled out their consent to be willing and agreed to participate in this study, and data was obtained anonymously. We also provide incentives in the form of IDR500,000 electronic money for some lucky respondents. The online questionnaire data collection was carried out for four weeks, starting from February 10, 2022, to March 12, 2022, and obtained as many as 445 respondents. Table 1 explains the demographic summary of the respondents.

Table 1: Respondents' Demographics

Demographics		Number of Respondents	Percentage
Gender	Men	189	42.47%
	Women	256	57.53%
Age	< 17 years old	16	3.60%
	17 - 25 years old	388	87.19%
	26 - 35 years old	34	7.64%
	36 - 45 years old	5	1.12%
	> 45 years old	2	0.45%
Domicile	Greater Jakarta	234	52.58%
	Outside Greater Jakarta in Java Island	161	36.18%
	Sumatera	25	5.62%
	Bali, NTB, and NTT	12	2.70%
	Kalimantan	6	1.35%
	Sulawesi	5	1.12%
	Others	2	0.90%

Then, after testing the hypothesis, it was found that some hypothesis was rejected. To explore the reasons why the hypothesis in this study was rejected, we conducted online interviews via online video conference with seventeen respondents.

3.2 Data Analysis

The data were processed using the IBM SPSS AMOS 24 application with the Covariance Based Structural Equation Modelling (CB-SEM) method. This CB-SEM approach is used, considering that the objective of CB-SEM is to test previously developed theories. The main stages in CB-SEM include testing measurement models, structural models, and hypotheses. Interview data were processed using the content analysis method without specific software tools. The online interview was recorded, and the interview transcript was made. Based on the transcripts, writing results were conducted to explain the reasons for rejecting any hypothesis.

3.3 Research Instrument

This research questionnaire was made using Indonesian in accordance with the respondents' nationality. The research questionnaire consists of three main parts: the first part provides the validation part, the second part is questions related to demographics, and the third part contains statements related to the research model and variables. In the first part, one question confirms whether the respondent has ever used a mobile language learning application. The first part is intended so only valid respondents can answer the follow-up questions in the next part. In the second part are questions related to the demographics of the respondents and the respondents' use of MALL. The third part consists of 36 measurement items that are mandatory questions. The answer to the measurement items is in the form of the respondent's level of agreement with the question, which is answered through a 5-point Likert Scale, that ranges from 1 (strongly disagree) to 5 (strongly agree). Appendix A describes the measurement items used in this study.

4. Results

4.1 Measurement Model

The following requirement for convergent validity is the average variance extracted, or AVE, which represents the convergence of indicators (Hair et al., 2013). For the AVE value, each indicator has a number above or equal to 0.5 (Hair et al., 2013). In addition, the reliability scale constraint should be achieved by looking at the construct reliability scores or CR and CA (Hair et al., 2013). The general rule for good CR and CA values is at least 0.7 (Hair et al., 2013). Values for AVE, CA, and CR for all variables are listed in Table 2.

Table 2: CR, CA, and AVE Values

Variable	CA	CR	AVE
PU	0.787	0.789	0.556
CN	0.775	0.991	0.975
US	0.773	0.991	0.972
CI	0.781	0.993	0.978
SR	0.706	0.993	0.978
IM	0.755	0.991	0.973
AU	0.738	0.990	0.972
RL	0.748	0.991	0.973
CM	0.702	0.990	0.971

Note: PU = perceived usefulness; CN = confirmation; US = user satisfaction; CI = continuance intention; SR = self-regulation skill; IM = integrative motivation; AU = perceived autonomy; RL = perceived relatedness; CM = perceived competence

4.2 Structural Model

The goodness-of-fit (GoF) test on the structural model is performed by checking numerous value criteria, such as chi-square fit statistics/degree of freedom (CMIN/df), goodness-of-fit index (GFI), root means square residual (RMR), normed fit index (NFI), comparative fit index (CFI), Tucker-Lewis index (TLI), and root mean square error

of approximation (RMSEA). Table 3 explains the GoF value where all the GoF criteria have met the requirements of Hair et al. (2013).

Table 3: GoF Values

No.	Criteria	Cut-off Value	Value	Description
1	CMIN/df	< 2	1.998	Good fit
2	GFI	>= 0.9	0.919	Good fit
3	RMR	<= 0.05	0.042	Good fit
4	NFI	>= 0.09	0.916	Good fit
5	CFI	>= 0.09	0.955	Good fit
6	TLI	>= 0.09	0.941	Good fit
7	RMSEA	<= 0.08	0.049	Good fit

4.3 Hypothesis Testing

Hypothesis testing is carried out to see the relationship between variables based on the structural research model (Kline, 2015). This test is conducted by calculating the P-value or probability. With these conditions, the hypotheses are accepted if the P-value does not exceed 0.05 (Hair et al., 2013). This research was performed through a two-tailed direction, with a significance level of 95%. Based on these provisions, 13 hypotheses can be accepted, and 1 hypothesis cannot be accepted (Table 4).

Table 4: Hypothesis Testing Result

Hypothesis				Estimate	P	Description
H1	PU	<---	CN	1.178	0.002	Accepted
H2	US	<---	CN	0.169	0.002	Accepted
H3	US	<---	PU	0.097	0.001	Accepted
H4	US	<---	AU	0.154	0.002	Accepted
H5	US	<---	CM	0.196	0.002	Accepted
H6	US	<---	RL	0.195	0.002	Accepted
H7	IM	<---	AU	0.250	0.002	Accepted
H8	IM	<---	CM	0.348	0.003	Accepted
H9	IM	<---	RL	0.197	0.002	Accepted
H10	SR	<---	IM	0.746	0.003	Accepted
H11	US	<---	SR	0.066	0.070	Rejected
H12	CI	<---	PU	0.725	0.003	Accepted
H13	CI	<---	US	0.115	0.002	Accepted
H14	CI	<---	SR	0.076	0.002	Accepted

5. Discussion

This study shows that confirmation can affect perceived usefulness in the use of MALL (H1). The findings of these results are in line with those of Wang and Lin (2021), Luo, Lin, Yang (2021), and Dai et al. (2021). This study found that MALL can exceed user expectations, so users will feel that the application provides benefits for them to learn. Confirmation points in the context of this research include meeting expectations on several indicators, such as features in general, the learning process offered, the assessment system applied, and the quality of

application use in general. Based on the demographic data of the questionnaire, as many as 74.38% of respondents often use the learning module feature, 62.92% of respondents often use the checkpoint quiz feature, and 56.40% of respondents often use the learning progress feature. In addition, this study shows that the more MALL exceeds user expectations, the more satisfied users will be with MALL (H2). The results of this study are in line with Wang and Lin (2021), Luo, Lin, and Yang (2021), and Dai et al. (2020). The results of this hypothesis are also supported by the results of interviews with two respondents *("… exceeded my expectations, which at first, I thought it would be very serious…"* – Respondent 1).

This study also shows that perceived usefulness can affect user satisfaction in the use of MALL (H3). The results of this study are in line with Wang and Lin (2021), Luo, Lin and Yang (2021), and Dai et al. (2020). The results of this hypothesis are also supported by the results of qualitative interviews where users feel satisfaction in MALL (*"… gives a lot of knowledge and is quite useful too…"* – Respondent 10; *"… because it is useful, I can learn new vocabulary…"* – Respondent 16). Furthermore, this study shows that perceived autonomy affects user satisfaction with MALL (H4). The results of H4 are supported by Abuhassna et al. (2021) and Abuhassna et al. (2020). Abuhassna et al. (2021) show that a good online learning platform must support the autonomous activities of students as it can affect students' flexibility in learning. In other words, an online learning platform that supports independent learning for students will provide satisfaction for its users because it provides the value of flexibility without having to study in a formal classroom setting or class via conference. One of the perceived freedoms is that the learning platform can be used exploratory in a module and facilitates repetition of learning on the desired material (Abuhassna et al., 2020). In addition, Akbari, Pilot and Simons (2015) suggest that if users feel the freedom to learn, especially in exploring new information, user satisfaction with learning to use the media will increase. The H5 is accepted in this study which defines that the user's perceived competence can affect user satisfaction with the use of MALL and is following Akbari, Pilot and Simons (2015). The results of H5 are also supported by qualitative interviews where users feel a sense of satisfaction in using it because it can improve the vocabulary competence of the user (*"… giving knowledge such as new vocabulary that I may not have known or never heard of…"* – Respondent 3; *"… I think the application is insightful and gives much new vocabulary …"* – Respondent 4). This study shows that the user's perceived relatedness can affect user satisfaction with the use of MALL (H6). The results of this study are in line with Akbari, Pilot and Simons (2015), Abuhassna et al. (2021), and Abuhassna et al. (2020). Based on the results of interviews, it was found that users felt a sense of satisfaction in using MALL because the application was reliable or minimal to errors (*"… the application is quite dependable, does not always crash …"* – Respondent 5).

Then, the user's perceived autonomy can affect the user's intrinsic motivation in using MALL in this study (H7). The results of this hypothesis are supported by Luo, Lin and Yang (2021), Aditia, Dahlan and Ilfiandra (2021), and Holzer et al. (2021). Those studies mention that freedom or flexibility of learning in several forms of implementation, such as re-learning, or material exploration, can stimulate student motivation (Aditia, Dahlan, Ilfiandra, 2021; Holzer et al., 2021). Based on the questionnaire results, as many as 74.38% of respondents use the learning module feature for learning exploration, and as many as 59.55% of respondents use the challenge feature as a form of additional exploration and self-actualization in the learning process. In addition, it is also known that as many as 48.0% of respondents expect a dictionary feature in the application, which can add to the exploratory nature. The use of the features mentioned earlier and the demand for the dictionary feature indicate user needs regarding features that facilitate users to freely learn and carry out their self-actualization during the learning process. In other words, the user's integrative motivation in using MALL will be greatly influenced by the fulfilment of the need for flexibility in learning, application responsiveness, and self-actualization during the learning process by the application in question. In addition, the user's perceived competence can affect the user's intrinsic motivation to use MALL (H8). The findings of this study are also quite in line with Aditia, Dahlan and Ilfiandra (2021) and Holzer et al. (2021). Both state that if students feel an increase in knowledge or knowledge or competence through activity, they will tend to increase their intrinsic motivation again. (Aditia, Dahlan, Ilfiandra, 2021; Holzer et al., 2021). Competence growth makes users feel motivated to learn because applications are judged according to user needs (Luo, Lin, Yang, 2021). Based on questionnaire data, as many as 74.38% of respondents often use the learning module feature, and 24.94% use the flashcard feature. In addition, as many as 38.43% of respondents use the script learning feature according to the needs of the language they are learning. Additionally, 62.92% of respondents generally use the checkpoint quiz feature to test their knowledge. These features indicate that users are using features that are expected to provide competency growth and confirm their ability to increase. In other words, the user's integrative motivation in using MALL will be strongly influenced by the development of the user's perceived competence, which includes increased knowledge, increased ability, increased confidence in abilities, and optimization of learning performance. The user's perceived relatedness can also affect the user's intrinsic motivation to use MALL (H9).

The results of H9 are supported by Luo, Lin and Yang (2021), who also prove that the user's sense of attachment to the application can increase student motivation intrinsically (Luo, Lin, Yang, 2021). Based on questionnaire data, 56.40% of respondents use and are aware of the learning progress feature, and 38.88% use the goal-setting feature to help them learn. In addition, as many as 41.80% of respondents also take advantage of the learning reminder feature as a form of their strategy or study plan.

This study shows that the more the application can make users feel motivated, the more users will have good self-control during application use and tend to be consistent and proactive (H10). This study's findings align with Bai and Wang (2021). The student's developing mindset becomes one of the predictors of self-control in independent learning activities (Bai & Wang, 2021). In addition, Alotumi (2021) states that students who have intrinsic interests tend to be more enthusiastic and actively participate in learning activities. Based on questionnaire data, as many as 86.07% use applications with the motivation to develop themselves, and as many as 37.08% use applications because of the respondent's desire to explore knowledge.

This study shows that H11 is rejected where the user's ability to exercise self-control while using the application does not affect their satisfaction. The results of H11 contradict Li (2019). Based on the results of interviews, users feel that their learning strategies or persistence of learning have no effect on their satisfaction but rather provide awareness about the functions or features of the application (*"… Does not make using the application more satisfied but becomes more aware of the application function ..."* – Respondent 15). In addition, respondents also felt that self-regulation skills did not affect their satisfaction with using the application. However, they became more aware of how to use it, and this has implications for adopting applications as a place to learn (*"… I do not think strategy affects satisfaction, but I think I understand more about the application…"* – Respondent 5). In addition, respondents also thought that the presence or absence of a strategy for using the application should not affect satisfaction because satisfaction should be obtained from the quality of the application and good experience with the application (*"… no, because the satisfaction felt is usually from the feeling when using the app…"* – Respondent 12)

This study shows that users' perceived usefulness can lead to the intention to use MALL (H12). The results of this study are in line with Wang and Lin (2021), Luo, Lin and Yang (2021), and Dai et al. (2020). The results of this hypothesis are also supported by the qualitative interviews conducted. From the interview results, it is known that users have the intention to use the application because, overall, the application is quite helpful for users (*"… I use the application continuously because I felt the application was useful for me ..."* – Respondent 5). In addition, several respondents specifically mentioned that users use MALL continuously because it is beneficial for their vocabulary learning (*"… secondly, because the application is useful for increasing vocabulary …"* – Respondent 16). Respondents also feel that the application can be a suitable means to facilitate respondents to learn (*"… The factor is because the application can facilitate me to learn. Because I have the urgency to learn and the application facilitates my urgency, so I will also continue to use the application …"* – Respondent 11).

In addition, this study shows that users who are satisfied with MALL will continue to use the application (H13). These results are in line with Luo, Lin and Yang (2021), Dai et al. (2021), and Wang and Lin (2021). This result is also supported by interviews where users are satisfied with the experience of MALL, which is easy to use *("… Because the application is easy to use and not difficult to use …"* – Respondent 4). In addition, the aspect of satisfaction is also felt thanks to the structure and approach to learning at MALL, which is quite good (*"… The factor that makes me want to use it offers quite good benefits, with a smooth approach …"* – Respondent 9; *"… I keep using the application because the application is quite fun, it feels like playing a game, and the learning mode is not too hard …"* – Respondent 14).

Finally, self-regulation skill influences continuance intention on the use of MALL. The findings of this study are supported by Lung-Guang (2019) and Lai et al. (2021). The results of this hypothesis are also supported by interview data where it is known that respondents who feel the need or urgency to learn have a continuous intention to use MALL (*"… I use this application because I feel it is necessary for my learning needs. In terms of my urgency, I continue to use the application …"* – Respondent 2). In addition, respondents who use MALL as the only strategy for learning have a continuous intention to use the application (*"… Third, I think this application is my only option to learn languages specifically, so because I have an urgency to study. So, I keep using it that way…"* – Respondent 5; *"… Second, because I do not have additional course lesson. So, I use this application as an option for studying…"* – Respondent 15).

6. Implications

In general, this study contributes to the research suggestions by Lai et al. (2022) by carrying out one application of mobile technology specifically for independent research related to language learning. This study answers these suggestions by researching one of the applications of MALL. This research is also one of the contributions to McEown and Oga-Baldwin (2019), where this study suggests applying the basic human psychological needs variable for research in education or language acquisition. The results of this study indicate that every aspect of basic human psychological needs, namely the need for freedom of learning, the need for competency development, and the need for feeling attached during learning, can influence the degree of satisfaction and integrative motivation of users to learn using MALL.

Moreover, the interaction between the three ECM variables, namely confirmation, perceived usefulness, and user satisfaction can be applied to course institution and MALL developers by implementing a learning curriculum that is in accordance with the user's initial use objectives, so that users feel the relevance of the application to user's benefits. For course institutions who decide to design MALL, they can consider creating a self-assessment tool or a student-centered learning application. By integrating language course learning with the MALL application, students can practice more so that they can further improve communication skills in learning foreign languages.

Furthermore, in developing the MALL, course institution or MALL developers need to pay attention to aspects of autonomy, competency growth, and a sense of connection that users will have to increase their perceived satisfaction. One example of a feature that can increase the aspect of autonomy is the dictionary feature and the discussion forum feature for sharing study tips. Both features can increase the aspect of autonomy felt by the user through the exploratory sense offered by the existence of these features. In addition, the discussion forum feature can trigger a sense of attachment for users, not only with the application itself but also with other users. With this, users can feel a good connection and are expected to have better motivation and satisfaction. In addition to these two features, the grammar feature can also increase user satisfaction by triggering the user's perceived competence.

7. Conclusion

This study shows that the factors that influence the continuance use of MALL are perceived usefulness, user satisfaction, and self-regulation skills. In this study, it was also found that the confirmation factor influenced the perceived usefulness. Another finding of this study is that integrative motivation factors influence self-regulation skills. Moreover, integrative motivation factors are influenced by perceived autonomy, competence, and relatedness. The first limitation is that most respondents currently reside in the Greater Jakarta area, and the age group is 17 to 25. In addition, the distribution of applications used by respondents is still the majority using the Duolingo application, where more than 90% of respondents are respondents who have used the Duolingo application. Future research can examine other factors that may affect the continuance intention variable from MALL because this study's coefficient of determination shows a moderate value.

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Appendix A: Questionnaire

Part 1: User's Validation

Have you ever used the MALL app to learn a foreign language? Yes/No (If no, the user can not proceed to fulfil the questionnaire)

Part 2: User's Demographics

Select only one answer for each following question:

Gender : a. Men b. Women

Age : a. < 17 years old b. 17 - 25 years old c. 26 - 35 years old d. 36 - 45 years old e. > 45 years old

Domicile: a. Greater Jakarta b. Outside Greater Jakarta in Java Island c. Sumatera d. Bali, NTB, and NTT

e. Kalimantan f. Sulawesi g. Others

Part 3: Measurement Items

Answer using 5-point Likert Scale, that ranges from 1 (strongly disagree); 2 (disagree); 3 (neutral); 4 (agree) to 5 (strongly agree)

Code	References	Measurement Items
CN1	Wang and Lin (2021)	I feel the features of the MALL are better than I expected.
CN2		I feel that the learning process using the MALL is better than I expected.
CN3		I feel that the feedback or assessment system in the MALL is better than I expected.
CN4		Overall, I feel that the quality of using the MALL is better than I expected.
PU1		With MALL, I feel I can improve my performance in learning languages.
PU2		With the MALL, I feel I can improve my skills in foreign languages.
PU3		I feel that MALL can effectively help me learn a foreign language.
PU4		I feel learning languages through MALL will be useful for me.
US1		I feel happy with language learning activities on MALL.
US2		I feel that my experience in language learning on MALL is quite good.
US3		I am satisfied with language learning with MALL.
US4		I feel that my needs in language learning can be met through a MALL.
AU1	Luo et al. (2021)	I feel free to learn and respond to MALL.
AU2		I use the MALL to study because of my own will.
AU3	Xi and Hamari (2019)	I feel that I can be myself during the learning process with the MALL.
AU4		Overall, I feel that I can use MALL for independent learning.
CM1	Luo et al. (2021).	I feel I have better foreign language skills because of the use of MALL.
CM2		I am satisfied with my learning performance when using MALL.
CM3	Xi and Hamari (2019)	By learning through the MALL, I feel more confident in the foreign language skills I am learning.
CM4		I feel that the MALL gives me the new knowledge that I need.

Code	References	Measurement Items
RL1	Luo et al. (2021)	When using a MALL, I feel that the application is reliable for my learning process.
RL2		When using a MALL, I feel that the application is reliable for my learning process.
RL3	Xi and Hamari (2019)	When using MALL, I feel that I have to study regularly to progress further.
RL4		When using a MALL, I feel that the application understands the input I give.
IM1	Luo et al. (2021)	I agree that the use of MALL can be used according to my needs.
IM2		I agree that MALL are a good way or approach to learning for me.
IM3		I agree that the use of MALL gives me freedom in learning.
IM4		I agree that the use of MALL meets my needs in using these applications.
SR1	Lai et al. (2022)	I re-evaluate my understanding of learning activities in MALL.
SR2		I try to be consistent in using MALL in language learning.
SR3		I'm trying to find a supporting solution if I feel that the learning activities on the MALL are not enough for me.
SR4		I can strategize for language learning with efficient and effective using MALL.
CI1	Wang and Lin (2021)	I intend to use MALL in the future.
CI2		I intend to continue to use the MALL on a regular basis.
CI3		I intend to utilize MALL for some other purposes.
CI4		If possible, I will continue to use MALL to learn other languages.

Motivationally Appealing Computer Science e-Learning Games: An Inclusive Design Approach

Joseph Osunde[1], Liz Bacon[2] and Lachlan Mackinnon[3]
[1]University of Greenwich, London, UK
[2]Abertay University, Scotland, UK
[3]University of South-Eastern Norway, Norway

j.o.osunde@greenwich.ac.uk
l.bacon@abertay.ac.uk
lachlan.mackinnon@usn.no

Abstract: Research has shown that e-learning games do not have the same level of appeal to girls, as they do to boys; particularly in the crucial 11-14 age group. In the United Kingdom, this is typically when they start to make subject choices that impact their future studies and careers. Given the shortage of females who choose computer science as a career, this study explores how e-learning games can be designed to be motivationally appealing to young learners. It further explores the role of game representations and its appeal to this age group. This empirical study addresses the research question: "Can we develop e-learning games which appeal and motivate girls of age 11-14 to study computer science concepts?" Two e-learning games were developed: one included game representations such as game colour, graphics, character, age appropriateness, storyline, number of players, violence, identified as appealing to young females and the other game included antithetical or neutral representations. The two developed prototypes were used to explore key e-learning game representations as used to teach computer science concepts. A total of 304 participants, comprising of 152 girls and 152 boys from a combination of same sex and mixed secondary schools in Southeast England, engaged with both experimental games. The experiment also elicited information on how learners interact with these games and the resulting game appeal, motivation and learning. The insight gained from the analysis of data captured during the experiments, provide the evidence to demonstrate that inclusive e-learning games which motivate and appeal to girls of age 11-14 can be developed. This can have a positive influence on their willingness to use such games to learn computer science concepts. This implies that the study found positive outcomes related to e-learning game appeal, motivation and the learning of girls of this age group. A follow-up longitudinal study could investigate the impact of significant e-learning game representations that appeal to the target group. This could provide additional evidence on the changes in the appeal of the investigated significant game representations over time, due to the influence of other factors such as socio-economic and socio-cultural differences. This understanding can further enhance inclusive e-learning strategies to improve diversity in computer science education and consequently the career pipeline.

Keywords: Motivationally appealing, e-Learning games, Digital entertainment games, Educational game framework, Gender and games

1. Background

The underrepresentation of females in computer science education and careers is prevalent in almost every western country irrespective of intervention strategies over the years (Osunde, Windall, Bacon and Mackinnon, 2015; Hancock et al., 2021). Based on related work, the major factor responsible for the low representation of females in computer science education and careers has been the progressive lack of interest in the subject. This is due to a poor perception of the subject and its professional image (Charlesworth and Banaji, 2019, Vrieler, Nylén and Cajander, 2021). This poor perception has been shown to be mainly influenced by negative gender-linked beliefs in the home, educational institutions, workplace and society (Hancock et al., 2021). These perceptions, even if they are not accurate, shape the academic choices that girls make (Charlesworth and Banaji, 2019; Vrieler, Nylén and Cajander, 2021).

As part of measures to improve representation, e-learning games have also been designed and used to improve engagement with technology, computer science and learning content (Duggal, Singh and Gupta, 2021). However, there is evidence from related studies that negative gender-linked beliefs are embedded in e-learning games for young people, and as a result, such games appeal more to boys than girls (Yucel and Rizvanoglu, 2019, Malik et al., 2020).

In attempting to address this problem, both gender neutral and gender specific e-learning games have been designed and implemented. The outcomes from both approaches have resulted in further research into the design of effective e-learning games for young people. This leads to the research question explored in this

Reference this paper: Osunde, J., Bacon, L. and Mackinnon, L. 2023. Motivationally Appealing Computer Science e-Learning Games: An Inclusive Design Approach, *The Electronic Journal of e-Learning, 21(4)*, pp 314-327, available online at www.ejel.org

study, which is: "*Can we develop e-learning games which appeal and motivate girls of age 11-14 to study computer science concepts?"*

The rest of this paper is structured as follows. First, a more in-depth discussion of the literature is provided, explaining what is currently known about this area and the gap in our knowledge. The design of the experiment is then explained in detail, which provided the evidence used in responding to the research question.

The main contribution to knowledge is the understanding that there are similarities and differences in game representations used in e-learning games for computer science education with this age group of learners. This understanding can be used to design e-learning games that appeal to girls of this age group. The findings from the study are relevant to e-learning game designers, domain researchers and policy makers in secondary education.

2. Overview of the Literature

E-learning games have been designed and implemented in recent years to engage more girls with technology and computer programming. Research work in this domain has suggested that the use of e-learning games involving both design and programming activities can support the learning of computer science concepts by girls of middle school age (Yucel and Rizvanoglu, 2019, Denner et al. 2019). Several studies conducted in this discipline show that this is a gender-neutral approach to teaching computer programming to girls because it supports higher-order thinking, abstraction skills, and activity enjoyment as summarised by Yucel and Rizvanoglu (2019).

Seminal studies have explored the use of games specifically designed to engage girls with programming concepts. Games such as *Talking Alice* for teaching basic programming concepts (Kelleher and Pausch, 2007; Denner, Werner and Ortiz, 2012), *Gram House* (Harteveld et al., 2014), *Gamher World* (Kamberi, 2015) and *CodeSpells* (Esper, Foster and Griswold, 2013) for teaching Java concepts to girls. Recent studies suggest that the use of such games can further improve the engagement of girls with computer programming and possibly support their interest in pursuing careers in computing (de Carvalho et al., 2020; Ottenbreit-Leftwich et al., 2021).

These games teach programming concepts using game representations that are motivationally appealing to girls. In the *Talking Alice*, appealing characters, pre-programmed behaviours such as dancing, talking etc. are used to engage the learners while learning key programming concepts (Zaidi, Freihofer and Townsend, 2017). The *Gram House* game is designed based on appealing game representations such as story and puzzle-based gameplay. In addition, other games such as *CodeSpells and Gamher World* implement the use of exploration in the multimedia environment to teach programming concepts.

Additionally, educational game frameworks have been designed and implemented to evaluate and provide guidelines for creating effective e-learning games for learning (Alsubhi, Sahari and Wook, 2020). Several educational game frameworks have been proposed and used to create e-learning games. Both seminal and recent work indicate that each design framework specifically focuses on the user experience by including appropriate game representations and embedding the learning outcomes in the game environment (Amory, 2007, Aleven et al., 2010, Nadolny et al., 2020). Significant to all e-learning game frameworks is the learning outcome, which fundamentally differentiates educational games from entertainment games. Common to both e-learning and entertainment games is the implementation of user-centric design frameworks.

Past studies have suggested that the changes in the design of e-learning games should result in the improvement of female perception and appeal of e-learning games (Boyle, Connolly and Hainey, 2012; Powell, Dainty and Bagilhole, 2012). The basis of this suggestion is the evidential improvement in the engagement demonstrated by girls when learning computer science concepts with games as *Talking Alice*, *Gram House*, *Gamher World, CodeSpells* etc. due to the appeal of these games.

There are no studies in the literature, or elsewhere, that focus on a holistic e-learning game design initiative to investigate the key game representations that could improve the appeal of learning games for computer science concepts with the 11-14 age group. Seminal and recent work have shown that this age group, in the UK and many other countries is where the pipeline leading to further study and careers in technology and computer science significantly starts to shrink, with the decline in the number of girls continuing to study these subjects particularly sever (Wang and Degol, 2013; Zaidi, Freihofer and Townsend, 2017, Charlesworth and

Banaji, 2019, Sun, Hu and Zhou, 2022). Furthermore, in the United Kingdom, the 11-14 year age group is also identified as a key age for educational choices (UK Royal Academy of Engineering, 2016, Cavaglia et al., 2020).

3. Methodology and the Design of the Study

To answer the research question, "*Can we develop e-learning games which appeal and motivate girls of age 11-14 to study computer science concepts?"* the methodology was broken down into two stages. The first stage was an exploratory study designed to identify the key game representation that improve the motivational appeal of e-learning games for girls and boys, aged 11-14. Details of the methodology and results of the qualitative exploratory study involving 24 girls and 8 boys engaging with e-learning games have been published in detail elsewhere (Osunde et al. 2015). The second stage, the main study, used these results to design two games, one with representations that appeal to girls, the second with neutral representations or the antithesis of what had been shown to appeal to girls.

With regards to the first stage, a combination of open and closed card sorting with 10 entertainment game videos from a range of game genres (Action, Maze, Adventure, Role Play, Simulation, Strategy, Arcade, Music, Puzzle and Casual) were used in this initial study. The open card sort was used to capture the possible constructs and the closed card sort was applied to aggregate the occurrence of the key constructs in the next phase of the experiment. The constructs that were common to participants by gender and the appeal were identified from the open card sort. The semantic clustering technique was used to analyse the constructs elicited from the participants of the study, identifying the constructs that had the highest commonality by gender.

The second stage explored the design of e-learning games, for learning basic computer science concepts, embedding the key game representations identified from the exploratory study. Seven significant game constructs as shown in table 1.0, with categories that appeal to girls, were selected based on the construct commonality frequency from the participating population, for further investigation in the main study. The seven characteristics were selected based on their importance in the overall set of characteristics identified, their discreteness, their higher relative importance to girls, and to reduce the complexity of the game design, which would have become unwieldy in trying to represent all the characteristics identified.

The design used the variations of the constructs, which are the different values within individual constructs e.g. the construct violence could have three variations - very violent, mild violence and no violence values, to identify antithetical values. The first prototype was developed based on the variations of the key representations that appealed to the girls. The second game was developed based on the antithetical representations to the first game. Both games were used in the main study experiment. The experiment was approved by the university ethics committee and parents / guardian consent was obtained in advance. The activities carried out in both stages are shown in figure 1.

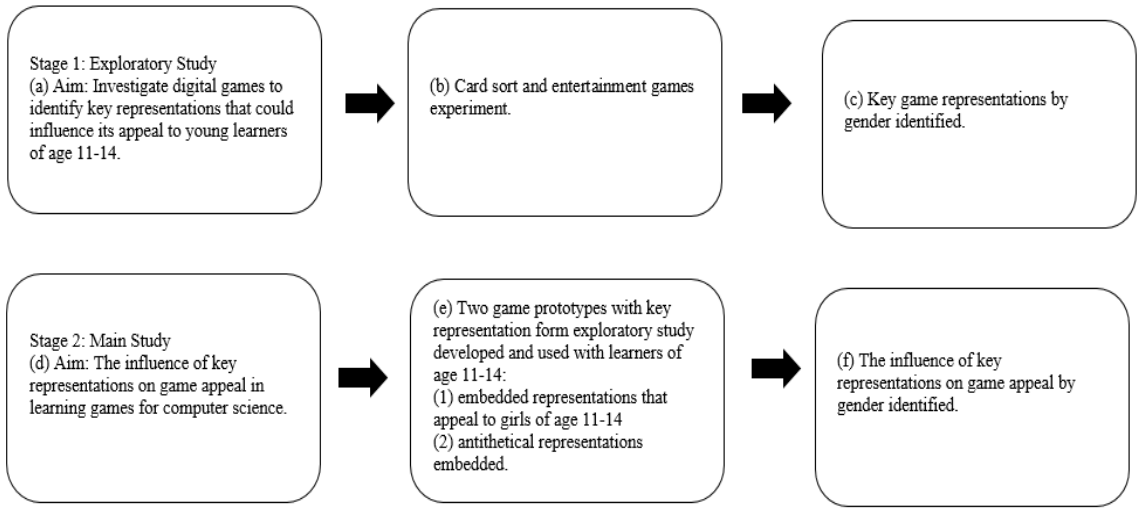

Figure 1: Diagrammatic representation of study methodology

3.1 Main Study Investigation Technique

To investigate if these games constructs can be used to successfully create motivationally appealing e-learning games, for learning basic computer science concepts, with 11-14 year-old girls, a suitable methodology had to be identified. The methodology had to meet the following requirements:

- Identify an approach that could be used to investigate the game characteristics identified to appeal to the target group from the exploratory study. Two possible approaches were considered. The first was to design and create an e-learning game for learning basic computer science concepts, while the second was to adapt an existing game for the investigation. The second approach was considered and used because several e-learning games for the study of basic computer science concepts are readily available. Secondly, adapting an existing e-learning game provides the opportunity to evaluate existing games for their effectiveness as educational tools. Thirdly, existing games have been evaluated and designed based on established learning principles and methodologies.
- Evaluate the chosen game to confirm its educational effectiveness and how to alter the game to include the game characteristics identified from the exploratory study without compromising the educational effectiveness and value of the game. The process produced two experimental games i.e., one that should enhance the motivational appeal of girls age 11-14 and the other antithetical to the first.
- The data from the investigation needed to be captured using a suitable technique. Several techniques such as interviews, reports, and questionnaires were reviewed as possibilities for collecting participants' feedback during the investigation. The chosen method needed to capture an extensive range of information with accuracy (Garcia et al., 2012) and make effective use of time and available resources.

Based on the requirements for the main study, online (pre and post-study) questionnaires were chosen and used to capture participant perception, as this is a tried and trusted technique for collecting survey data. Questionnaires can also be used to measure preferences, opinions and intentions. The data captured can be analysed qualitatively and quantitatively, and most participants should be familiar with this information collection method.

Furthermore, questionnaires can be used to collect a range of information with accuracy and enable the study to be carried out in multiple locations without the researcher present, while still ensuring all participants are asked the same questions. The pre-study questionnaire captured participant perception and understanding of digital games before engaging with the games. The post-study questionnaire was used to collect participant feedback after engaging with the games.

The data collected using the pre and post-study questionnaires utilised a participant identification number provided by the instructors or teachers running the instance of the study, to ensure anonymity, and demographic information such as age and gender. The identification number was required to correlate the pre- and post-study data collected during the main study.

Other information captured using the pre-study questionnaire included information on entertainment gameplay habits (referred to as computer games in the questionnaire for simplification purposes for participants) and educational computer gameplay habits.

The data captured from participants using the pre-study questionnaire elicited existing knowledge of significant game characteristics, the perception and influence of computer games that appeal to the target audience. In addition, existing knowledge of the influence and perception of e-learning games (referred to as educational computer games in the questionnaire for simplification purposes) were captured using the pre-study questionnaire.

Three post-study questionnaires were created for the main study. One post-study questionnaire was created for each experimental game and was used to capture participant responses about each game after engaging with it, the participants were finally asked to answer an evaluative post-study questionnaire. The questionnaires also captured data on the appeal of specific game characteristics, the appeal of the game and the overall impact of the game. The evaluative post-study questionnaire captured comparative data on the impact of the games, and the more appealing of the two games to the target group.

This information showed the impact of the experimental games on the target audience by correlating the data with the pre-study data, exploratory study outcome, and related literature.

The questionnaires comprised open ended, Likert-scale (4, 5 and 7 points), and numeric scale (1-5) type questions. The Likert-scale point used for questions was determined by the level of granularity required from the responses. The scale values for the 4 point Likert –scale: *1= A lot, 2=Some, 3= Little, 4= Not A Lot;* 5 point Likert–scale value: *1= Strongly prefer, 2=Somewhat prefer,3= No preference, 4=Somewhat do not prefer, 5=Strongly do not prefer;* 7 point Likert-scale value: *1= Like very much, 2=Like moderately, 3=Like slightly,4= Neither like nor dislike, 5=Dislike slightly, 6=Dislike moderately, 7=Dislike very much.* The numeric 1-5 scale value was: *1=Very poor, 2=Poor, 3=Fair, 4=Good, 5=Excellent.*

3.1.1 Study sample size and materials

A total of 304 participants, comprising of 152 girls and 152 boys (the fact that the same number from both genders participated is purely coincidence), engaged with both experimental games for the main study and completed the study pre- and post-study questionnaires. The experiment with the participants, which lasted for about 60 minutes, involved the completion of the pre-study questionnaire, playing both games, completing the post-study questionnaire about each game and the comparative post-study questionnaire. The gameplay duration for each game was a maximum of 20 minutes. The participants could choose the order of gameplay hence randomised to reduce or eliminate the effect of order bias.

The rationale for this approach was to obtain two sets of data on the influence of both games on girls and boys involved in the study. The data collected from participants' engaging with each game included information on how much each game appealed to the participants, the appeal of the specific game characteristics used in the games and the influence of each game on participants' perception of e-learning games. It is important to note here that the study was carried out in five different schools, during computer Science lessons and each instance was run by the class teacher, thereby ensuring the participants were in a familiar and comfortable environment. There was no bias introduced by the presence of an unfamiliar researcher and learning environment. The class teachers were coached to run the instance of the study by the researcher.

The *Google Blockly maze game* was used for the design of both games as it met the study requirements (technical and educational) for customisation. Figure 2 illustrates the *Google Blockly maze game*, which was customised to create two experimental games for the investigation.

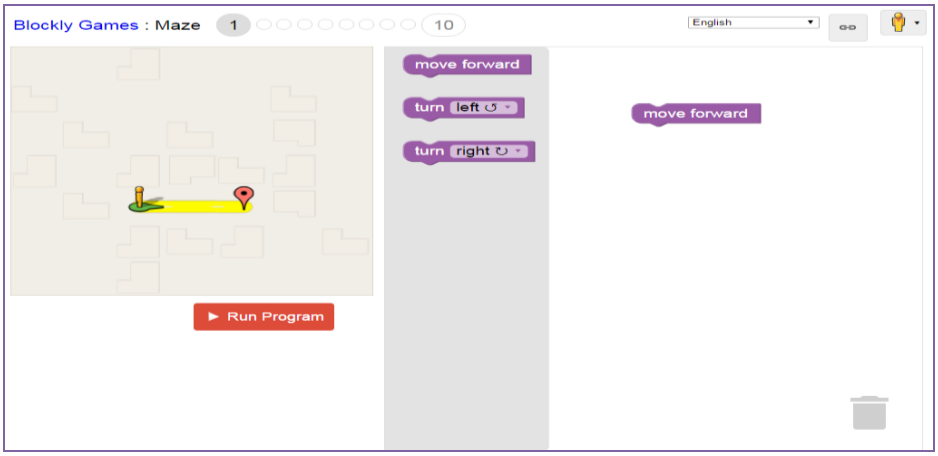

Figure 2: The Google Blockly maze game

There are 10 levels of play in the gaming environment, each focuses on the use of different programming constructs such as sequencing, decisions and repeat (loop) instructions. The less challenging levels of the game allow the player to use an unlimited number of instruction blocks. However, higher levels would limit the number of instructions blocks to successfully create a functional script making the game more challenging.

The first experimental game (*The Lost Astronaut*) included the variations of the significant game characteristics that positively appeal to the girls and the second *(The Lost Hippo),* the antithesis of the characteristics selected for the first game as shown in table 1.

Table 1: Selected construct category pairings for further investigation in the main study

No	Female game constructs	Categories of appeal and game representations in *The Lost Astronaut*	Categories with antithesis appeal and game representations *in The Lost Hippo*
1.	Age-appropriateness	All ages/everybody (The use of the astronaut character, colour, narrative, cartoons instead of pictures and images that appeal to a wide age range)	Teenage games suited for the age group (The use of representations that appeal to a younger age group such as the use of the hippo as the main character in a fantasy scenario, dark colours, pictures instead of cartoons etc.)
2.	Game violence	No violence (No violent representations included)	Violent (Some violence such as explosions included in the gaming environment when the character navigates incorrectly)
3.	Game graphics	Cartoons (The use of cartoon graphics of the main game character and the background images)	Photographs (The use of real photos in the game background)
4.	Colour used	Bright colours (The use of bright colours for the main character and gameplay background)	Dark colours (The use of dark colours for the main character and gameplay background)
5.	Game character	Human with real scenarios (Human used as the main character in a realistic scenario of a lost astronaut in space)	Animal in fantasy scenarios (Animal used as the main character in a fantasy scenario of a lost hippo in space)
6.	Number of players	Player interaction (Multiple player social interaction using a chat room facility during gameplay)	Single player (No social interactive facility within the gaming environment)
7.	Storyline	Include a definite storyline (A pre-defined storyline or narrative of the lost astronaut in space included in the gaming facility)	No storyline (No storyline or narrative of the gameplay included in the gaming facility)

The framework proposed by Aleven et al. (2010) was used to confirm the educational effectiveness of the *Google Blockly maze game* which was customised to develop the two prototypes. This framework was chosen because it could be used to analyse the learning objectives of the games, the instructional principles and game mechanics, design and aesthetics (MDA). The MDA component, which is also a framework in its own right (Hunicke, LeBlanc and Zubek, 2004) provided the taxonomy for the game mechanics and aesthetics.

The selected key game representations i.e., the game materials as components of the mechanics were used to improve the aesthetics elements of the game e.g., fantasy, narrative, challenge, discovery, expression and submission. These in the player perspective is the "fun" associated with the games. Other game mechanics components such as game rules, play levels etc. did not change for either game as the focus was the game representations and their influence on player appeal.

Whilst in both games, the game aesthetics were near-enough identical, the game representations included variations of similar characteristics. For example, *The Lost Astronaut* included an age-appropriate main character of a human in a realistic scenario (space). In contrast, *The Lost Hippo* included an age-inappropriate main character *(The Hippo)* in an unrealistic scenario (space). Other variations between both games such as including a social interactive facility, a pre-defined storyline, violence etc. are further described in table 1.0.

Figure 3 illustrates the customised experimental games (a) *The Lost Astronaut* and (b) *The Lost Hippo.*

(a) *The Lost Astronaut* **(b)** *The Lost Hippo*

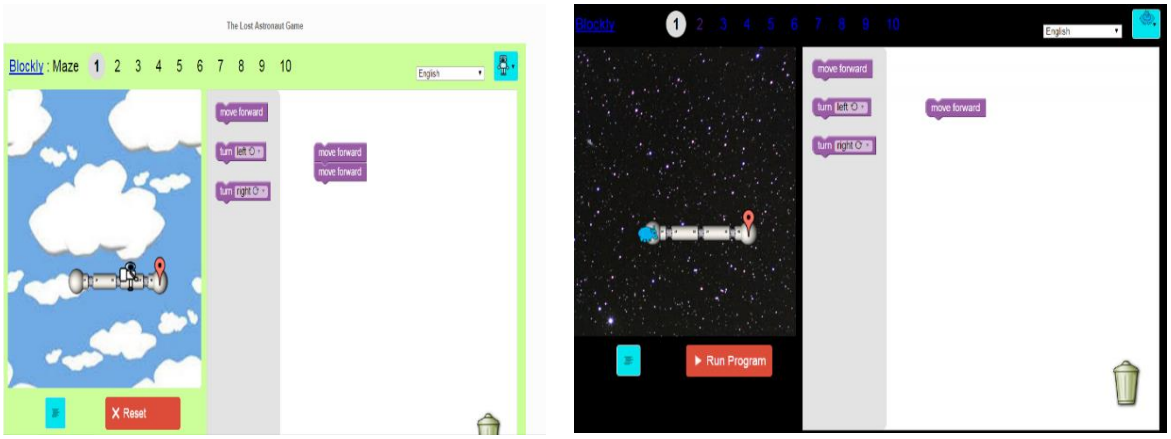

Figure 3: Example screenshots from the customised experimental games

To ensure that the findings from the experiment were valid, a threat analysis was conducted to establish the cause–effect relationships during the study, and actions were taken to minimise or eliminate the effect of confounding variables, which can bias the outcome of a study. Both internal and external threats were considered. Three internal validity threats including history, maturity and mortality had the potential to significantly impact the result of the study. The actions taken to eliminate or minimise the impact of these threats included conducting the experiment in a familiar environment to the participants (history), the session was a similar duration as lessons to ensure participants were not bored or tired (maturity). In addition, the comparative number of participating girls and boys at the start of the experiment were similar such that dropout of participants should not significantly threaten the validity of the experiment (mortality).

Irrespective of the internal validity threat elimination or minimisation, there are possibilities of the impact of confounding factors mistaken for the effect of experimental variables (selection interaction effects). An Example of this includes previous experiences of e-learning games for learning computer science concepts by participants. This can influence study outcomes favourably or otherwise. Providing measures to control internal threats such as history, maturity and mortality further minimises the impact of selection interaction effects.

The external validity threats of the study were minimised or eliminated during the study as the sample population of the study represented a real-world population. The ecological validity ensured the same study was conducted in five different locations with the same age groups and both genders.

The main study conducted across five different locations in Southeast England, United Kingdom comprised of three single sex schools (one girl only and two boys only) and two mixed gender schools. The data collected on the boys' interaction with the experimental games were used for comparative analysis with the results obtained from the girls.

3.2 Main Study - Data Analysis Technique

The analysis of the pre-study questionnaire data was designed to provide a better understanding of the perception of e-learning games by the target group before engaging with the experimental games designed for the study. The analysis of data collected using the pre-study questionnaire involved the use of qualitative analytical methods such as content analysis of participant responses by gender to establish a correlation with experimental games results.

Both qualitative and quantitative analyses were carried out on the data captured from the post-study questionnaires. The qualitative analysis also involved content analysis and the use of graphical representations to identify the trends in the data captured. The purpose of the qualitative analysis was to identify the game characteristics and the game that appealed more to the girls. It should also identify the reasons for the appeal of the game. The quantitative analysis involved the use of statistical tests to confirm the statistical significance of the qualitative findings and its generalisation to a wider context of the sample population. The results of these analyses are required to provide the empirical evidence of the impact on the girls.

For the qualitative analysis of data captured using the pre and post-study questionnaires, the requirement for suitable application software involved the computation of data captured from participants and its visual representations. Microsoft Excel and the Statistical Package for Social Scientists (SPSS) were used for the analysis of data.

4. Results and Discussions

4.1 Comparative Analysis of *The Lost Astronaut* and *The Lost Hippo* games

Based on the responses of participants, the ranking of the game representations as used in table 1.0 in each of the experimental games were analysed using the *Friedman mean rank* to obtain a statistical ranking to enable us identify differences by gender, the motivation to play the game. The ranking of the representations by gender for both games are shown in tables 2 and 3 respectively.

Table 2: Statistical ranking of game representations investigated in the study as used in The Lost Astronaut by gender

No	Game representation	Friedman statistical ranking of *The Lost Astronaut* representations (Female)	Friedman mean rank of *The Lost Astronaut* representations (Male)
1.	Number of players	1	4
2.	Colour used	2	1
3.	Game graphics	3	3
4.	Game character	4	5
5.	Age-appropriateness	6	2
6.	Storyline	5	6
7.	Game violence	7	7

From the statistical ranking of the characteristics used in *The Lost Astronaut*, the interactive feature, colour used, and the game graphics were the top three in the rankings for the girls. For the boys, the colour used, age appropriateness of the game and game graphics were the top three representations ranked. The bottom ranks for both genders were game violence. Violence was absent in this experimental game and as a result, being the least rank was understandable for both genders as it was absent.

A similar analysis of the data captured for *The Lost Hippo* game is illustrated in table 3.

Table 3: Statistical ranking of game characteristics investigated in the study as used in The Lost Hippo by gender

No	Game representation	Friedman statistical ranking of *The Lost Hippo* representations (Female)	Friedman mean rank of *The Lost Hippo* representations (Male)
1.	Age appropriateness	1	4
2.	Colour used	2	1
3.	Game character	3	3
4.	Game graphics	4	2
5.	Number of players	5	5
6.	Game violence	6	6
7.	Storyline	7	7

The statistical ranking of *The Lost Hippo* indicated that the top three game characteristics for the girls were age appropriateness, colour used and game character. For the boys, it was the colour used, game graphics and character. Both genders had the number of players, game violence, and the storyline as the lowest ranked. There were no storylines and interactive facility (number of players) for this game; hence, the lowest ranking could be explained. However, for the game violence, it was either a case of the violence not appealing to the

girls because it was included and maybe too mild for the boys, hence it didn't appeal to either group. It is important to also note from the result of the analysis that whilst some of the game representations were equally or almost equally ranked, there were differences in the variations of the representations and how they may appeal to both genders. For example, colour used, appeared to be significant to both genders. However, bright colours appear to appeal to the girls, while dark colours to the boys.

4.1.1 The appeal of The Lost Astronaut and The Lost Hippo

The appeal of The Lost Astronaut game to the girls from all three locations (Locations 1 & 2 mixed gender; Location 3 single gender) is illustrated in figure 4. This data was extracted from the response to the 7-point likert-scale question – "How much do you like the game The Lost Astronaut?" in The Lost Astronaut post-study questionnaire. Cumulatively, across the three locations, an average of 28% of the girls liked the game very much as compared to 2% that disliked the game very much.

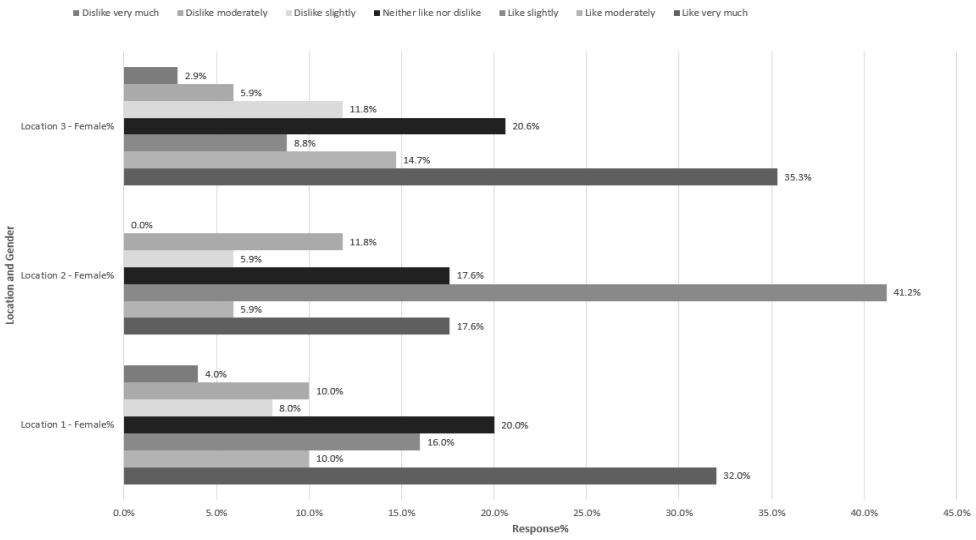

Figure 4: The appeal of The Lost Astronaut game to the girls by location

A comparative analysis of the boys' data indicated that most boys disliked this game *very much* or *moderately* (see figure 5.0). Cumulatively, across the four locations for the boys, an average of 9% of the boys indicated that they *liked* this game *very much*, compared to 45% that *disliked* this game *very much*. Generally, the boys from the mixed gender schools (Locations 1 & 2) appear to dislike the game more than the boys from the single gender schools (Locations 3 & 4). A possible reason for this trend could be the impact of *"gender role socialization"* in the mixed gender school. The analysis of data by gender suggested that *"The Lost Astronaut"* appealed more to the girls than the boys (average value of 28% girls as compared to 9% boys).

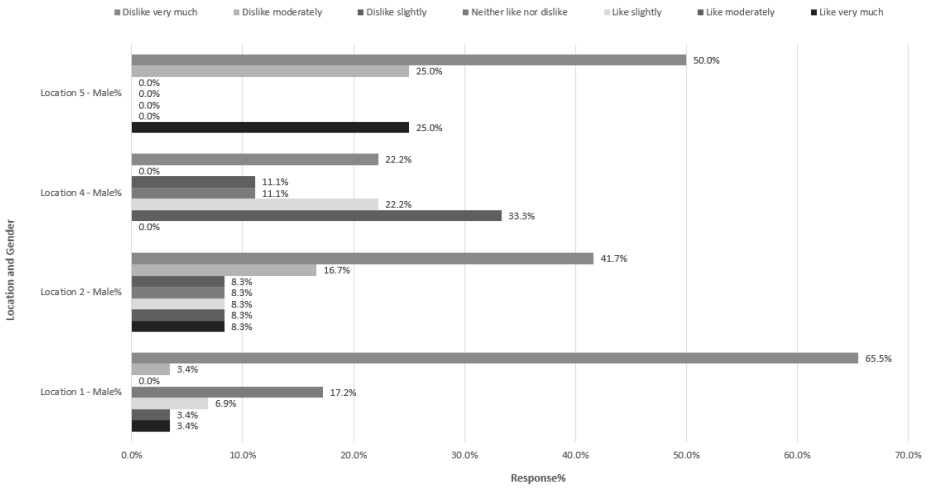

Figure 5: The appeal of The Lost Astronaut game to the boys by location

A similar analysis for *"The Lost Hippo"* game was also carried out by gender for all locations of the study. Figure 6 illustrates the analysis by location for the girls. It indicated that this game was not as appealing as *"The Lost Astronaut"* game to the girls. This is evidenced by the fact that the average *dislike* for all three locations was 31% as compared to 5% *liking it very much*. The girls in the single gender school (Location 3) appeared to *dislike* (43.3%) this game *very much* more than the girls from the mixed gender schools-locations 1 and 2 (25.0% and 25.6% respectively).

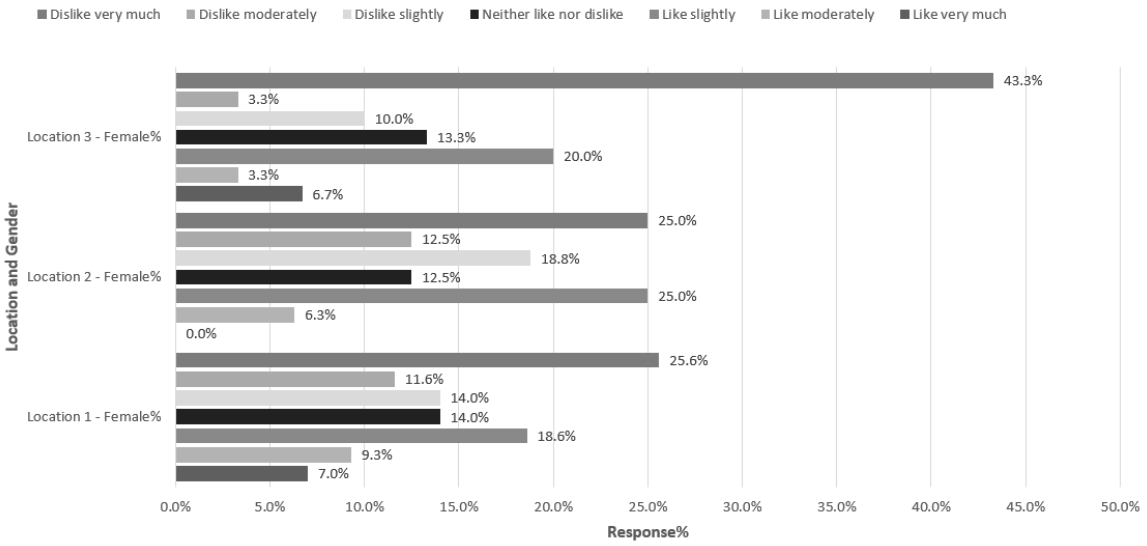

Figure 6: The appeal of The Lost Hippo game to the girls by location

A similar analysis by location for the boys as illustrated in figure 7 suggested that cumulative average for *like very much* was 32% for *"The Lost Hippo"* game as compared to 19% disliking *it very much*. The boys from the single gender school (66.7%) *liked* this game *very much* more than the boys from the mixed gender schools - locations 1 and 2 (45.8% and 10.0% respectively). The boys from the single gender school also appeared to be very clear on how they perceived this game. The analysis by gender for *"The Lost Hippo"* game suggested that it appealed more to the boys than the girls.

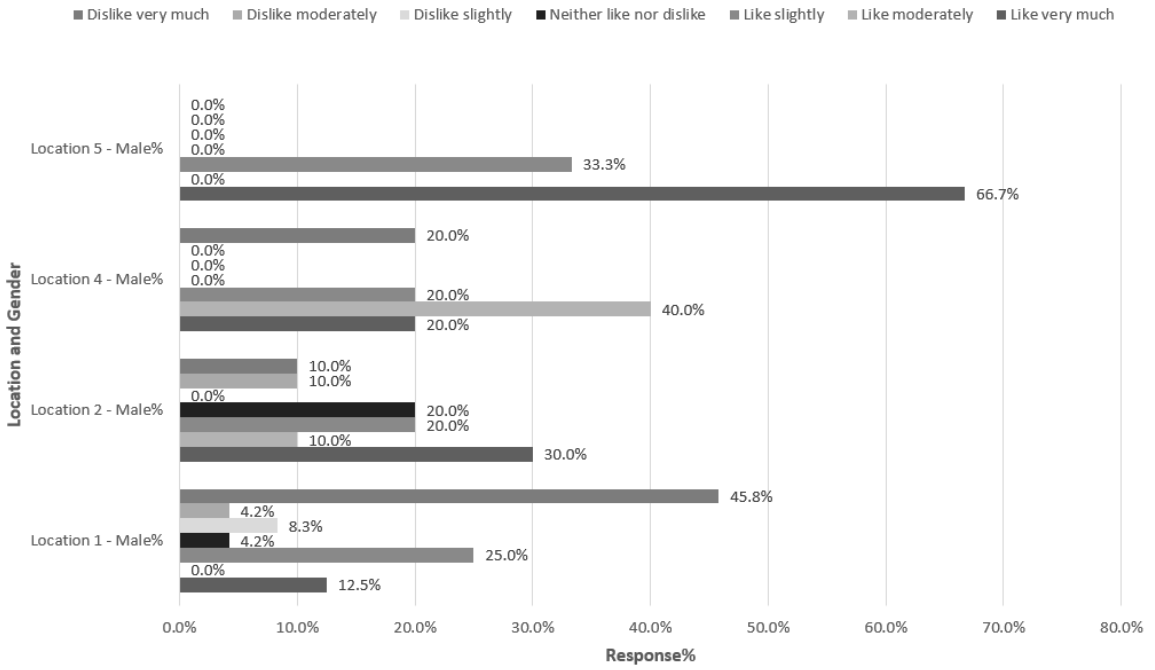

Figure 7: The appeal of The Lost Hippo game to the boys by location

An insight into the comparative appeal of both games to participating girls and boys was also gained from the analysis of data captured using the post-study evaluative questionnaire. The question used to capture the data was *"Which of the games (The Lost Astronaut or The Lost Hippo) do you like the most"?* This analysis investigated if there were any significant differences in the appeal of the games, considering that they included variants of the selected significant game representations obtained from the exploratory study. The result is illustrated in figure 8, which indicated that the girls found *The Lost Astronaut* (68%) more appealing in comparison to *The Lost Hippo* game (44%). In contrast, the boys found *The Lost Hippo* (56%) more appealing than *The Lost Astronaut* (32%).

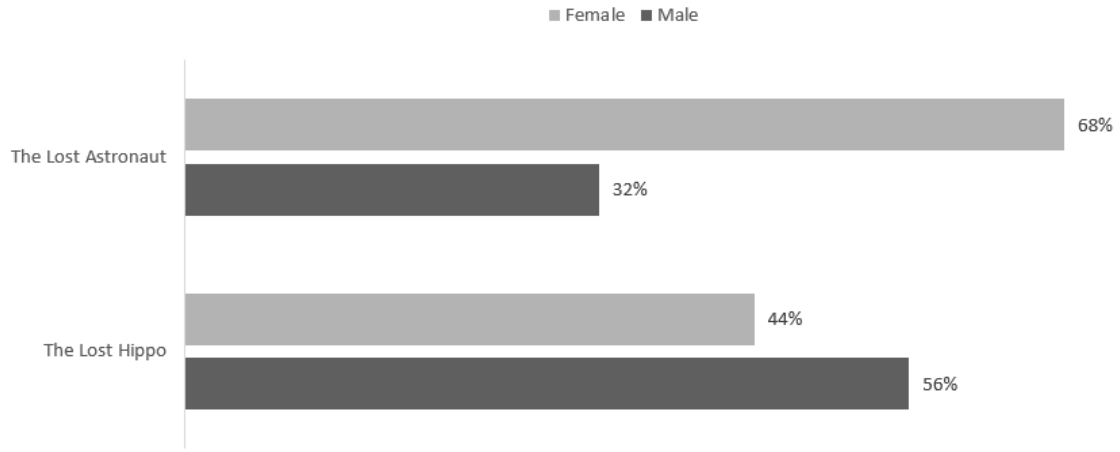

Figure 8: Comparative appeal of The Lost Astronaut and The Lost Hippo to participating girls and boys

To examine this result quantitatively in the context of the sampled population, a statistical analysis was carried out. A procedure to determine the normality of the distribution of the data was required to generalise the result. A normality test, described below, was completed to confirm the distribution of the data within the sampled population.

The test indicated that the data were not consistently normally distributed, by comparing the results provided from all three component outputs of -the *Kurtotic check* test (Doane and Seward, 2011), *Box plot* and the *Shapiro-Wilk test* (Razali and Wah, 2011).

The assumption that the data captured for analysis was not normally distributed was therefore made. Hence, parametric analytical tools were not used for the quantitative analysis, but rather non-parametric measures such as the *Mann-Whitney test*, which can measure the difference between two independent samples (*The Lost Astronaut* and *The Lost Hippo*) with ordinal data, was considered and used.

The *Mann-Whitney* test was used to test the significance of the difference in the appeal of the game that appealed more to the girls in comparison with the boys. On average, the appeal for *The Lost Astronaut* game for the girl participants (*Mean rank =64.10, n=80*) significantly exceeds those of the boy participants (*Mean Rank =76.95, n= 58), U=1888.000, z= -2.154, p=0.031 two tailed*. The null hypothesis for the test statistics is that there is no significant difference in the appeal as indicated by participating girls and boys for the game if *p>0.05*. The null hypothesis is rejected here as *p = 0.031*, hence there is a significant difference in the appeal of the games as indicated by participating girls and boys groups.

From this test, there is evidence that the difference in appeal is *statistically significant.* This has to be set against the fact that the differences between both games used in the study were only that the game representations were altered between both games - *The Lost Astronaut* and *The Lost Hippo.* This provides clear evidence that there are differences in the games that appeal to girls and boys.

It also confirms earlier findings from the exploratory study (Osunde et al., 2015) and related investigations (Poels et al., 2012; Melzer and Engelberg, 2016) that suggest that there are gendered characteristics in game representations. This study however extends the body of knowledge by providing empirical evidence that there are variants of game representations and different game representations that can improve the appeal of e-learning games. In the context of this study, educational games for learning computer science concepts for girls of age 11-14.

4.1.2 *The influence of the preferred game on the perception of educational games for learning computer science*

The influence of the *preferred game* on the perception of the participants was also investigated in the analysis of data collected during the survey. The data was captured based on the 4-point Likert –question, *"How much has your preferred game influenced how you feel about educational computer games for learning computer science?"* The result is presented in figure 9 with, 48% of girls indicating that the *preferred game* influenced their perception of educational games for learning computer science *a lot*. Cumulatively, *The Lost Astronaut* game appeared to influence the perception of 75% of the girls as compared to 25% who indicated that the influence was *not a lot.*

Similarly, the *preferred game* for the boys – *The Lost Hippo* influenced their perception 30% (*A lot*), 30% (*Some*), 18% (*Little*). Cumulatively, 78% of the boys' perception appeared to be influenced compared to 21% who indicated that the influence was *not a lot*. Based on the qualitative analysis, conclusively the preferred game appeared to influence the perception of 75% of the girls and 78% of the boys.

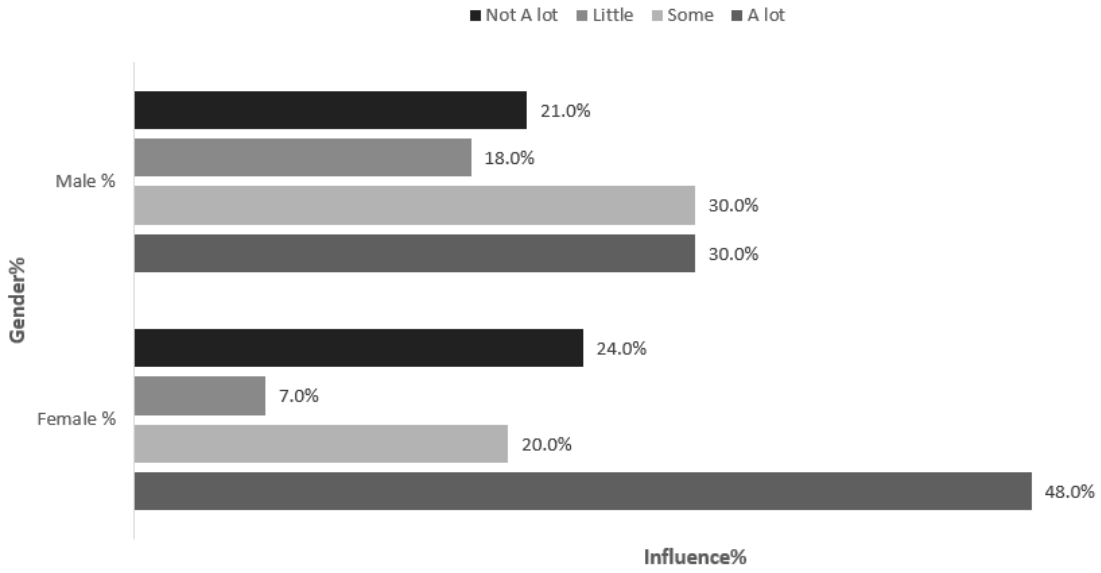

Figure 9: The influence of the preferred game on perception of educational games for learning computer science concepts

To confirm the statistical significance of the responses from the girls and boys, on the influence of the preferred game on their perception of educational games for learning, the *Mann-Whitney U test* was carried out on the analysed data from both games. On average, the influence of *The Lost Astronaut* with the girls, *(Mean rank =35.32, n=53)* significantly exceeds *The Lost Hippo (Mean rank =50.67, n=27), U=441.000, z= -2.897, p=0.*004 two tailed. The *Mann-Whitney U test* result conducted for the boys' population also indicated that on average, the influence of *The Lost Hippo* with the boys*, (Mean rank =23.91, n=34)* significantly exceeds *The Lost Astronaut (Mean rank =37.42, n=24), U=218.000, z= -3.164, p=0.002* two tailed.

For both genders, e-learning games that are preferred due to the inclusion of game representations that appeal to the target audience can significantly influence their perception of educational games for learning computer science programming concepts. Considering that the gameplay of both experimental games were identical with only the representations varied, it can be concluded from the analysis that the motivationally appealing game (preferred game) does support learning programming concepts and influences positively the perception of the subject to girls of age 11-14. This understanding, based on the study outcome, is that educational games which appeal to learners, supports learning and this is reinforced by Huang, Johnson and Han (2013) and Boyle et al. (2016).

This study has provided empirical evidence in support of the understanding that game representations that appeal to a specified group can be used to create learning games that appeal to that group. In the instance of this study, girls of age 11-14 in the context of learning computer science concepts. The study further provided evidence that e-learning games that appeal to a specified age group can also support their learning.

5. Conclusion

This research set out to answer the question – "Can we develop e-learning games which appeal and motivate girls of age 11-14 to study computer science concepts?"

An exploratory study was carried out to identify some key game representations that make some successful digital entertainment games appealing to this age group of girls. Based on the results of this exploratory study two experimental games (The Lost Astronaut and The Lost Hippo) were designed, one to be appealing to girls in the 11-14 age group and the other being an antithetical design. Both games were adapted from an existing e-learning game for learning basic computer science concepts – The Google Blockly maze game. Once these games had been developed, a main study was carried out comparing the reaction to both games and their impact on the perception of e-learning games for learning computer science concepts, with participants across five study locations.

The comparative analysis of the data captured from the interaction of participants with the games in the main study showed that, whilst the participating girls found The Lost Astronaut more appealing, the boys found the antithetical game The Lost Hippo more appealing.

Subjecting this insight to statistical analysis both validated the outputs of the exploratory study (Osunde et al., 2015) and confirms existing research (Poels et al., 2012; Melzer and Engelberg, 2016, Naranjo-Bock, 2023) that there are differences in the game representations that appeal to girls and boys in e-learning games. This study further provides the evidence to show that the motivational appeal is because of the variation of game representations, which could be similar or different between both genders. This motivational appeal was also shown to impact positively on the perception of the subject by both genders.

Whilst the study was predominantly concerned with the motivational influence on the perception of learning games for 11-14 year old girls, the evidence shows that the effect on the boys in the same age group was also significant, reflecting gendered variations of the game representations.

This study provides empirical evidence, until now missing from the literature, which shows that e-learning games which are motivationally appealing to girls in the age group 11-14 can be developed and can have a significant positive influence on their perception of computer science learning games, and hence their willingness to learn computer science concepts. The wider implication of this study is that the design and creation of e-learning games, which are inclusively motivationally appealing, could be used to effectively influence the perception of subjects that are identified as not motivationally appealing to a target group. Whilst previous studies (Esper et al., 2013; Zaidi et al., 2017) have suggested the use of e-learning games to encourage more girls into computer science, this study provides the empirical evidence on how this can be successfully implemented.

Future work will comprise of a longitudinal study to investigate the impact of significant e-learning game representations that appeal to girls of age 11-14. This study can provide empirical evidence of possible changes in appeal and motivation over time due to the influence of other factors such as socio-economic and social -cultural factors.

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Experience Report: EXaHM – Application Oriented, Digital EXamination System at Hochschule München

Hanna Kubrak[2], Mareike Ehlers[1], Kristina Piecha[1], Thomas Walcher[1], Georg Braun[1] and Philipp Prade[1]

[1]Munich University of Applied Sciences, Germany
[2]University of the Bundeswehr Munich, Germany

hanna.kubrak@unibw.de
mareike.ehlers@hm.edu
kristina.piecha@hm.edu
thomas.walcher@hm.edu
georg.braun@hm.edu
philipp.prade@hm.edu

Abstract: The COVID-19 pandemic put academic institutions around the world in the difficult position of suddenly having to organize many lectures and examinations over online channels only, due to students' physical access to their campus buildings being restricted. While the search for possible solutions to this problem was often challenging, this situation also offered the unique opportunity to establish remote examination options, that might hold the potential to be continued even after the pandemic has hopefully ended. This report looks at how the Munich University of Applied Sciences (MUAS), one of the biggest universities of applied sciences in Germany, established its own solution for remote examination over the Internet. This report provides an overview of how MUAS developed its on-site competence- and application-oriented digital examination tool to work remotely during the pandemic, its general framework and experiences that were made during its inception. Included are descriptions of the technical setting of the solution, as well as some challenges that were had when implementing it and how those were resolved. As part of this research it was concluded, that support and administrative work for this kind of remote examination was much more intensive than for on-site digital examinations, but also lessened each subsequent semester. A well-organized support system makes it possible to offer remote digital examinations with good conditions regarding, for example, student equal opportunities and secure examination environments, although even now perfect conditions cannot be guaranteed. While not without its own deficiencies, MUAS new established system was lauded by many Bavarian educational facilities and is in the process of being deployed to other Bavarian universities. This paper serves to highlight a qualitative example of how e-learning approaches can be of use in the context of higher education examinations and hopefully provide ideas for others trying to establish their own similar solutions.

Keywords: Competence oriented examinations, Application oriented examinations, Digital examinations, Remote examinations, Examination during pandemic

1. Introduction

During the COVID-19 pandemic from the summer semester 2020 onwards, at the Munich University of Applied Sciences (MUAS), or Hochschule München in German, on-site examinations were prohibited for several semesters. The already existing examination framework called 'application oriented, digital Examination System at Hochschule München' (EXaHM) was expanded to be used for remote examinations. This paper describes the technical and organizational development for "Remote-EXaHM", remotely accessed EXaHM, examinations including the point of view of the EXaHM competence team, which supports the departments in the realization of their examinations, with special consideration of the support effort and the lessons learned during this period.

1.1 What is EXaHM? - Technical Setup

EXaHM is a service provided to all faculties of MUAS by the Center for Innovation in Teaching and Higher Education. The service includes advice, technical realization, and on-call duty (technical support) during the examination and storage of same. EXaHM is a computer-based examination system for application- and competence-oriented, digital examinations, which consists of three basic parts:

- A Linux-Server running the EXaHM-System software.
- PCs with EXaHM software installed in computer labs at campus, called EXaHM-PCs (EPCs).
- The EXaHM-App: WebApp used to create and manage Examinations and EPCs.

The overview of a typical on-site EXaHM examination situation is shown in Figure 1.

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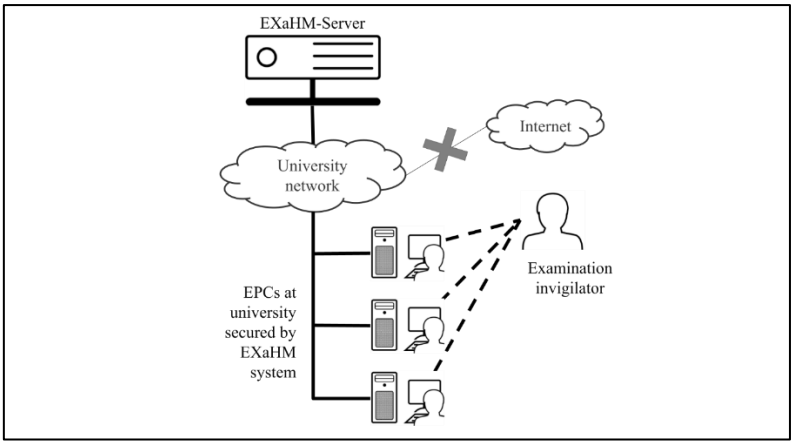

Figure 1:EXaHM Examination overview

In contrast to many other existing online examination systems, EXaHM optimizes the use of selected, locally installed applications in a protected desktop environment. With EXaHM, almost any Windows third party software (installed on the examination PC) can be individually allowed for each examination. It is also possible to use additional hardware connected to the PCs. Access to unneeded applications is blocked, as well as communication options via the Internet or to adjoining computers. However, an EXaHM examination can also have individual network configuration: Usually access to all networks is prohibited, but it is possible to allow, for example only certain server. A typical use case for this is when a certain type of license is needed, for example for “MATLAB”.

The student files are initially saved on the EPC, but are regularly backed up, versioned and automatically collected to the EXaHM server at the end of an exam. Instructors receive the students' files digitally for grading purposes, afterwards the graded student files are stored on the EXaHM server. EXaHM also allows the flexible allocation of EPCs: It is possible to start multiple examinations simultaneously in one room or across rooms. It is also possible, for example, to have two different examinations in one room at the same time or two different examinations in two rooms. Combining this with an alternating seat pattern, this can reduce cheating attempts and the amount of supervision needed. For some examinations every student sends in a project work they developed themselves, as data file to the instructor, which is then returned as their individual file to work with during the exam. This way, an instructor can effectively test whether the student is actually familiar with the previously sent in project work. Sometimes students are additionally given access to course notes or other background information.

EXaHM is also an automation framework for digital exams: All steps from booting up the computers, switching to examination mode and starting the examination, to the end of the exam and the shutting down of the computers are automated and can be controlled remotely with the help of a central server. A typical workflow of an on-site EXaHM examination is shown in Figure 2.

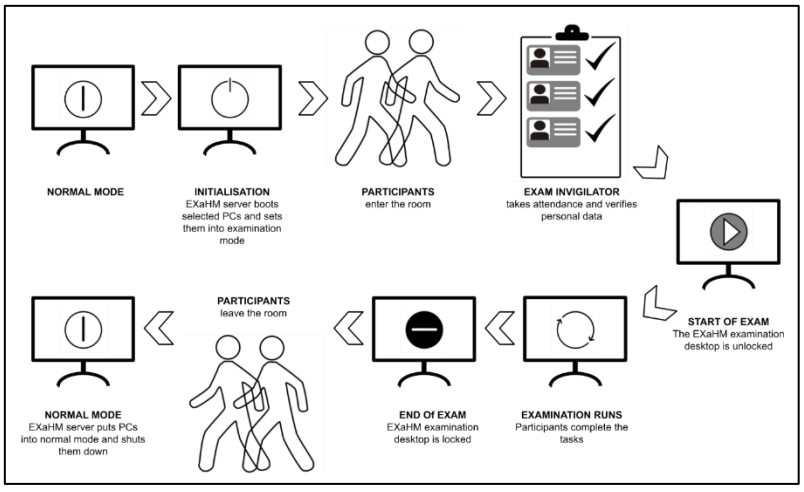

Figure 2:Workflow of an on-site EXaHM Examination

1.2 Competence- and Application-Oriented Digital Examinations

EXaHM works application-oriented, meaning that the examination can be conducted using any application installed on an EPC. Different IT solutions allow a wider range of tasks and activities, enabling instructors to assess students' skills and competences beyond simple recollection. This allows more authentic assessments, that are also aligned with the learning outcomes (University of Reading, n.d.). It is possible to use the same applications and real-life tasks, that students will later need to solve problems during their professional lives, making the examination performance-based and giving an authentic assessment (NCSSFL, n.d.). The aim is to use a computer, with given software, as a problem-solving medium for real life challenges.

2. COVID-19 and Remote-EXaHM

EXaHM has been offered at MUAS for competence and application-oriented examinations since 2018 and the number of examinations taken with EXaHM has increased every year through 2020. To make this possible, prior to the service being offered university-wide, the legal and data protection requirements for the service were clarified and enforced with the involvement of the MUAS Data Protection Officer. Also, other Bavarian universities of applied sciences had shown interest in adopting the system, and steps to facilitate this were already progressing well. These plans were disturbed in March 2020 when MUAS, like so many other educational institutes, was forced to move to emergency remote teaching. Soon it became clear that a return to “normal” teaching would not be possible before the examination period. Therefore, the examinations needed to be done remotely (Bozkurt & al et, 2020). At MUAS the following overall conditions for remote examinations were set:

- Examination must be feasible from home.
- The infrastructure must be in place, established and stable by June 2020.
- The legal requirements must be set by the Bavarian Ministry of Education.

At first, it was unclear whether or not EXaHM could be used to provide any sort of examinations at all, as students were not allowed onto campus under any circumstances. After some brainstorming, it was decided to try an approach where students use remote access, earlier reserved only for support staff, to access EPCs on campus using their own equipment and web browser at home. This way, students would be able to use software not installed and/or licensed on their own device.

This also solved the important equal opportunities' requirement for examinations, as students with better equipment (at home) would not have a considerable advantage over others, as all processing is done on EPCs at campus.

As an additional measure, it was decided upon to use a lockdown browser tool called “Safe Exam Browser” when using EXaHM. Safe Exam Browser (SEB) is a separate browser application students install on their personal computers before the exam. While running, SEB restricts access to system functions, specific websites, applications and more. After the examination, students can either just close the SEB application, in order to not have to reinstall it again for future exams, or uninstall the application altogether. The Examiner can decide which resources are permitted or prohibited (ETH Zürich, Educational Development and Technology, 2021). Figure 3 visualizes the interplay of SEB and EXaHM.

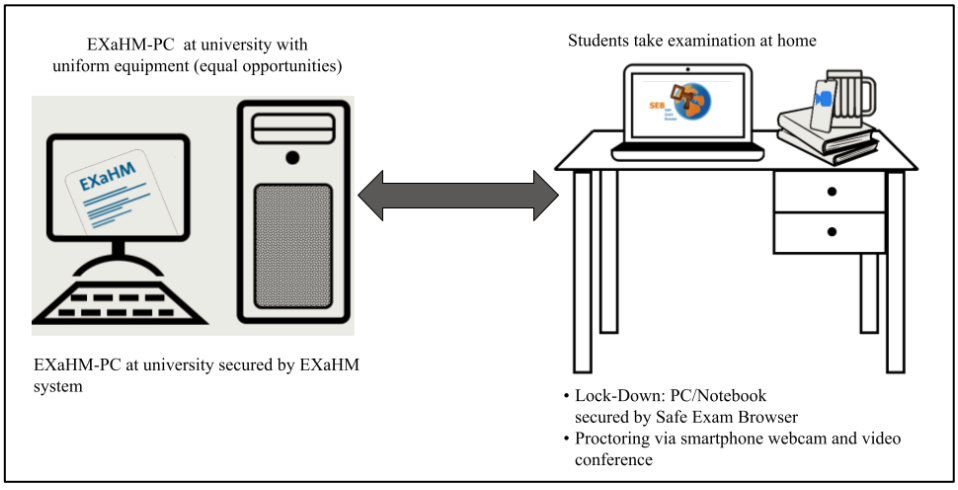

Figure 3: Remote-EXaHM setup

The legal basis for Remote-EXaHM is "The Bavarian regulation for the testing of electronic remote assessments (BayFEV)" from September 16th, 2020. This regulatory text applies to all Bavarian universities retroactively to April 20th, 2020, thus ensuring legal certainty for the examinations that were conducted as electronic remote examinations in the 2020 summer semester during the Corona pandemic. This law is meant to be tested and reevaluated over the next four years regardless of the pandemic situation. BayFEV states that at Bavarian higher education institutions electronic remote assessments can be offered, under firm legal guidelines, in the form of proctored examinations, conducted in a specified time slot using electronic communication technology and video supervision.

3. Organizational Challenges

The first task for the Center for Innovation in Teaching and Higher Education, after committing to this approach, was to define the minimum requirements for the IT equipment of the examinees. This was:

- A PC/notebook with Safe Exam Browser installed (Windows 10 or MacOS, as there is no Linux version of the SEB) and VPN access to the "Münchner Wissenschaftsnetz" with the VPN service of the Leibniz Supercomputing Centre (Leibniz-Rechenzentrum, LRZ).
- A smartphone (or other secondary device capable of videoconferencing) with the "Zoom" app.
- A stable internet connection on both devices.

On the technical side, the following modifications of the EXaHM system were needed:

- Increase in server capacity for remote connections.
- Secure gateway for the internet connection of the EXaHM servers.
- Automated, individualized, and secure connection between the participant (at home) and the EPC at the university (particularly for the creation and protection of access URLs).

In the first test run with students, it was noticed that, in our setting, SEB did not work well on Apple devices (Local Mac device/keyboard connected to a remote Windows desktop screen). Therefore, it was decided to limit access to Windows devices only. Students who do not own a Windows device were encouraged to borrow a device from friends/relatives or from their department or faculty.

During this process the guiding principle has been to ensure equal opportunities for all examinees, and at the same time, ensure as secure an examination environment as possible. Regarding both these issues, it was acknowledged that it would not be possible to achieve completely satisfactory results or avoid all critique. Some issues considered are:

- Some students have bigger or more displays than others. This was solved with a limitation of the resolution of the remote access. It was restricted to full HD (1920x1080). SEB can be configured in such a way that it allows only one (browser) window with a given size to be opened. A student with a bigger display does not have more working space than a student with a smaller display.
- There are methods to "cheat" the Safe Exam Browser. That is the reason the examinations are proctored with a second camera. It is placed so that proctors have a view of the examinees monitor. This way, though the text an examinee is writing cannot be seen, it is observable whether he/she is working in the EXaHM environment.
- Because of Data Protection concerns proctoring and support is done only in person by university personnel.
- Due to server capacities and functionalities in Zoom, the number of participants is limited to approx. 50 (2x25) participants per examination run. In big examinations with more than 25 students, breakout rooms are being used and have one proctor and one support in each room.
- According to BayFEV, students must have the opportunity to familiarize themselves with the examination setup. This is being offered in the form of a mock exam.
- As not all problems were solvable (e.g. unstable or poor internet connection, no Windows device) it was decided to give those students the possibility to write their examination at the campus under strict hygiene rules (this offer was used very little) or postpone their examination without any consequences. This only affected three students.

3.1 Examination Administration

For administrative work, a Moodle course was created for each individual exam. All examinees were required to register to the respective courses prior to examination. In these courses, examinees were given the following information:

- Technical and other requirements for taking part in the remote examination.
- Date and time of their examination, Zoom meeting information.
- Detailed instructions on how to prepare their PC and Smartphone for the exam (installation of SEB, VPN and Zoom, creating a VPN connection, and joining the Zoom-conference via Single sign-on).
- Test-Link for the SEB with detailed video instruction guides to find out whether the SEB is working.

All examinees also had to read a disclaimer, declare their voluntary willingness and consent to data processing before they were shown their individual link to start the examination. The student's point of view on the Moodle Course is shown in figure 4.

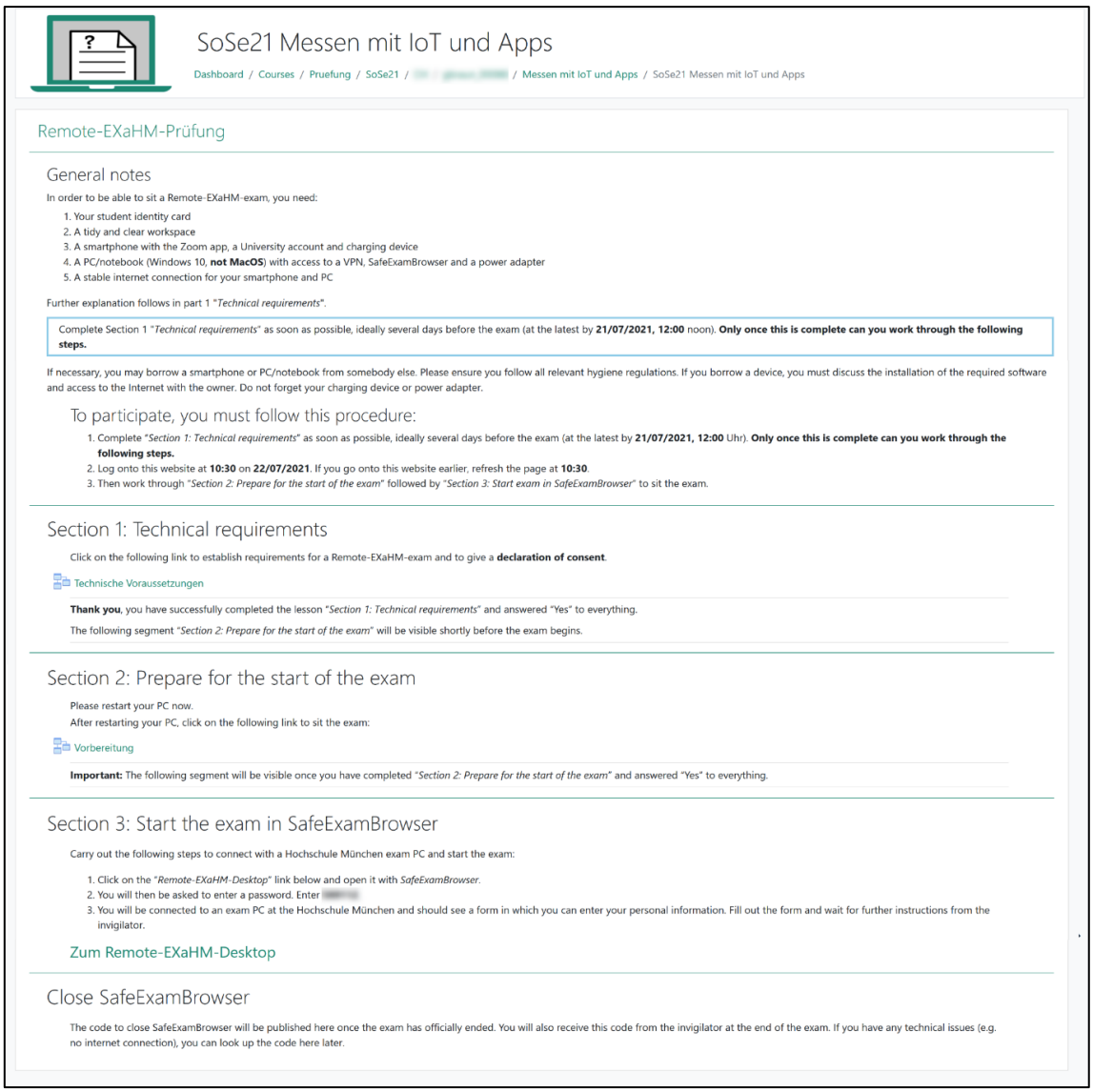

Figure 4:Example of a Moodle Course used for administrative work

3.1.1 Workflow of a Remote-EXaHM:

- A member of the support team starts the exam via EXaHM server.
- The last part of the Moodle course is unlocked. Here students find the Zoom meeting ID, password, and code for starting the SEB.
- At the starting time of the examination, an SEB-link in the Moodle course is unlocked. This link automatically starts the Safe Exam Browser and opens a remote connection to an EPC on campus.

- Students land directly at the EXaHM start-window and can fill in their personal information.
- The EXaHM starter-code is announced via Zoom meeting. Then, the examination proceeds exactly as an EXaHM examination at the campus.

As an additional security measure, SEB-configuration files used in the exam are uploaded to EXaHM server only for the duration of the examination and removed afterwards.

4. An Example of Remote-EXaHM

The module "Measuring with IoT and Apps" of the bachelor's degree programs Mechatronics and Technical Physics was assessed with Remote-EXaHM in the winter semester of 2020/2021. The module had the following learning objectives:

- Students learn how to gather, store, and evaluate measurement data in the context of the Internet of Things (IoT).
- Students learn the Python programming language with open-source frameworks.
- Furthermore, students are introduced to basic network concepts.

A total of 37 examinees took part, supervised via two "breakout rooms" per Zoom. To test whether the sought-after competencies were achieved, the examination was designed to contain the following components:

- A HTML viewer for the assignment and lecture notes (which were permitted to be used).
- A Local IoT development environment with VSCode as Python IDE and a local MQTT (Message Queueing Telemetry Transport) server with a MQTT explorer.

A Text editor for answering questions about the basics of network technology.

Figure 5 shows the lock screen for EXaHM and the EXaHM desktop in use, as they were encountered and used by students taking the exam.

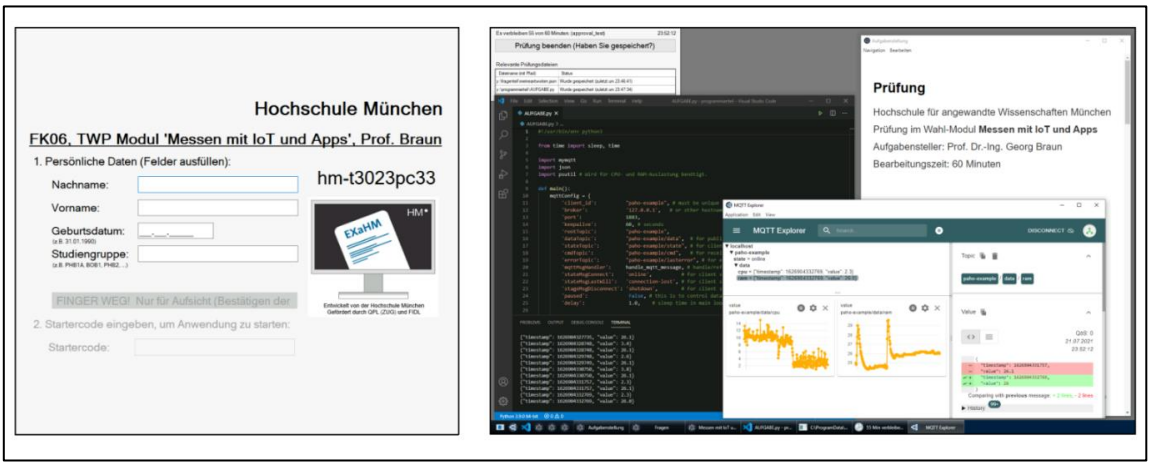

Figure 5:EXaHM lock screen and EXaHM-Desktop with third-party applications

The great benefit of this kind of examination, when compared to so-called pen and paper examinations, is that not only is it possible to test the student's ability to use the applications they will later need in their professional lives, but also assessment can be conducted with those same applications. Thus, the practical knowledge of the chosen software can be tested with authentic real-life assignments and conditions.

5. Lessons Learned and Perspective

5.1 Lessons Learned by the Support Team

The commitment to offer a mock exam on the grounds of the BayFEV showed to have distinct benefits. Remote exams offer both students and examiners the chance to become acquainted with the new situation. In every mock session, support staff were present, so that bigger technical problems could be resolved beforehand. Every student was also advised on what were the best positions and angles for their cameras beforehand. This way, students were less stressed and the time it took to begin the actual examination was shorter. In three terms, only one of the approximately 600 students taking the remote exams was not able to complete the examination

due to technical difficulties. Even learning about how many students could realistically be supervised by one proctor in one Zoom conference (the number differs depending on what kind of exam is being run) is considered useful information.

The support during Remote-EXaHM has been much more intensive than on-site. However, a deeper understanding of the students' problems was gained and the workflow, e.g. the Moodle courses were improved upon. One of the big improvements to the Moodle courses was a test-link students could use to test their SEB-installation on their own before the mock exam. This drastically reduced the support work during the mock exams.

As the students became used to Remote-EXaHM in the three terms, the number of exam takers for mock exams decreased in comparison to that for real exams, because the students have become accustomed to the setup. At the moment, it is considered dropping the individual mock exam before every examination and offering general technical framework mocks instead.

Other lessons learned included: During the first two semesters, each EPC had its own SEB configuration file with a unique "start URL" address for remote connections. This was necessary because in the Moodle course each student had to be assigned to a specific EPC. This was done via Moodle's group assignments. Each group corresponded to an EPC, so only one student was assigned to each group. However, this approach was very time-consuming as it required a lot of manual work (manually creating hundreds of configuration files and preparing each Moodle course so that each student could only see one link), so for the third semester this was changed.

Currently only one SEB configuration file is used for each examination and students are assigned to EPCs via a remote desktop gateway.

5.2 Perspective Plans for the Near Future

In the near future, the work that was postponed due to the Corona-pandemic will be continued. There are many PC-Pools at MUAS that would be a benefit if tied to the EXaHM framework. The cooperation with other Bavarian Universities of applied sciences is planned to be continued and expanded upon. MUAS has the leading role in a project called "digitales kompetenzorientiertes Prüfen implementieren", or ii.oo for short (Hochschule für angewandte Wissenschaften München, 2023), a joint project with eight other Bavarian universities of applied sciences with the aim of developing good practices for digital competence-oriented examinations. In this project, the plan is to expand the research on didactic methods and the implementation of digital face-to-face and online exams, as well as the integration of experiences gained during the Corona semesters. A technical implementation of the software should ensure compatibility with campus management systems, as well as a cloud solution that universities can utilize jointly. The ii.oo project started in August of 2021 and will continue until July 2024. The final goal, as of now, is to develop the EXaHM platform in a way that decreases the workload on the support team while the number of examinations per semester grows.

With the current progression of the Bavarian-wide implementation, there are good chances, that the remote-EXaHM system will serve as a prominent solution for remote digital exams for years to come.

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Leadership in Online Education: A Scoping Review

Ammara Awais
Bayes Business School, City University of London, UK
The University of Lahore, Pakistan

Ammara.Awais@bayes.city.ac.uk
ammara.awais@uol.edu.pk

Abstract: Over the last two decades, we have witnessed a growing interest in online learning. There is an increased focus on online education research due to the COVID-19 pandemic, as the crisis led to online education platforms becoming a necessity for educationists and students. This article reviews online education, purely, in the context of leadership. Past reviews have focused on concepts surrounding online learning such as technology, pedagogy, and student satisfaction. However, limited attention has been drawn to leadership exclusively in relevance to online education. The scoping review analyses 63 articles published between 2002-2022 to answer two research questions. First, what are the research concepts, theories, models, and frameworks operationalized in the publications within this topic domain? Second, who are the stakeholders and leaders identified in literature? Through synthesizing alternative research perspectives in the field of leadership, education, and information and communication technology (ICT), this review identifies four categories of research literature relevant to the topic domain. Following themes emerged from the analysis of the publications: impact of leadership on online education; student experience in an online leadership programme; impact of online education on leadership development of actors in an online education setting; and perception of leadership in an online education setting. Based on the review, an agenda is proposed for future research to enhance our understanding of the role of leadership in online education and elucidate the relationship between leaders and online learning in educational institutions. A lack of focus on the key leaders in the existing literature is made apparent, and further empirical research is recommended. This review makes a theoretical contribution by consolidating existing research in leadership in online education through the synthesis categories and identifying future research pathways. The findings have practical implications for leadership in online education in educational organizations through identification of stakeholders and the entities in leadership positions.

Keywords: Leadership, Online learning, Scoping review, Educational leaders, Digitized education

1. Introduction

> *'Education is a prime target for disruption given advances in computer technology, communications platforms, and the internet, which are not currently in widespread use for baseline programs but are becoming more common by existing universities' (Friga, Bettis, and Sullivan, 2003).*

Circa start of this century, Friga et al. (2003), in their discussion of the strategic options for business schools, stated the circumstances in which technology was permeating education: as an option for innovation, and not a desperate requirement for educational institutions. Departing from the above statement, in the post-COVID era, and in a world of disruption, division and displacement (Creed et al., 2022), we find online education democratizing access to education (Razmerita et al., 2020). It is becoming a necessity for schools, colleges, and universities across the globe in times of crises, as was evident during the pandemic in the shift of emergency remote teaching in educational institutions (Crick et al., 2021). Online education has been defined as the "use of network technologies for collaborative learning" (Harasim, 2000; p 41) and curriculum delivery through online learning platforms (Singh, 2019).

Effective implementation of technology driven learning innovations entails a discussion of the leadership associated with institutional change (Garrison and Vaughan, 2013). Graham, Woodfield, and Harrison (2013) presented through their framework for adoption of blended learning, the 3S (strategy, structure, and support) indicating the relevance of leadership and its role in technology-based innovations in education. However, as Martin, Sun, and Westine (2020) pointed out, scarce attention has been given to leadership in the context of online education. A scoping review of the literature on leadership and online education is warranted for two reasons. First, to explore how leadership and online learning, as individual concepts, interact with each other in research. The paper aims to provide scholars with a deeper understanding of the current state of literature through consolidating ideas generated in published research in both these research areas. Second, to identify the stakeholders, leaders, and decision makers in adoption and implementation of online education in higher educational organizations. Ligon, Hunter, and Mumford (2008) differentiated between leaders and people as "their abilities to move beyond description of current system operations to prescriptions of a system as it could be" (p 314). This comment raises a few questions relevant to the topic domain. Who plans for online education

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based on the contingencies in the organization? Who are the expert leaders (Goodall, 2010) responsible for its successful implementation?

This review allows us to gain an insight into the topic domain of leadership in online education through critical analysis and synthesis of research conducted in the past twenty years. The paper also identifies knowledge gaps to guide future research. E-leadership as a concept has initiated discourse on virtual leadership; however, it needs to be explored further in an online education context. There has been no prior attempt to conduct a scoping review on the topic of "leadership in online education". Reviews conducted exclusively on leadership (Avolio, Walumbwa, and Weber, 2009) or online learning and teaching, e-learning and distance learning (Alem et al., 2014; Martin et al., 2020; Nortvig, Petersen, and Balle, 2018) cover a broad spectrum of research and do not holistically serve our purpose of closely examining the relationship between the two concepts. This paper examines how research conducted in leadership in online education stems from various disciplines, and refers to concepts, theories, models, and frameworks from research areas which include leadership, education and ICT. This study makes an important contribution by identifying how online education and leadership interact, the stakeholders involved and by defining coding parameters for the synthesis of the literature, developing a roadmap for further interdisciplinary research in leadership in online education.

The scoping review is presented to answer the following research questions:

RQ1. What are the research concepts, theories, models and frameworks operationalized in the research within the topic domain of "leadership in online education"?

RQ2. Who are the stakeholders and leaders identified in existing research literature in the topic domain of "leadership in online education"?

2. Methodology

A scoping review is used as the knowledge synthesis vehicle for this study. Scoping reviews can serve the purpose of mapping the existing multidisciplinary research literature, identifying the gaps, and informing scholars of further research pathways (Munn et al., 2018). PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed for reviewing and screening of articles (Tricco et al., 2018).

2.1 Literature Search

Peer review articles were identified from the following data bases: ProQuest RefWorks, Sage Journals online, Academic Search Ultimate, Taylor & Francis Online, Elsevier, and Google scholar was employed as a search engine. The keywords used were: "leadership" and "online learning" OR "online teaching" OR "online education" OR "online programme". The initial search yielded a total of 110 articles. Table 1 presents the inclusion and exclusion criteria.

Table 1: Inclusion and exclusion criteria

Included Publications	Excluded Publications
Primary research articles	Books, systematic reviews, conference proceedings
Published in English	Not published in English
Published in past 20 years (2002-2022)	Not published in past 20 years (2002-2022)

Based upon the above criteria in Table 1, 13 articles were removed as they did not meet the above inclusion criteria. 1 article was removed as it was a duplicate article. Through forward/backward search of the above articles, and secondary database search, 20 more articles were identified which had relevance to the topic. As a part of the further refinement process, articles which did not have an explicit discussion of online learning and leadership, or any synthesis of the relationship between the two concepts were excluded from the study (n=53) leaving us with the remaining 63 articles. Figure 1 is the diagrammatic representation outlining the selection procedure for articles selection for the study.

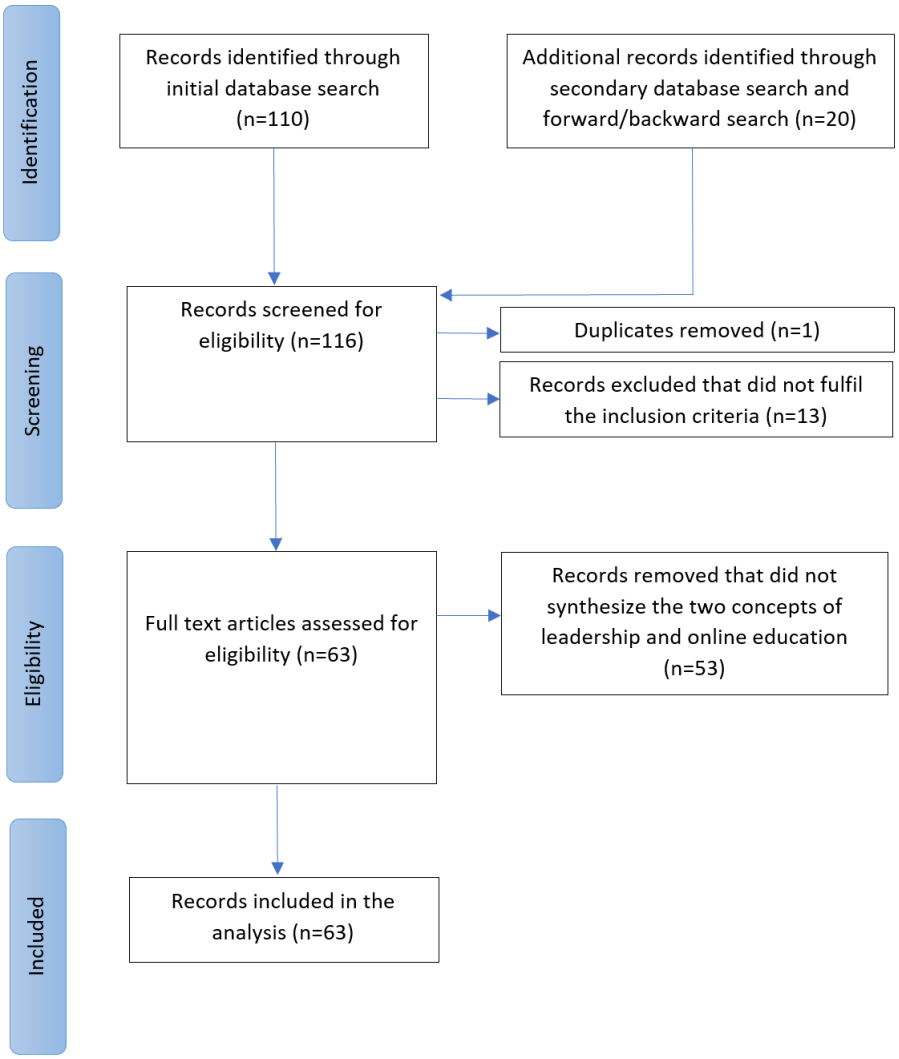

Figure 1: Flow diagram of searched, included/excluded, screened and selected articles (adapted from Tricco et al. (2018)

2.2 Defining Coding Parameters

The articles included for this study were coded through the coding parameters presented below in Table 2.

Table 2: Coding Parameters

Parameter	Details
Foci	Individual, group or organizational level
Research methodology	Qualitative, quantitative, mixed methodology
Study specifics	Case study/essay, longitudinal or cross-sectional, location
Level of education	K-12 school, college, higher educational institution (undergraduate or postgraduate), diploma, or programme
Concept or theory	The theoretical framing of the study in the context of the topic domain of leadership in online education.

Parameter	Details
Synthesis category	Impact of leadership on online education Student experience in an online leadership programme Impact of online education on the leadership development of actors (students, faculty members, administrative staff, and heads of departments) in an online education setting. Perception of leadership in an online education setting

The focus for each publication was identified as individual, group, or organizational level based on the unit of analysis in the study. Research methods adopted were coded under methodology and study specifics. The level of education at which the particular study is conducted was documented. Given the topic domain, it is not surprising that the research was conducted across k-12 schools, colleges, and universities. However, due to the fact that online leadership development programmes have been on the rise during the past two decades, a proportion of the articles were also based on these being offered to participants. Theoretical framing in Table 2 documents the concepts, theories, models, and frameworks which were referred to in each publication, leading us towards broader research areas such as education, leadership, and ICT (Figure 3). This signifies an interdisciplinary approach in the research previously conducted in the topic domain and highlights the potential of future research across a spectrum of research domains in the context of leadership in online education.

2.3 Publication Trend

Figure 2 is indicative of the interest in the topic domain in the review timeline. Two specific peaks are apparent, signifying two eras when the relevant conversations in research and practice were transpiring, in the context of leadership in online education.

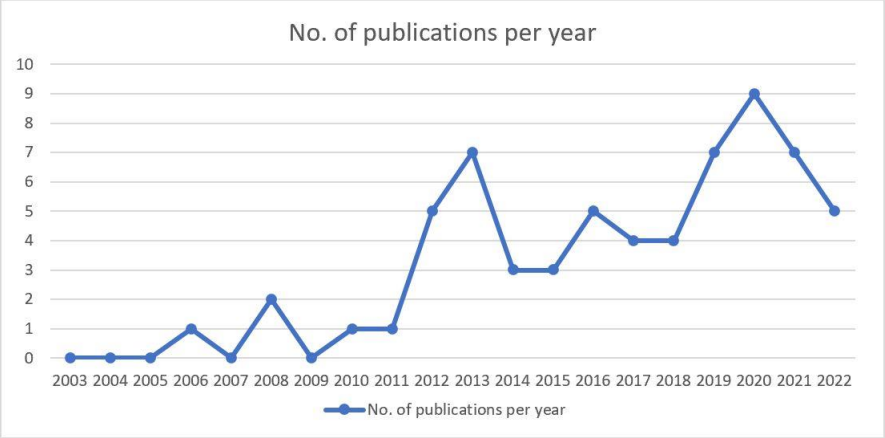

Figure 2: Number of publications per year (2003-2022)

Around the start of the century, growing ease of communication and acceptance of social media tools and online communication paved the way for progress in development of online education platforms (Redpath, 2012). As Proserpio and Gioia (2007), predicted the "virtual generation of students" (p 69) to be the future recipients of education; scholars, practitioners and leaders prepared for the challenges of imparting education to this generation of students. The growing interest in massive online open courses (MOOCs), and the possibility of conducting trainings from participants across the globe, also triggered the development of online leadership programmes for students, faculty members, educators and professionals from various backgrounds and disciplines (Passarelli, 2014)

The second era of interest in research on this topic was during the COVID-19 pandemic. The challenges faced by the global community became the impetus for research scholars to redirect research (Muzio and Doh, 2021) and seek solutions to overcome the impact of the pandemic on education. This was an era when academic leadership was steering the way into the unknown territory of emergency remote teaching and learning (Fernandez and Shaw, 2020). Closures of educational institutions across the world forced scholars to take stock of leadership research during the crisis, in the political, social, and organizational aspects (Bailey and Breslin, 2021). For educational researchers, the digital disruption in pedagogy provided an opportunity to evaluate the outcome of integration of technology with the curriculum in schools, colleges, and universities (Watermeyer et al., 2021).

Presented below is the analysis of the review based on the synthesis categories identified in Table 2.

3. Analysis and Synthesis Categories

Categorization of the papers revealed the following four emergent themes synthesized through analysis of the articles. Seven articles were categorized in more than one category.

3.1 Impact of Leadership on Online Education

Critically analyzing the research on educational technology research, Jameson (2013) comments on the need of the strategic alignment of leadership with technology research in higher education. This is a deviation from the predominant practice of primarily focusing only on research on the online classroom and technology driven instructional design and pedagogy. Digital leadership (Tigre et al., 2022) and e-leadership (Avolio et al., 2014) are concepts arising from the discussions on the rise of technology and its implementation in organizations. In the field of educational research, the research on these concepts has been extended to explore the role of leadership in adoption and implementation of these technologies in educational institutions (Chua and Chua, 2017, Garrison and Vaughan, 2013, Chang and Lee, 2013). During the pandemic, the role of academic leadership shifted towards management of the crisis, and effective implementation of the emergency remote teaching and learning (Fernandez et al., 2021, Borup et al., 2020). With this notion that leadership has played a pivotal role in the adoption of technologies in educational institutions, and continues to do so, the 17 papers of this category are summarized in Table 3, and discussed below.

Table 3: Summary of articles reviewed in the category of "Impact of leadership on online education"

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Otte and Benke (2006)	Organization	-	Essay	-	• Strategic leadership
Brigance (2011)	Group	-	Essay	Higher education	• Collaborative leadership • Learning agility model
Ashbaugh (2013)	Organization and individual *(instructional designer)*	Qualitative	Case study Canada US	Higher education	• Leadership competency • Strategic leadership • Learner satisfaction theory
Chang and Lee (2013)	Group	Quantitative	Case study Taiwan	University	• Leadership style: Transformational/ transactional
Holt et al. (2013)	Organization, education sector	Qualitative	Longitudinal case study Australia	Higher education	• Distributed leadership/ shared leadership
Kahai, Jestire, and Huang (2013)	Individual *(student)*	Quantitative	Case study US	University	• Leadership style: transformational/ transactional • Collaborative learning
Garrison and Vaughan (2013)	Organization	Qualitative	Two case studies Canada	Higher education	• Collaborative leadership • Inquiry through blended learning (ITBL)

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Gallego-Arrufat, Gutierrez-Santiuste, and Campana-Jimenez (2015)	Organization and individual *(teacher)*	Qualitative	Case study Spain	K-12 school	• Distributed leadership
Hilliard (2015)	Organization and individual *(student)*	-	Essay	Higher education	• Blended learning
Mirriahi et al. (2015)	Organization	Qualitative	Case study Australia	Higher education	• Strategic leadership • Constructivism theory • Principles of adult learning
Makina (2016)	Organization	Qualitative	Conceptual	Higher education	• Connectivism theory
Kranzow (2013)	Individual *(student)*	Qualitative	Conceptual	Higher education	• Intrinsic motivation • Community of inquiry framework
Alward and Phelps (2019)	Group	Qualitative	Case study US	University	• Leadership traits
Cheng, Hwang, and Lai (2020)	Individual *(student)*	Quantitative	Case study Taiwan	University	• Group leadership • Collaborative learning
Fernandez and Shaw (2020)	Organization and individual *(leader)*	Qualitative	Essay	Higher education	• Shared leadership • Servant leadership
Bebbington (2021)	Organization and education sector	Qualitative	Essay	University	• Strategic leadership
Rahman and Subiyantoro (2021)	Individual *(principal)*	Qualitative	Case study Indonesia	University	• Strategic leadership

Otte and Benke (2006) proposed institutional transformation through strategic planning at all levels of the organization, instead of online education remaining an isolated function of the educational institution. This resonates with the discussion by Brigance (2011) on collaborative leadership and "shared vision" (p 43) between university management, faculty members and instructional designers. Ashbaugh (2013) explored leadership competencies required by instructional designers. Collaborative leadership was also considered in a case study by Garrison and Vaughan (2013) of two Canadian universities, to gauge the impact of leadership on online education through the *inquiry through blended learning* (ITBL) approach (Garrison et al., 2010). Meanwhile, strategic leadership was the focus of publications by Bebbington (2021) and Rahman and Subiyantoro (2021), during the pandemic.

Leadership styles, transformational/ transactional, were used for the theoretical framing of case studies in the discussion of impact of leadership in case studies by Chang and Lee (2013) and Kahai et al. (2013). Alward and Phelps (2019) focused on perceived leadership traits and competencies required to effectively lead virtual teams in higher education. Contrary to the discourse of individual leader style and traits theories, distributed leadership

was used as the lens for research by Gallego-Arrufat et al. (2015), Holt et al. (2014), and in an essay by Fernandez and Shaw (2020). Fernandez and Shaw (2020) also indicated the relevance of servant leadership, a concept that was visited earlier by van de Bunt-Kokhuis and Sultan (2012) where the authors advocated the case for servant leadership in online learning communities.

3.2 Student Experience in an Online Leadership Programme

Leadership talent is a key component in the constitution of an organization's human capital (Avolio, Avey, and Quisenberry, 2010). Hence, "strategically relevant" (p 129) leadership development programmes can play a pivotal role in an organization's contingency planning and growth (McCall Jr, 2004). Technology has also facilitated access to leadership development opportunities in the form of online leadership development programmes being offered. This paper reviews 31 articles in which the student experience is the theme of the study conducted in an online leadership programme. The findings are summarized below in Table 4.

Table 4: Summary of articles reviewed in the category of "student experience in an online leadership programme"

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Krieger and Stockton (2004)	Individual *(educational group leader)*	Qualitative	Case study US	Training programme for educators	• Developmental theory
McCotter (2008)	Individual *(student)*	Quantitative	Case study US	University	• Communities of inquiry • Intrinsic motivation
Moore (2008)	Organization	Qualitative	Case study US	University	• Reel leadership • Learning communities
Phelps (2012)	Individual *(student)*	-	Essay	College and university	• e-Leadership
Powell et al. (2012)	Individual *(course leads in a medical college programme)*	Quantitative	Case study UK	Higher education	• Medical leadership competency framework
van de Bunt-Kokhuis and Sultan (2012)	Individual *(educational leader)*	-	Essay	-	• Servant leadership
Haber-Curran and Tillapaugh (2013)	Individual *(student)*	Qualitative	Case study US	Undergraduate leadership minor course	• Adaptive leadership
Passarelli (2014)	Organization	-	Essay	International leadership programme	• Leadership development
Mirriahi et al. (2015)	Organization	Qualitative	Case study Australia	Higher education	• Strategic leadership
Curtin (2016)	Individual (student)	Qualitative	Case study US	University	• Leadership theory (broad range)

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Jenkins (2016)	Individual *(participants of a leadership programme)*	Quantitative	Case study International	Higher education	• Instructional learning theory
Sweetman (2018)	Individual *(participant of leadership programme)*	Qualitative	Case study US	Post-graduate program	• Transformative learning theory
McRay, Goertzen, and Klaus (2016)	Individual *(student)*	Qualitative	Case study US	Higher education	• Community of inquiry framework
Purcell (2017)	Organization	-	Essay	Education sector	• Community engaged pedagogies
Manning-Ouellette and Black (2017)	Individual *(student)*	Qualitative	Case study US	Higher education	• Experiential learning
Könings et al. (2018)	Individual *(participant of leadership course)*	Quantitative	Case study The Netherlands	Professional Public Health programme	• Problem-based learning
Bowden, Guignard, and Davis (2019)	Organization	Qualitative	Case study US	University	• Leadership competencies
Goertzen and Squire (2019)	Individual *(student)*	Qualitative	Case study US	University	• Action learning
Moldoveanu and Narayandas (2019)	Organization and individual *(leader)*	-	Essay	Executive education	• Leadership development
Shah et al. (2019)	Individual *(student)*	Qualitative	Data analysis	Health care professional programme	• Leadership development
Cathro (2020)	Individual *(participant of course)*	Qualitative	Case study International	Professional training programme	• Experiential learning
Curtindale, Krylova, and Minyurova (2020)	Individual *(student)*	Quantitative	Case study International		• Collaborative learning
Haber-Curran and Cooper (2020)	Individual *(student)*	Qualitative	Case study International	Higher education	• Emotionally intelligent leadership model
Hayes and Irby (2020)	Individual *(principal)*	Qualitative	Case study US	University	• Instructional leadership

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Fernandez et al. (2021)	Individual *(participant of leadership course)*	Quantitative	Case study US	Healthcare professionals' leadership program	• Leadership development
Greenleaf and Goertzen (2021)	Individual *(student)*	Qualitative	Case study US	University	• Theory of service learning • Collaborative learning
Vito and Schmidt Hanbidge (2021)	Individual *(student)*	Qualitative	Case study Canada	University	• Theory of service learning
Whitehall, Bletscher, and Yost (2021)	Individual *(student)*	Quantitative	Case study	Post-graduate leadership course	• Authentic leadership
Zhu, Shek, and Chan (2021)	Individual *(student)*	Quantitative	Case study Hong Kong	University	• Service leadership model
Guthrie, Batchelder, and Purita (2022)	Organization	Qualitative	Case study US	Leadership programme for college students	• Leadership development
Klaus, Mcray, and Bourgeois (2022)	Organization	Qualitative	Case study US	University	• Student learning outcomes

Action research conducted by McCotter (2008) observed the role of intrinsic motivation and operationalized the communities of practice concept (Wenger, McDermott, and Snyder, 2002), in a study of an educational leadership program. In the context of learning experience of students in online leadership classes, learning communities were discussed by Moore (2008), and by Phelps (2012) in an essay highlighting the need for the development of students' digital literacy and e-leadership skills.

Leadership development through online leadership programmes remained the focus of publications by authors in the areas of executive education (Passarelli, 2014; Moldoveanu and Narayandas, 2019), professionals in healthcare (Shah et al., 2019; Fernandez et al., 2021), students (Guthrie et al., 2022), and education leaders such as principals and instructional designers (Hayes and Irby, 2020). Haber-Curran and Cooper (2020) observed the participant outcomes of a hybrid, global leadership programme through the lens of *emotionally intelligent leadership model* (Levy Shankman, Allen, and Haber-Curran, 2015). Similarly, service-learning, as a concept, was used to guide research in studies by Greenleaf and Goertzen (2021), Vito and Schmidt Hanbidge (2021), and Zhu et al. (2021). Klaus et al. (2022) conducted a comparison between face to face, hybrid and an online leadership programme and observed student outcomes in a US university.

3.3 Impact of Online Education on the Leadership Development of Actors in an Online Education Setting

Lord and Hall (2005) proposed learning beyond training and emphasized the significance of leadership development at a deeper, cognitive level. In the context of youth leadership development, early developmental factors include early learning experiences such as education. In an online education setting, this experiential learning can be translated to peer-interaction, teamwork related to online learning, and the required motivational drive for academic progress (Murphy and Johnson, 2011). Whereas, in the context of the teacher and educational administrative staff leadership development through experience, prior research has emphasized the development of technology leadership, and a higher teacher morale during the technology-education integration activities of schools (Baylor and Ritchie, 2002). Below, Table 5 summarizes the articles

reviewed of the synthesis category of the impact of online education on leadership development of the actors in an online education setting.

Table 5: Summary of the publications reviewed in the category of "impact of online education on the leadership development of actors in an online education setting"

Publication	Focus	Methodology	Study specifics	Level of education	Theory/ concept
Moore (2008)	Group	Qualitative	Case study US	University	• Reel leadership • Learning communities
Ellis, Polizzi, and Rushton (2017)	Individual *(teacher)*	Qualitative	Case study US	K-12 school	• Teacher leadership
Xie et al. (2018)	Individual *(student)*	Quantitative	Case study US	University	• Collaborative learning
Shelton and Archambault (2019)	Individual *(teacher)*	Qualitative	Case study US	K-12 school	• Teacher leadership
Xie et al. (2019)	Individual *(student)*	Quantitative	Case study US	University	• Collaborative learning
Cheng et al. (2020)	Individual *(student)*	Quantitative	Case study Taiwan	University	• Collaborative learning
Downing (2020)	Individual *(student)*	Quantitative	Case study	University	• Active learning • Experiential learning
Kim, Lee, and Wang (2020)	Individual *(student)*	Qualitative	Longitudinal case study	University	• Leadership style: transformational and transactional

Moore (2008), in a study of American university students' leadership development through online book discussions, emphasized the significance of 'fostering a sense of community' (p 34). Similarly, in an analysis of group discussions in an online collaborative learning course, Xie et al. (2018) focused on team leadership and the development of leadership skills of students. Collaborative learning is further discussed by Xie et al. (2019) and by Cheng et al. (2020) in this category. Meanwhile, Downing (2020) presented a case for facilitation of relational leadership development through active learning. Analysis of online group discussion of an online course identified students as emerging leaders (transformational or transactional) in the longitudinal study by Kim et al. (2020).

3.4 Perception of Leadership in an Online Education Setting

In this review, 11 articles have been identified that focus upon the perception of leadership in an online educational setting. These are presented below in Table 6.

Table 6: Summary of articles reviewed in the category of "perception of leadership in an online education setting"

Publication	Focus	Methodology	Study specifics	Level of education	Concept/ theory
Bogler, Caspi, and Roccas (2013)	Group	Quantitative	Case study Israel	University	• Transformational leadership • Passive leadership

Publication	Focus	Methodology	Study specifics	Level of education	Concept/ theory
Pacios and Bueno de la Fuente (2013)	Group	Mixed methodology	Case study Spain	University	• Team leadership
Holt et al. (2014)	Organization	Qualitative	Case study Australia	Higher education	• Distributed leadership
LaFrance and Beck (2014)	Individual *(teacher)*	Qualitative	Case study United States	K-12 school	• Modes of learning
Gallego-Arrufat et al. (2015)	Organization and individual *(teacher)*	Qualitative	Case study Spain	K-12 school	• Distributed leadership
Holland and Piper (2016)	Individual *(teacher)*	Qualitative	Essay	K-12 school	• Teaching leadership • Student leadership development • Technology integration education (TIE) • High trust leadership
Chua and Chua (2017)	Organization	Qualitative	Case study US	K-12 school	• e-leadership
Xie et al. (2019)	Individual *(student)*	Quantitative	Case study US	University	• Collaborative learning
Azukas (2022)	Individual *(principal)*	Qualitative	Case study US	K-12 school	• Virtual leadership • Contextual leadership • Professional standards for educational leadership
Lee (2022)	Organization	Quantitative	Multiple case studies Hong Kong	K-12 school	• Strategic leadership
Luo et al. (2022)	Individual *(student)*	Quantitative	Case study China	University	• Collaborative learning • Student leadership development

Nworie et al. (2012) examined the leadership positions in online educational programmes in higher educational institutions to reveal that "distance education leaders are not managers who oversee specific programs but rather educational leaders" (p 196). Extending the debate towards academic leadership, Holt et al. (2014) conducted senior leadership interviews to gain insight in the perception of distributed leadership in the quality management of online learning environments in higher educational institutes.

Perceptions of instructors as leaders in an online education setting is the topic of the study by Bogler et al. (2013). Transformative and passive leadership styles were discussed, with higher student satisfaction where the

instructor's leadership style was perceived as transformational. Contrarily, perception of passive leadership correlated with lower student satisfaction. Transformational leadership was also discussed by Kim et al. (2020), in their analysis of online group discussions identifying emerging leaders exhibiting either transactional or transformational leadership.

Pacios and Bueno de la Fuente (2013) observe an online higher education program and posit that team dynamics led to participants' capacity building for teamworking and leadership. Similarly, group dynamics, self-regulation, and perceived leadership are focused upon in an online learning group in a graduate program by Xie et al. (2019).

In this category, five studies were identified that were conducted in k-12 schools. LaFrance and Beck (2014) operationalize *modes of learning theory* (Norman, 1978) in their critique of educational leadership programs for k-12 school leaders. Similarly, instructional leadership in k-12 schools, and how it is perceived by students, is the topic of research by Gallego-Arrufat et al. (2015). Lee (2022) explores inclusive education in the context of leadership in schools through a relational perspective. Whereas e-leadership is the focus of a study by Chua and Chua (2017) which employs the grounded theory method to develop an e-leadership model. Furthermore, k-12 leadership perspectives through the lens of the *professional standards for educational leadership* are observed in research by Azukas (2022).

Student leadership development was focused upon by Holland and Piper (2016), through the theoretical framing of the *technology integration education* (Holland and Piper, 2014) and by Luo et al. (2022).

3.5 Stakeholders and Leaders

This review identified various stakeholders in the existing literature in relevance to the topic domain. Distributed, shared, and collaborative leadership were predominantly discussed in most articles, hence the focus of most studies was organizational. For example, Holt et al. (2014) focused on the organization wide role of distributed leadership in universities. Therefore, several stakeholders such as academic heads, teachers, and students were mentioned. In articles focused on online leadership programmes, the primary stakeholders identified were the participants of the programmes such as students, teachers, educational leaders, and health care professionals (Fernandez et al., 2021; Hayes and Irby, 2020; McCotter, 2008). Research addressing the leadership development due to online learning and teaching focused on either group (study groups/ teams) (Moore, 2008) or individual stakeholders (students and teachers) (Ellis et al., 2017; Kim et al.,2020).

While there is reasonable conceptualization of leadership in the literature, the identification of who the key leader is in an online educational setting remains limited. The role of instructional designers is acknowledged (Ashbaugh, 2013, Brigance, 2011), but only as the developers of the curriculum for online delivery. Principals, teachers, and academic leaders are mentioned in the literature as playing a pivotal part in the adoption of online education (Fernandez and Shaw, 2020; Gallego-Arrufat et al., 2015; Mirriahi et al., 2015). *However, the entity that acts as the custodian of the entire process is not revealed.* Virtual leaders (Alward and Phelps, 2019) actively lead virtual teams but it is not clear as to whether they contribute to the process through their technological expertise. Authors have gravitated towards the idea of distributed leadership in online education, yet the key question that remains: who makes the decisions regarding distribution of roles, delegation of authority, and horizontal and vertical coordination, in an online educational setting?

4. Discussion and Conclusion

Although the literature on online education has yielded important insight, further alignment of online education research with leadership research is needed. An interdisciplinary approach has been sought in analysis of the publications in this review. A subset of research area papers was identified through the coding criteria. Figure 3 encapsulates the diverse theories, models, and frameworks being operationalized across the papers selected for the review, drawing attention to the complexity of the alternative theoretical starting points for research in online education. Stakeholders and main actors have also been identified in the online educational leadership setting (Figure 3).

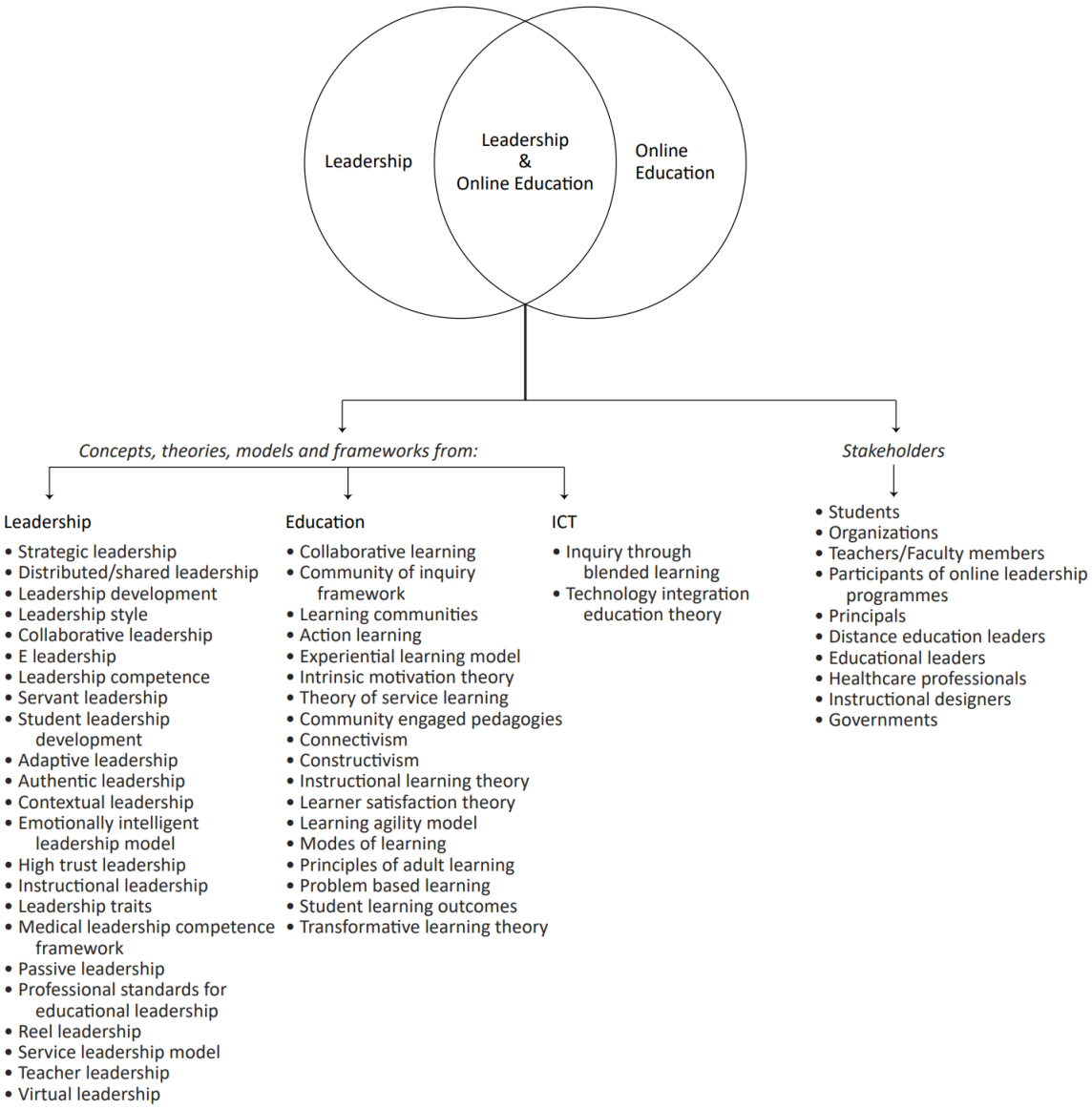

Figure 3: An overview of the leadership in online education research. (The data is shared in descending order of the frequency in publications)

Bryman (2007) identified a lack of research on evaluation of leadership effectiveness in higher education. Years later, we find this phenomenon compounded in the online education terrain. Upon reflection of the content of articles within each category, it is discovered that insufficient attention has been given to the direct impact of leadership on online education. Given the relevance of digitization of education currently (and in the future), discourse and research regarding leadership of online education is necessary. Assuming that leadership is contextual (Oc, 2018), an agenda is proposed for further research that brings together diverse streams of research to explore the role of leadership in online education adoption, implementation, and delivery in educational institutes. This research situates our understanding of online education research as an interaction point with leadership research, highlights existing themes that converge through the synthesis categories identified, and recommends further in-depth, extended research.

Additionally, this review identified the stakeholders in literature on the topic domain. Although various actors have been identified, there is limited discussion of the leaders in such a setting. For the most part, empirical research surrounding online education adoption is more process oriented with an emphasis on systems rather than people. Authors have advocated distributed leadership and shared leadership as a viable solution to the problem of successful implementation of online education (Fernandez and Shaw, 2020; Garrison and Vaughan, 2013). Yet, organisations have always existed in a state of shared leadership where tasks and functions are delegated through effective lateral and vertical coordination (Lumby, 2003). Hence, a focus should be on the

leader, who acts as the custodian of the function of online education in its state of distributed responsibilities across the organisation. Principals, academic heads, and instructional designers are discussed in few papers (Ashbaugh 2013; Azukas, 2022; Brigance, 2011; Hayes and Irby, 2020) but can these entities be called 'expert leaders' when it comes to the adoption and sustainability of online education in institutions? Nworie et al. (2012) focus upon distance education leaders, but it is an umbrella term for leadership engaged in the management of online education. Leadership for online education implementation requires technical expertise and competence (Goodall, Artz, and Oswald, 2016), experience in management of virtual teams (Kahai et al., 2017), besides the knowledge of the core function of education delivery. Individuals leading the online education function require certain skills specific to virtual environments and technology, beyond the "foundational skills traditionally associated with leadership" (Pulley et al., 2001; p. 225). These experts can work in tandem with the academic leadership of schools, colleges, and universities to successfully deliver online education. In this topic domain of leadership in online education there has been no discussion surrounding *chief information officers* or *chief digital officers* which have been known in literature for their role in digital transformation of various organisations, including educational institutes (Davison, Wong, and Peng, 2023). There is tremendous opportunity to explore through focused research on these actors in this setting. Therefore, further empirical research is recommended to observe the role of these experts in their organisations, in relevance to the success of the outcome envisioned.

In conclusion, leadership is a key topic in the online education domain that can yield important insight into how educational organisations adopt, implement, and sustain online education. However, leadership for online education is least researched upon in literature. Interdisciplinary research is proposed to expand our knowledge on how, through effective leadership, institutions navigate the challenges posed by online education. Theories extracted from diverse streams of disciplines also direct us to various stakeholders in the online education setting. As this review makes clear, there is a need to explicate leadership in these organisations to identify the integral actors engaged in the decision making, innovation and management of the online learning systems. Through relevant empirical research, further theory development is encouraged, giving due attention to the actual leaders of online education. In the world of online learning, such theory development and research can have a practical, direct impact on the quality of education.

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LAA: Learn the Arabic Alphabet: Integrating Gamification Elements with Touchscreen Based Application to Enhance the Understanding of the Arabic Letters Forms

Abdullah Al Hejaili[1] and Paul Newbury[2]
[1]Faculty of Computers and Information Technology, University of Tabuk, Saudi Arabia
[2]School of Engineering and Informatics, University of Sussex, UK

a.alhejaili@ut.edu.sa
P.Newbury@sussex.ac.uk

Abstract: Touchscreen devices provide a variety of features and engaging interaction which offer a significant incentive for them to be adopted for learning purposes. They facilitate access to educational resources at any time and broaden the study contents beyond the formal curricula of educational institutions. This is promoted by employing educational applications that stimulate learners to interact effectively with the learning material to gain motivation, influencing their accomplishments in the targeted subject. However, some applications fail to provide a variety of feedback to their stakeholders by relying on evaluating learners either negatively or positively in a simplistic manner and with a lack of reinforcement. This unsuitability and the lack of feedback can lead to a weak level of interaction and decrease students' comprehension levels. In this paper, a multi-platform touchscreen-based application has been developed by adopting gamification to support learners with limited literacy skills in acquiring the Arabic alphabet. A study was conducted on 75 native Arabic learners studying in the first and second year of elementary level in Saudi Arabia to evaluate the system's ability to increase learners' knowledge of the Arabic alphabet. The sample was divided into three groups; experiment, and control groups (both first-year) and second-year groups. The experimental group utilized the application after taking the pre-test, while the control group interacted with the learning material traditionally with their teachers. The second-year group results assisted the study in investigating the system's ability to rapidly boost the experiment group's comprehension of the targeted subject since the second-year learners were more experienced in Arabic letters than the experiment or control groups. The results of the comparison of the pre-test and post-test showed that the experiment group overtook the control and the second-year group regarding the post-test score, which indicates the system's ability to increase learners' knowledge level. By providing an interactive and engaging learning experience, the developed application has shown the ability to increase learners' knowledge levels significantly. These research findings have implications for educators, learners with limited literacy skills, curriculum developers, and researchers who are seeking effective tools to improve language learning outcomes.

Keywords: Touchscreen technology, Feedback, Reinforcement, Language learning, Gamification

1. Introduction

Mastering language letters strongly predict learners' s' literacy levels, such as reading ability and comprehension (Piasta, Petscher and Justice, 2012; Roberts, Vadasy, and Sanders, 2019). The acquisition of letters is considered simple, but the reality is that young learners find learning the alphabet challenging and complex (Seidenberg, 2013). Moreover, learning the Arabic alphabet is specifically considered a challenging task for learners due to the complex visual orthographic features, making it hard to master among 1st and 2nd-grade students (Yassin, Share and Shalhoub-Awwad, 2020). Traditional learning approaches are widely utilized in language learning classrooms, and they are derived from teacher-centered learning that relies on improving learners' memorizing skills by repetition (Gibson, 2008). These approaches are inflexible regarding location and time, and usually deliver knowledge to students in a standardized form without considering the individual differences between students like language proficiency, technological skills, cultural background and learning context (Mohammadi, Ghorbani and Hamidi, 2011a). Also, they rely on teacher-centered learning which gives teachers the job of delivering knowledge and restricts the students to a passive role (Mohammadi, Ghorbani and Hamidi, 2011b). Additionally, traditional language learning approaches have other limitations and shortcomings, such as the failure to provide feedback to individual students, particularly when dealing with a large class, which leads to a lack of students' attention and create a gap between classroom learning and real-life language usage (Schwerdt and Wuppermann, 2011). Utilizing technology to enhance language learning in traditional classroom environments can have several benefits such as; allowing students to obtain immediate feedback, boosting their learning achievement, and increasing students' literacy skills (Wang, An and Wright, 2018). Also, integrating technology in the field of language learning can decrease students' anxiety level and increase their motivation, engagement and confidence (Riasati, Allahyar and Tan, 2012; Lai, 2019). Touchscreen devices such as tablets are

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being utilized in language classrooms due to their accessibility to various language learning applications (Yang, 2020). Touchscreen devices offer new opportunities for students to improve their skills development and support young learners' literacy development (Dickinson, Nesbitt and Hofer, 2019; Piasta *et al.*, 2021). A user-friendly interface and a simple finger-based interaction offered by touchscreen devices can support young students' essential skills development, such as cognitive and literacy skills (Couse and Chen, 2010; Liu and Hwang, 2020). Touchscreen devices have the ability to incorporate various learning techniques, such as gamification. The benefit of the idea of integrating gamification elements in education has been discussed in different studies. Hoffman and Nadelson (2010) and Watson, Mong and Harris (2011) point out that gamification can considerably increase users' level of motivation engagement and the flow of the learning content. Therefore, employing gamification in classrooms can lead to an enhancement of their class progression and achievement (Kuh *et al.*, 2006; Watson, Mong and Harris, 2011).

In recent years, the integration of touchscreen-based applications has shown potential for enhancing language learning outcomes among students. Therefore, this study aims to investigate the impact of a touchscreen-based application on native Arabic-speaking learners' Arabic letter comprehension. Specifically, this research addresses the following research questions:

RQ1. How does the use of a touchscreen-based application impact native Arabic-speaking students' comprehension of Arabic letters?

RQ2. What are the differences in Arabic letter comprehension between learners who interact with the touchscreen-based application and those who receive traditional instruction?

RQ3. What are the implications of incorporating gamification and interactive technologies, such as the touchscreen-based application, for language learning outcomes in elementary education settings?

In this paper, a touchscreen-based application called Learn the Arabic Alphabet (LAA) was designed and developed to teach the Arabic alphabet to young learners. This study demonstrates the potential of multi-platform touchscreen-based applications and gamification techniques in supporting learners with limited literacy skills in acquiring the Arabic alphabet. The findings of the research study have the potential to positively impact teaching and learning practices, curriculum development, and educational policies in the context of Arabic alphabet acquisition and potentially extend to other areas of education as well.

Section 2 provides a literature review. Section 3 examines the characteristics of Arabic letters, followed by Section 4, which discusses gamification elements. Section 5 presents the system framework, and Section 6 presents the interface. Additionally, Section 7 describes the methodology, and Section 8 highlights the results. Section 9 presents the discussion, followed by Section 10, which concludes the study.

2. Literature Review

2.1 Touchscreen Based Applications

Touchscreen applications are software programs that are designed to run on touchscreen devices such as smartphones and tablets. They let users engage with the screen directly using touch gestures. These programs serve a variety of purposes, including education, gaming, productivity, and entertainment. They provide intuitive and user-friendly interfaces that are optimized for touch inputs, making them mobile-friendly and accessible (Neumann and Neumann, 2014). These applications have changed the way we engage with technology, making it more engaging and immersive. Various attempts have been made to develop touchscreen-based applications to improve and support learners' language acquisition needs. For instance, Hashim, *et al.* (2017) developed a mobile-based application named ARabic by integrating augmented reality technology with the methodology based on Analysis, Design, Development, Implementation, and Evaluation (ADDIE) to support young learners with limited literacy skills to learn the Arabic language. Lee, *et al.* (2017) designed an application based on augmented reality to teach pre-school learners different aspects of English language such as speaking, reading and vocabularies. Rahmat, *et al.* (2018) integrated augmented reality with mobile devices to develop an interactive learning application to learn Arabic letters. Chiu (2017) utilized a Virtual Reality (VR) approach with mobile VR glasses to build an immersive environment to teach Taiwanese language. Wen (2018) developed a touchscreen-based application by utilizing augmented reality to teach the Chinese characters. Aljojo, *et al.* (2019) designed a touchscreen-based application to enhance kindergarten learners' literacy skills. Their system was able to develop users' pronunciation skills with high satisfaction. Also, Aljojo, *et al.* (2018) developed a system based on a mobile touch screen targeting language skills of children with dyslexia and the system aimed to enhance their attention ability.

2.2 Game Based Learning

A game-based learning strategy is one that combines aspects of games into the learning process. It entails engaging learners and improving their educational experience by utilizing game mechanisms such as challenges, rewards, and interactive components (Kapp, 2014). Game-based learning tries to make learning more interesting, engaging, and successful by applying game design ideas to educational content. Through the engagement and motivation given by games, it stimulates active involvement, problem solving, critical thinking, and skill development (Al-Azawi, Al-Faliti and Al-Blushi, 2016). Gamification, on the other hand, is the act of incorporating game features, mechanics, and design concepts into non-game environments such as education by using game components like points, badges, leaderboards, levels, and incentives to inspire and engage learners in non-game tasks (Al Fatta, Maksom and Zakaria, 2018; Hamari, Koivisto and Sarsa, 2014). Different researchers employed game-based learning in their applications to enhance user motivation and engagement. Yang, Lin and Chen (2018) developed a tablet-based game for English language learning to reduce anxiety among learners. The study found an inverse correlation between the participants playing performance and their stress levels. In other words, as the participants' performance improved, their stress levels decreased. Wihidayat, Utami and Budianto (2018) added a gamification element to a transformed version of an Arabic language textbook that could be played on mobiles to increase learners' engagement and motivation.

Several studies concentrated on providing different formats of feedback. For instance, Liu, Wang and Lee (2021) developed a digital game for language learning that aims to provide information feedback to the user. The study found a strong relation between feedback and motivation. Castañeda and Cho (2016) developed a mobile game to assist learners in learning Spanish verbs. The experiment showed learners were motivated by the immediate feedback given by the application. Al-Razgan and Alotaibi (2022) developed a mobile game application aimed at teaching young students the Arabic orthography. The study indicated that students receiving instant feedback were encouraged to perform better during the experiment.

However, some researchers argue that some touchscreen applications failed to provide appropriate feedback (Niels and Benjamin, 2012; Soni *et al.*, 2019) and how the feedback was delivered to their users (Benton *et al.*, 2018). This point was evident in El-Sawy, Loey, and El-Bakry's (2016) research that developed a multi-agent touchscreen system to teach young learners the Arabic alphabet by giving immediate feedback. The system provided feedback which was based on displaying sentences and hints, making it difficult for learners with limited literacy skills to read them. Previous research (Al-Razgan and Alotaibi, 2022; El-Sawy, Loey and El-Bakry, 2016) found that feedback and gamification or game-based learning are important tools which can be applied to produce more effective learning. Touchscreen and game-based application, with well-designed effective feedback has been shown to be a promising way forward. However, there are limitations to previous research related to Arabic language learning for children, like those approaches failed to offer a diverse range of feedback and reinforcement, which could result in a weak level of interaction and decreased comprehension levels among learners. This study addresses these limitations by adopting gamification (Multi-Platform Touchscreen-Based Application), which aims to provide an engaging and interactive learning experience, which can potentially address the issue of inadequate feedback variety and increase learner motivation. Furthermore, the study incorporates a comparative design by dividing the sample into three groups: an experiment group, a control group (both groups consisted of first-year learners), as well as a second-year group. The inclusion of a second-year group allowed for investigating the system's ability to rapidly boost comprehension levels, given the second-year learners' prior experience with Arabic letters.

3. Characteristics of Arabic Letters

The Arabic alphabet contain 29 letters, including Hamza (ء) serves as a marker for indicating the stress sound as discussed in section 3.4), and are written from right to left. The Arabic letters' complexity features are based on similarity, allography, ligaturing and diacritics. (Yassin, Share and Shalhoub-Awwad, 2020). Similarity refers to shared visual characteristics or patterns among certain letters, allography involves multiple ways of writing the same sound in Arabic, ligaturing refers to the joining or connecting of specific letter combinations, and diacritics (also known as tashkil or harakat) are small marks or symbols that are added above or below the letters to indicate the pronunciation or phonetic value of the letters. These features and the complex orthography of the letters slow the reading process causing difficulties in learning the Arabic language even for Arabic native speakers (Ibrahim, Eviatar and Aharon-Peretz, 2002) and cause difficulties and confusion to young learners aged 6 to 9 when learning to spell (Yassin, Share and Shalhoub-Awwad, 2020). The following sections will describe each feature of the Arabic letters.

3.1 Letters' Similarity

Many Arabic letters are identical in their fundamental letter structure but differ in the number and placement of their dots. For instance, the letter ث/tha:ʔ/ /th/ has three dots above the main shape of the letter and the letter ت /ta:ʔ/ /t/ has only two dots above the letter's shape. Also, some letters change their shape based on their place in the word. For instance, letter هـ /ha:ʔ/ /h/ changes its structure form to a different form to be ـه or ه at the end of the word and to this shape ـهـ in the middle of the word.

3.2 Letters' Ligaturing

The Arabic letters have a joining shape called ligaturing and depend on the letter's position in the word (Table 1). It is considered the most visual feature of the Arabic language (Yakup *et al.*, 2015). Some words can have an isolated form of letters, such as the word وردة /warda/"a rose" and some words can have a fully connected form of letters, such as the word بنت /bent/"girl". Also, some words can contain both isolated forms of letters and connected, such as the word اثاث /athath/"furniture".

Table 1: The Ligaturing in the Arabic Letters

Final non-ligated	Final ligated	Medial ligated	initial	Isolated	Final non-ligated	Final ligated	Medial ligated	initial	Isolated
ض	ـض	ـضـ	ضـ	ض	ا	ـا	ـا	ا	ا
ط	ـط	ـطـ	طـ	ط	ب	ـب	ـبـ	بـ	ب
ظ	ـظ	ـظـ	ظـ	ظ	ت	ـت	ـتـ	تـ	ت
ع	ـع	ـعـ	عـ	ع	ث	ـث	ـثـ	ثـ	ث
غ	ـغ	ـغـ	غـ	غ	ج	ـج	ـجـ	جـ	ج
ف	ـف	ـفـ	فـ	ف	ح	ـح	ـحـ	حـ	ح
ق	ـق	ـقـ	قـ	ق	خ	ـخ	ـخـ	خـ	خ
ك	ـك	ـكـ	كـ	ك	د	ـد	ـد	د	د
ل	ـل	ـلـ	لـ	ل	ذ	ـذ	ـذ	ذ	ذ
م	ـم	ـمـ	مـ	م	ر	ـر	ـر	ر	ر
ن	ـن	ـنـ	نـ	ن	ز	ـز	ـز	ز	ز
ه	ـه	ـهـ	هـ	هـ	س	ـس	ـسـ	سـ	س
و	ـو	ـو	ـو	و	ش	ـش	ـشـ	شـ	ش
ي	ـي	ـيـ	يـ	ي	ص	ـص	ـصـ	صـ	ص

3.3 Letters' Non-Linearity and Diacritic

The Arabic language uses diacritic (Tashkeel) which are symbols located above or under the letter to indicate its phoneme (Daniels and Share, 2018). The diacritics in Arabic language also referred to as harakat include "fatha" (/ʔal-fatħatu/ ◌َ) produce the sound /a/ , "damma"(ʔa-dˤammatu/◌ُ) produces the sound /u/ and "kasra" (/ʔal-kasratu/◌ِ) which produces the sound /i/ (Saiegh-Haddad, 2018). These diacritics can appear in a double form to represent the letter phoneme at the end of the word (Yassin, Share and Shalhoub-Awwad, 2020). These diacritics are "double damma" (◌ٌ) /un/, "double fatħa" (◌ً) /an/, and "double kasra" (◌ٍ) /in.

3.4 Hamza in the Arabic language

The Hamza (ء) in Arabic guides the stress sound of the glottal stop, and it can appear in isolated form or above or under only four letters (Abdelhadi, Ibrahim and Eviatar, 2011). Therefore, hamza does not change its shape but changes the forms of these four letters depending on their position in the word (Table 2).

Table 2: The Hamza in the Arabic Letters

Hamza isolated					Final non-ligated					Final ligated					Medial ligated					Initial				
ء	أ	ؤ	ئ	إ	ء	أ	ؤ	ئ	إ	ء	ـأ	ـؤ	ـئ	ـإ	ء	ـأ	ـؤ	ـئ	ـإ	ء	أ	ؤ	ئ	إ

4. LAA Overview

The system is designed to be used by a single user aged 6 to 9, as it targets individual learners with limited literacy skills to teach them all forms of Arabic letters. The application is touchscreen-based which does not require a complex level of interaction since the main users are learners. Utilizing touchscreen devices seems ideal due to their affordability, ease of use and popularity. Therefore, the application can run on different platforms, such as the iPhone operating system (IOS) and Android, and can be installed easily without the researcher's intervention.

5. Gamification

The proposed system employed different gamification elements such as feedback, difficulty levels, and badges to increase and sustain the users' motivation. Also, it integrated the Arabic alphabet learning contents into the game scopes. Figure 1 illustrates the gamification elements and they are explained as follows:

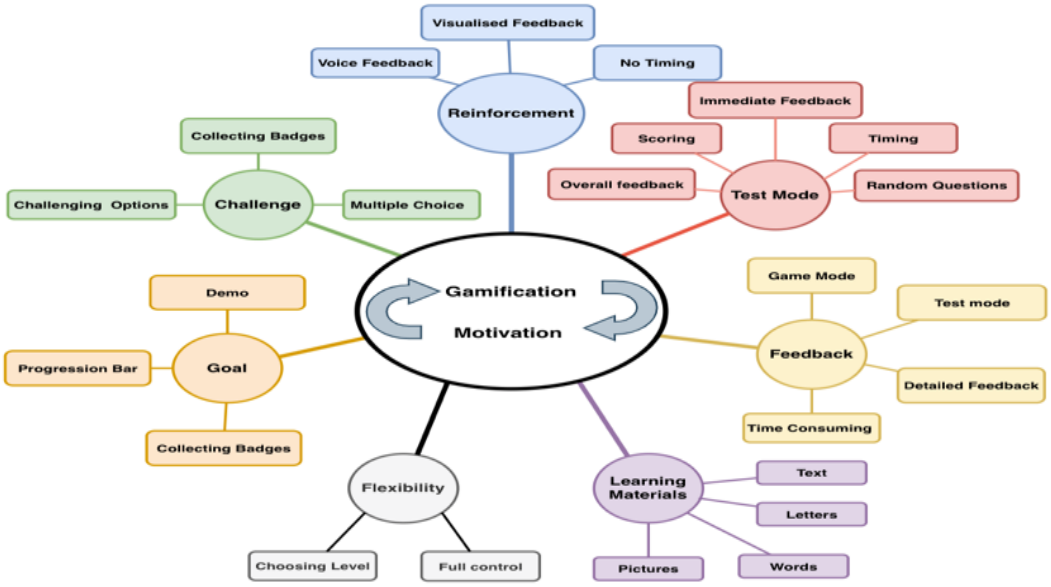

Figure 1: The Application Gamification Elements

5.1 Reinforcement

The system increases learners' motivation by reinforcing and supporting them during the game by utilizing visual and sound reinforcement. The reinforcement response occurs in the playing mode when the user has a wrong attempt. A mixture of visual and sound hints will play and appear to give the user a clue of the correct answer. Also, when the user has a correct answer, a spoken reinforcement plays to increase their satisfaction while playing.

5.2 Test Mode

The application allows learners to examine their achievement and understanding of Arabic letters. The test mode is based on two kinds of feedback: immediate feedback after each answer and overall feedback after finishing the test. Learners will answer ten questions with timing and be able to see their progression score during the test.

5.3 Learning Materials

The learning contents of the application are critical due to the limited literacy level of the main users. Thus, the application learning materials avoid complex words and are chosen based on the Saudi official curriculum and different Arabic lexicons. Furthermore, the learning content is specifically adapted to increase engagement by

adding voices and images and making them more interesting for young learners. The learner profiles are utilized for adaptive learning within the touchscreen-based application. The learner profiles serve as dynamic records of each learner's progress, strengths, and areas for improvement. By leveraging this valuable information, the system can tailor the learning experience to meet the individual needs of each learner.

5.4 Feedback

The application contains four types of feedback:

5.4.1 Immediate feedback

The immediate feedback aims to evaluate learners' answers after their attempts in the play and test mode. In the play mode, learners receive feedback only after their correct attempts, while in the test mode, they receive them after either their wrong or right answers. Also, the added multimedia elements aim to guide learners while interacting with the game and show them the pronunciation of words and letters.

5.4.2 Overall feedback

This occurs after finishing the game and the test task. Stars will appear alongside their score to show the user the status of their progression.

5.4.3 Reinforcement feedback

Learners need to be reinforced while interacting with the application. The reinforcement occurs in the playing mode when learners have wrong or correct attempts. When their answer is correct, a cheering sound will play with fireworks appearing on the screen, and the progression bar will be increased. When they have a wrong attempt, voiced feedback will play with a visualized hint showing learners how their answer is matched with the provided word.

5.4.4 Detailed feedback

Learners can access the results page to see their attempts. The detailed feedback will show users their attempts and the time taken to answer them. Therefore, learners will improve their performance after seeing their weak points and concentrating on which letter, they got wrong the most.

5.5 Challenge

While interacting with the game, learners aim to collect stars to boost the progression bar. This challenge must be achieved to complete the game cycle. Some of the game levels contain multiple choice questions with seven tricky options that challenge learners to choose from. Therefore, these features can enhance the challenging, motivating feeling in learners. Also, the exam mode brings a challenging experience to the user since only immediate feedback appears during the test mode.

5.6 Goal

The game goal is illustrated to the young learners as a demo at the beginning of the game. The step gives learners instructions on interacting with the game and their goal while playing. Learners must answer 28 questions to complete the game cycle; every seven questions mean that learners earn one star. Learners must collect all four stars to finish the game and make the reward.

5.7 Flexibility

The application gives learners complete control of the game by allowing them to start from any point they desire. Learners can switch between questions and skip answering questions when they feel it is too difficult for them, and they can return to the question later in the game. It is worth to mention this feature is only applicable during the playing mode.

6. System Framework

The development of a touchscreen-based application required different programs and platforms. The game was designed by utilizing the Unity game engine ('Unity', 2020). Unity is a well-known game engine that can offer the ability to create different aspects of the game, such as the game scene and allows the application to run on various platforms such as IOS and Android. The application scripts and code are written in C# language through Microsoft Visual Studio, which enables linking them to the game objects in Unity. Unity has some shortcomings regarding compatibility with the Arabic language. Thus, Adobe XD was used to create the learning materials,

such as words and letters. The game icons and pictures were downloaded from royalty-free websites. However, some of the images required some adjustment regarding the regulation to allow them to be fitted into the application and needed to utilize Adobe Illustrator. Also, Adobe Illustrator can change the image format to be compatible with Unity.

7. The Game Scene

First, the user signs in by adding a username and a password. Then, a demo will play to illustrate the game interaction method and the main challenge of the game and how the user can finish the game cycle (Figure.2). After the demo, the screen will show three options to be chosen from, let's play, take the test and result. In let's play mode, the user must answer 28 multiple-choice questions to finish the game stage. Every correct answer will increase the progression bar; when they have seven correct answers, they will collect one star. Users in the playing mode must collect four stars to finish this stage. The application shows and articulates the word with a missing letter, and the user must drag the correct answer and drop it on the blank part of the word. If the answer is correct, immediate feedback will show that the answer is right with a cheering sound and fireworks. If the answer is wrong, reinforcement feedback will give users a visualized and sounded hint to show the user that their response is supposed to go with the hinted word (Figure.3). When the user finishes the game cycle, the overall feedback will appear to the user. The test mode is similar to the playing mode but with no reinforcement feedback. When the user has a negative attempt, immediate feedback will appear with an (X) symbol indicating their answer is wrong (Figure.4). If the answer is correct, immediate feedback will play a cheering sound with fireworks. By the end of the test, the overall feedback will appear to show the user their performance during the test. The user can access their results at any time through the results option on the main screen. The result screen offers users detailed feedback regarding their attempts in both playing and test modes.

Figure 2: The game Demo

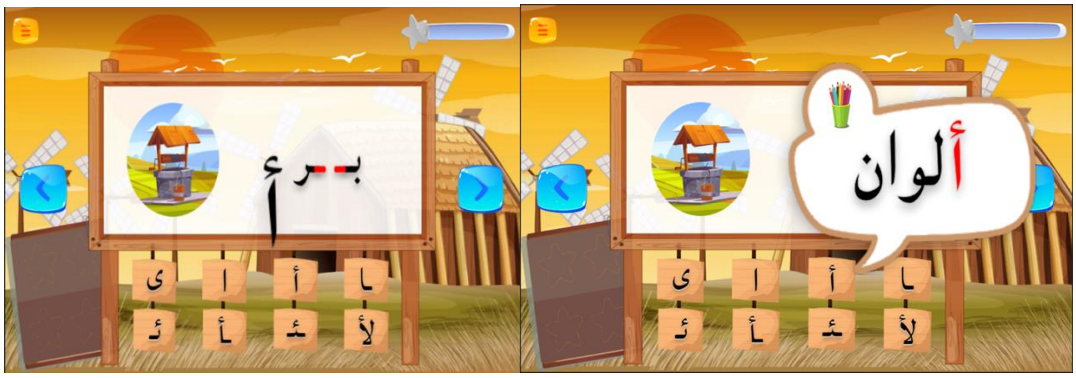

Figure 3: The wrong answer attempts with the reinforcement feedback in the playing mode. The figure on the right shows how the reinforcement feedback appears to the user

Figure 4: The immediate feedback during a wrong attempt in the test mode

8. Methodology

The study aimed to assess the effectiveness of the system in enhancing and boosting learners' comprehension of Arabic letters. To achieve this, a total of 75 native Arabic speakers enrolled in the first and second years participated in the experiment. The participants were divided into three groups to measure the differences between them. Specifically, the experiment and control groups consisted of 25 learners each from the first year, while the second-year group comprised 25 learners.

Before interacting with the application, the experiment group learners underwent a pre-test that assessed their knowledge of the characteristics of all Arabic letters. This pre-test served as a baseline measurement of their understanding. Subsequently, after engaging with the application, the experiment group learners completed a post-test to evaluate their progress and improvement in Arabic letter comprehension.

In parallel, the control group followed a similar process but instead of interacting with the application, they received traditional instruction from their teachers. They also took a pre-test and a post-test, which allowed for a comparison of their progress with that of the experiment group. The second-year group solely participated in the post-test since they were assumed to have a higher level of knowledge compared to the experiment and control groups due to being one year ahead in their studies.

The use of pre and post-tests enabled the researchers to effectively analyze and identify differences between the groups before and after exposure to either the application or the traditional learning approach. Both the pre-test and post-test included the various characteristics of Arabic letters described in section 3 of the study, allowing for an investigation into which specific aspects the learners exhibited the most improvement in. To analyze the quantitative data collected from the participants, IBM SPSS (Statistical Package for the Social Sciences) was utilized (IBM Corp, 2021). This statistical analysis software facilitated the examination of the data and enabled the researchers to draw meaningful conclusions regarding the effectiveness of the system in enhancing Arabic letter comprehension among the different groups.

9. Results

The study compared learners' grades before and after using the application or interacting with their teachers. The study compared both groups' pre-test to ensure that learners had a similar level of knowledge before taking the post-test. Then, the study compared all of the groups' post-test to spot any differences regarding their knowledge level and investigate if the application increased the learners' knowledge level regarding the Arabic letters. The reason behind the second-year group is to examine the application's ability to boost learners' level of comprehension of Arabic letters.

9.1 Differences Between Conditions in Pre-Test

To measure the differences between groups in the pre-test, a non-parametric Mann-Whitney U test is employed since the data is not normally distributed (Ruxton, 2006). Table 3 shows the differences between independent samples regarding pre-test scores. The results indicate no significant differences in the pre-test score between the experiment and control groups. The pre-test scores are (U=296.000, p=.744), and the p-value is greater than 0.05, which means that both groups had the same level of knowledge before taking the post-test.

Table 3: Results of Independent Samples Mann-Whitney Test for Differences between The Median and Mean Pre-test Scores for the two Groups (Experiment and Control)

Variable	Group	N	Mean	Std. Deviation	Median	Mean Rank	Sum of Ranks	U-Value	p-Value
Pre-Test	Experiment Group	25	5.64	1.551	6.00	26.16	654.00	296.000	.744
	Control Group	25	5.48	1.686	6.00	24.84	621.00		

9.2 Differences Between Experiment Group and Control Group in Post-Test

The Mann-Whitney U test is applied to measure the differences between two groups in the same condition. The results in Table 4 shows a significant difference between the control and the experiment group regarding the post-test score (U-184.500, p=.009). The p-value is less than 0.05, indicating that the experimental group performed better in the post-test.

Table 4: Results of Independent Samples Mann-Whitney Test for Differences between The Median and Mean Post-test Scores for the two Groups (Experiment and Control)

Variable	Group	N	Mean	Std. Deviation	Median	Mean Rank	Sum of Ranks	U-Value	p-Value
Post-Test	Experiment Group	25	7.24	1.268	8.00	30.62	765.50	184.500	.009
	Control Group	25	6.20	1.633	6.00	20.38	509.50		

9.3 Differences Between Experiment Group and Second-Year Group in Post-Test

Similar to the previous comparison, the Mann-Whitney U test has been applied to indicate the differences between both groups. Table 5 shows significant differences between the experiment and second-year groups (U=176.500, p=.005). This result suggests that the experiment group outperformed the second-year group since the p-value is less than 0.005.

Table 5: Results of Independent Samples Mann-Whitney Test for Differences between The Median and Mean Post-test Scores for the two Groups (Experiment and Second Year)

Variable	Group	N	Mean	Std. Deviation	Median	Mean Rank	Sum of Ranks	U-Value	p-Value
Post-Test	Experiment Group	25	7.24	1.268	8.00	30.94	773.50	176.500	.005
	2nd Year Group	25	6.32	1.574	7.00	20.06	501.50		

9.4 The differences between groups in correct and wrong answers

Both pre and post-tests contain all of the Arabic letters' characteristics. Table 6 shows the percentage of the learners' correct and wrong answers in pre and post-test regarding the Arabic letters' features. The results showed that the experiment group learners improved their performance in all Arabic alphabet aspects. Their performance was outstanding in the hamza, which is considered a confusing feature. The control group has slightly better achievement in some parts, such as letters allography and ligaturing. However, their post-test scores were lower in the letter similarity, with no change in hamza.

Table 7: The Average Score of All Groups Regarding the Arabic Letters' Characteristics

Group	Factor	Pre-Test Average Score		Post-Test Average Score	
		Correct	Wrong	Correct	Wrong
Experiment Group	Letters Similarity	88%	12%	96%	4%
	Allography	76%	24%	88%	12%

Group	Factor	Pre-Test Average Score		Post-Test Average Score	
		Correct	Wrong	Correct	Wrong
	Hamza	28%	72%	72%	28%
	Ligaturing	69.33%	30.67%	94.67%	5.33%
Control Group	Letters Similarity	84%	16%	82%	18%
	Allography	66%	34%	78.67%	21.33%
	Hamza	60%	40%	60%	40%
	Ligaturing	61.33%	38.67%	78.67%	21.33%
Second Year	Letters Similarity			88%	12%
	Allography			82%	18%
	Hamza			60%	40%
	Ligaturing			77.33%	22.67%

10. Discussion

This study investigates the system's ability to improve the learners' knowledge level of Arabic letters' characteristics. To assure the experiment's validity, pre and post-tests are applied in the study to allow group comparison. Learners had similar knowledge levels in Arabic letters in the pre-test. This step ensures no differences between groups before exposing them to the targeted learning method and taking the post-test. The post-test results of the experiment and the control groups showed a significant difference, and it emphasizes that learners who interacted with the system were able to improve their performance significantly more than learners who interacted with teachers traditionally. In addition, their performance was considerably better than the second-year group, whom it was assumed would have better knowledge than the control and experiment group. This result indicates the system's ability to boost learner performance regarding the targeted subject rapidly. Also, the experiment group students improved their knowledge of all the features and aspects of the Arabic alphabet. The experiment group learners improved their performance by 44% in Hamza. However, the control group learners performed better in the post-test, which tightened their knowledge with the second-year group. Also, they improved their performance regarding the allography and ligaturing of the Arabic letters, while their achievement remained the same in Hamza. This result might be related to the teachers' methods in delivering the learning content or the learners' class engagement level.

The research helps answer the first research question by demonstrating that the use of a touchscreen-based application has a positive impact on native Arabic-speaking learners' comprehension of Arabic letters. The study's findings indicate that learners who interacted with the application showed significant improvements in their knowledge of Arabic letters, thereby confirming the positive effect of the technology on comprehension. The second research question, which investigates the differences in Arabic letter comprehension between learners who use the touchscreen-based application and those who receive traditional instruction, is also addressed. The research findings reveal that the experimental group, which utilized the application, outperformed the control group that received traditional instruction. This provides empirical evidence of the superiority of the touchscreen-based approach in enhancing comprehension compared to traditional methods. The third research question explores the implications of incorporating gamification and interactive technologies, such as the touchscreen-based application, for language learning outcomes in elementary education settings. The research directly addresses this question by demonstrating that gamification elements and touchscreen technology positively influence language learning outcomes. The study highlights the potential of these technologies to engage and motivate learners effectively, resulting in improved language learning outcomes.

Overall, the implications of this experiment highlight the potential of incorporating touchscreen-based applications with gamified elements in language education, showcasing its positive effects on learning outcomes, motivation, engagement, and accessibility. This suggests that incorporating game elements in educational tools can help create an enjoyable and stimulating learning environment, potentially leading to increased learner interest and commitment to learning. These implications can guide educators, curriculum developers, and researchers in utilizing technology effectively to enhance language learning experiences. The research findings present opportunities for further investigations into the use of touchscreen-based applications and gamification in language education. This can encourage future studies to explore the impact of similar

interventions on other language skills and subjects, leading to the development of evidence-based practices for educational technology integration.

11. Conclusion

Based on the potential benefits of integrating touchscreen-based technology and gamification, an educational application was developed to assist learners in learning the Arabic alphabet's different forms. The application comprised multi-feedback techniques to assist learners while interacting with the learning content. The system was evaluated in terms of boosting and improving the learner's understanding of the Arabic letters. The application supports learners' learning of Arabic letters by giving them different forms of feedback to reinforce their performance. A total of 75 learners studying in their first and second year participated in the study, and they were divided into three groups (experiment, control, and second year). The experiment group outperformed both the control and the second year based on post-test results. In addition, they improved their comprehension of all Arabic letters' characteristics. The control and second-year groups had no significant differences regarding their post-test results. In addition, the control group improved their understanding of only two characteristics of the Arabic letters. These results indicate that integrating gamification elements and touchscreen devices and offering learners different types of feedback can positively and considerably influence learner achievement and performance. In future, we will consider fine-tuning gamification elements, personalizing learning paths, conducting cross-cultural studies, integrating these tools into formal education systems, and inclusivity, enhancing assessment and feedback mechanisms, and exploring multilingual applications. These research directions aim to optimize the effectiveness and inclusivity of touchscreen-based learning, making it a valuable tool for educators and learners worldwide.

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Exploring Students' Perceptions on Effective Online Tutoring at a Distance Education Institution

Prince Chukwuneme Enwereji[1], Annelien van Rooyen[1] and Alet Terblanche[2]
[1]Department of Financial Accounting, University of South Africa, Pretoria, South Africa
[2]Department of Auditing, Faculty of Economic and Management Sciences. University of Pretoria, South Africa

enwerpc@unisa.ac.za
vrooyaa@unisa.ac.za
alet.terblanche@up.ac.za

Abstract: Online or e-tutoring is a component of e-learning that involves teaching in an online setting where the e-tutor provides support to a small group of students, which can increase confidence, improve topic comprehension and develop critical learning skills. To enhance e-tutoring in the Department of Financial Accounting at the University of South Africa, this study examined student perspectives or evaluations on the effectiveness of e-tutoring in a distance learning environment, as well as the challenges encountered during its implementation. The study adopted a quantitative design where online questionnaires were used as data collecting instruments. A total of 3,837 questionnaires were completed by students who indicated their willingness to participate in the study. Statistical Package for Social Sciences (SPSS) was used to analyse the data. The major findings revealed that e-tutoring has enhanced students' learning options in financial accounting modules, through the provision of assistance and the promotion of interactive classrooms. The study revealed that students expressed a need for increased training for e-tutors to enhance their abilities in supporting academic goals, while technological challenges such as bad internet and internet cost were identified as significant barriers to successful e-tutoring. Recommendations include promoting e-tutoring in higher education institutions to support students' academic endeavours, providing regular training for e-tutors to handle technical content and overcome technological challenges, and establishing effective communication channels to facilitate student-tutor interactions. These measures aim to improve teaching and learning in the online environment, fostering a supportive and engaging experience for students.

Keywords: Distance learning, e-Tutor, Online learning, Online support, Student support, Technology

1. Introduction

Higher education institutions (HEIs) have experienced significant shifts, in recent years, with the introduction of modern technologies and methodologies to enhance teaching and learning (Treve, 2021). Iivari, Sharma and Ventä-Olkkonen (2020) found that the method of delivery has undergone a remarkable transformation, and students are more informed and technologically inclined than they were in the past. HEIs have embraced technology-enhanced learning and creative delivery methods for student assistance. Online or e-tutoring has been introduced to foster collaborative learning due to the geographic dispersion of students, availability and other personal constraints. Globally, HEIs are faced with massification, student retention, large classrooms, student engagement and shortage of resources to keep up with the rapidly rising number of enrolments (Msiza, Ndhlovu & Raseroka, 2020). Regarding these issues, several HEIs, including those in South Africa, have incorporated e-tutoring to meet their teaching and learning obligations. This method of online tutoring is seen as a crucial approach to enhancing student participation and increasing the understanding of the module content (Maré & Mutezo, 2021).

The use of modern technologies has aided the facilitation of online learning and students from various geographical locations, the world over, can easily connect and form groups with a single objective (Regmi & Jones, 2020). The adoption of e-tutoring has promoted teamwork amongst academic stakeholders, which creates new opportunities and academic excellence (Sauti, 2021). Maré and Mutezo (2021) affirm that e-tutoring is among the technological trends in education that developed quickly due to the outbreak of the Covid-19 pandemic and HEIs have adapted their teaching methods towards providing an optimum learning environment for students. With the aid of internet-based technologies, Goosen and Molotsi (2019) assert that the e-tutoring system provides a platform where students can learn, interact with the e-tutor, communicate with other students, ask questions, share materials and track academic progress. The primary goal of e-tutoring is to increase students' success rates and learning experiences, and to ensure that the online learning environment is handled in a way that creates the right conditions for effective learning outcomes (Sauti, 2021).

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Concerning the significance of online learning in achieving academic competence, the purpose of this study was to investigate students' perspectives on the effectiveness of e-tutoring in an online environment. The study investigated the insights of accounting students registered in the Department of Financial Accounting at the University of South Africa (Unisa). Unisa is a learning institution that operates through open distance and e-learning (ODeL) methods, caters to a student population exceeding 370,000 individuals with various backgrounds, and who are geographically dispersed across Africa and other countries (Joubert & Snyman, 2018; Ramorola, 2018). These large student numbers create challenges to most academics in the Department of Financial Accounting in terms of effective communication, personalized support, and timely feedback. Timely student support, encouragement, and regular communication between students and lecturers, to enhance teaching and learning, must be done in conjunction with e-tutors who take responsibility for around 400 students at a time. The e-tutoring concept was introduced recently and, therefore, it was deemed paramount to examine students' perspectives regarding its success in actualising their academic dreams.

The main research objectives of this study were to investigate the students' evaluations of the effectiveness of online tutoring and the challenges that hinder its implementation in the Department of Financial Accounting. The study is motivated by the need to address the gap in knowledge regarding the effectiveness of online tutoring in distance education. The outcome of the study seeks to improve online educational practices, student support mechanisms and optimise the delivery of e-tutoring services by understanding students' perspectives. The study specifically focuses on undergraduate students in their first to third years in the Department of Financial Accounting at Unisa. It further examines the effectiveness of the e-tutoring platforms such as Moodle, Microsoft Teams, Skype and Zoom, or other online communication tools and challenges encountered during online engagements. In addition, it is important to note that the e-tutors in this study play a specific role in facilitating the module content of financial accounting modules. Their primary objective is to support students in achieving their learning goals within the Department of Financial Accounting. The study aims to provide insights into the effectiveness of this specialised support in meeting the learning objectives of the students, by examining students' views. The recommendations of this study will serve as a guide in making further policies on the methods of e-tutoring delivery at Unisa and other HEIs that adopt online teaching and learning across the globe.

2. The Concepts of Tutoring and e-Tutoring

Tutoring is viewed as the most instructive and stimulating activity for students, since it helps them build capacities for critical analysis and paradigms that they can use throughout their entire careers (Yung, 2020). Crow, Luxton-Reilly and Wuensche (2018) assert that tutoring is a type of specialised teaching, centred on face-to-face communication between the tutor and the student. From the standpoint of effective instruction, Amamou and Cheniti-Belcadhi (2018) concur that tutoring focuses on the social development of students on both personal and cognitive levels. Kim and Kim (2018) view a tutor as a person who supports and educates students, while giving each student personal attention and providing constant backing to be successful in their academic pursuits. Also, Qwaider and Abu-Naser (2018) agree that tutoring refers to teaching students, putting them through academic preparation and inspiring a passion to pursue their right careers.

E-tutoring is increasingly gaining popularity, which is not surprising, given how effective it has been in improving students' success and strengthening their practical understanding of the subjects (Youde, 2020). The prefix "e" in the word "e-tutor" only designates an additional information technology contribution to communication between the tutor and the student. E-tutoring refers to an online learning method that allows tutors to work one-on-one or in small groups with students and allows students to get immediate answers to their questions (De Metz & Bezuidenhout, 2018). The e-tutor communicates with students digitally, to facilitate learning, and communication can take place synchronously or asynchronously through text, voice or video (Johns & Mills, 2021). E-tutoring can also take on a wide range of forms depending on the technological capabilities, aptitudes and instructional techniques used by the e-tutor and the student (Maré & Mutezo, 2021).

The adoption of e-tutoring by HEIs all over the world has provided opportunities for students to receive modified attention and quicker responses to their questions (Barnová, Krásna & Gabrhelová, 2019). Doukakis, Michalopoulou and Chira (2020) point out that e-tutoring has assisted students to participate actively in social and academic activities on an online platform, which has a beneficial effect on student progress and support. Consistent with this assertion, Tan (2019) reflected that e-tutoring provides students, in a distance education setting, with a supportive learning environment, which is one of its most significant advantages. Some students who pursue remote learning may find it incredibly difficult to follow some topics, thereby losing motivation to study, but e-tutoring often closes this gap through online instructions and guidance (Novillo & Pujolà, 2019). In

the view of Molotsi and Goosen (2019), e-tutoring enhances collaborative learning, giving students additional options to benefit from one another's expertise and get practical experience through collaborations. Joubert and Snyman (2020) further assert that the e-tutoring system can save students from failing, improve a sense of support, resolve academic issues, and stop students from feeling lonely and disconnected. As an online learning approach, Rakoma (2018) augments that e-tutoring offers free private coaching in the comfort of the student's home, which minimises any physical discomfort.

Pitsoane and Lethole (2022) point out the roles of e-tutors to include identifying students' needs, assisting them in their personal growth, describing the material to be used, assessing progress, providing feedback, involving students in promotional activities, inspiring and motivating students, and resolving issues that may arise during the learning process. The primary responsibility of an e-tutor is to direct and facilitate the learning process by assisting students in locating resources and helping to empower students to succeed (Tan, 2019). E-tutors can also assist by ensuring that learning activities are planned and carried out in a way that encourages students to interact with one another on the subject matter (Maré & Mutezo, 2021). Similarly, De Metz and Bezuidenhout (2018) state that e-tutors ensure that they convey their ideas, opinions and inputs to the students, to assist them in their academic endeavours. E-tutors are required to be flexible and possess essential technological abilities, which is key in the online learning environment (Van der Poll & Van der Poll, 2018). Although e-tutoring is a relatively new concept, tutors need to possess the same fundamental qualities regardless of the delivery mode (Maré & Mutezo, 2021). The qualities required of exceptional e-tutors include good organisation skills, familiarity with the course content, subject knowledge, enthusiasm, ability to use resources effectively, positive relationships with students, communication skills and a flexible approach (Fandiño & Velandia, 2020).

In Figure 1, the combined e-tutor role model, which depicts the four primary roles of e-tutors, is presented.

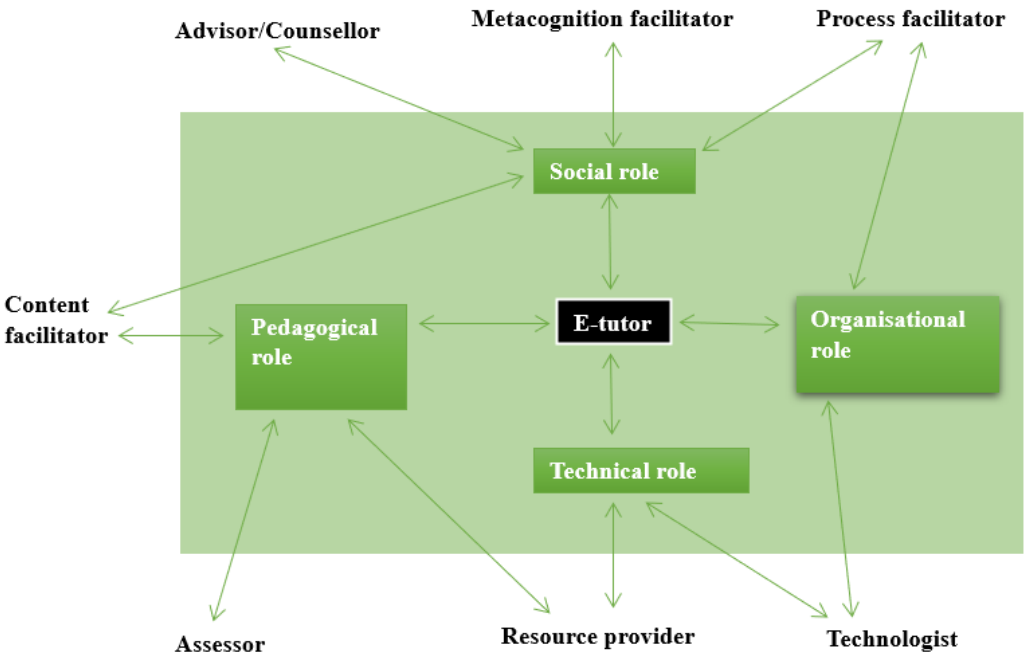

Figure 1: Combined e-tutor role model

Adapted from Goold, Coldwell and Craig (2010)

As is evident from Figure 1, the combined e-tutor roles include pedagogical roles, organisational roles, technical roles and social roles (Goold, Coldwell & Craig, 2010). The e-tutors' primary pedagogical roles are to facilitate student learning, encourage and uphold their participation in discussions (Halimah & Sukmayadi, 2019). Regarding organisational roles, the e-tutors' roles include planning learning activities and tasks, outlining procedures and establishing standards for decision-making (Goold, Coldwell & Craig, 2010). The technical roles of the e-tutor include understanding the Information Communication Technology (ICT) systems and software that make up the e-learning environment – this is regarded as the most crucial job (Goold, Coldwell & Craig, 2010). This is a prerequisite for e-tutors since online technologies are employed as the platform for teaching,

assistance, management and student assessment. Technology is essential to all facets of higher education, but it is especially crucial in institutions of distance learning where it is used for engagement, research, as well as teaching and learning (Bond *et al*., 2020). Finally, the social roles of the e-tutor include facilitating lectures and providing counselling for students to succeed (Sauti, 2021). These roles should be held in high esteem by all e-tutors in the online environment to ensure that students meet their learning expectations and achieve academic excellence.

3. E-tutoring at the University of South Africa

Unisa, an ODeL institution, offers e-tutoring services as part of its comprehensive teaching and learning approach. E-tutoring is an online mode of learning that provides academic support to remote students through platforms like video conferencing, e-mail, instant messaging and the Moodle online Learning Management System (LMS) (Bakkali, 2023). E-tutoring at Unisa refers to the online delivery of teaching and learning through the internet, and e-tutors are qualified experts who support and enable students, via online platforms, to learn effectively in various subjects (Maré & Mutezo, 2021). These tutors, sourced nationally, work as independent contractors on a part-time basis, interacting with students virtually from anywhere in the country (Unisa, 2021). Students are notified of their allocated e-tutor through system-generated e-mails and can access them by logging into the myUnisa LMS platform. The tutor site on myUnisa provides communication tools, such as discussion forums, for students to interact with their e-tutor and collaborate with peers (Unisa, 2021). E-tutoring utilises tools like discussion forums and announcements on the online platform for teaching and learning (Sauti, 2021).

Unisa implemented e-tutoring across all undergraduate programmes in 2014 to provide support to all students, regardless of their location, thus reducing the teacher-learner ratio and improving teaching effectiveness (Unisa, 2021). E-tutors undergo training sessions to familiarise themselves with the available tools and receive subject-specific training from module lecturers. The LMS facilitates both synchronous and asynchronous communication through discussion forums, enabling students to engage with their peers and receive immediate feedback (Ali *et al.*, 2021). According to Maré and Mutezo (2021), e-tutors work closely with individual students, providing personalised academic support, feedback on written work and facilitating online discussions. They also create and share resources, monitor students' progress and collaborate with other support services to ensure comprehensive assistance (Pitsoane & Lethole, 2022). E-tutoring not only serves pedagogical purposes, but also creates a social learning environment that addresses students' feelings of isolation and lack of motivation (Unisa, 2021).

The Department of Financial Accounting at Unisa has almost 60,000 registered undergraduate students, making it the largest department within the College of Accounting Sciences and one of the largest in the institution. E-tutoring has been adequately facilitated in the department and this study seeks to find out the students' evaluations of the effectiveness of this programme, as well as the challenges of its facilitation. The findings of this study will contribute significantly to shaping e-tutoring practices not only in South Africa, but also in other developing countries. Obtaining views from these students will enhance the effectiveness of e-tutoring and improve the learning experience for distance learning students at Unisa, and other higher education institutions.

4. The Challenges of e-Tutoring in Online Institutions

Many HEIs are showing their support for increasing levels of technology in e-learning services, by adopting tools like tablets and personal computers, enhancing internet connectivity and developing programmes to increase computer literacy for both educators and students (Eze *et al.*, 2020). As a result, digitalisation in institutions of learning has grown in importance and even before the Covid-19 pandemic, e-tutors encountered numerous challenges in adjusting to online teaching, keeping at least a basic level of communication with students, and fostering the growth and learning of students (Parte & Herrador-Alcaide, 2021). There are various issues that e-tutors encounter and one of these includes the adoption of online curricula and teaching methods to accommodate new online educational resources (Adnan, 2018). With learning now being more active, contextual and collaborative, e-tutors must establish their objectives, cultivate a conducive environment and determine how the online environment can assist in achieving set goals (Ismailov & Laurier, 2022). Van Leeuwen and Janssen (2019) suggest that pedagogical adjustments are needed for these.

Even while cloud-based collaboration tools and video conferencing software have advanced significantly in recent years, technological problems continue to be a barrier, hindering the growth of e-tutoring platforms, especially in developing countries (Akhter *et al*., 2022). Tan (2019) confirms that the top technical concerns for e-tutors include unreliable connections or a lack of good equipment. E-tutors and students may encounter

problems with operating systems and browser compatibility, which can be frustrating and cause them to give up on their academic pursuits (Rakoma, 2018). The main issues surrounding insufficient equipment or connectivity are considered the access constraint, and Adnan and Anwar (2020) point out that the implementation of educational technology will not be feasible if an institution is unable to possess adequate computers and a fast internet connection. Regarding inadequate technological development, Pitsoane and Lethole (2022) suggest e-tutors should be provided with effective professional development on new technologies, to be able to apply them to their full potential. Maré and Mutezo (2021) opine that the e-tutor support constraints should be enhanced through the facilitation of technology integration, including technical support and administrative/peer support.

Youde (2019) discovered that the lack of experience is another challenge to e-tutoring. Consistent with this assertion, Kebritchi, Lipschuetz, and Santiague (2017) affirm that e-tutors who lack experience may struggle to effectively manage the virtual classroom, engage with students and provide adequate support. To address this challenge, Kebritchi *et al.* (2017) recommend that e-tutors receive adequate training on online pedagogy, technologies and instructional strategies to ensure that they are well-equipped to facilitate virtual learning environments. In the view of Altmann *et al*. (2022), the experience level of the e-tutor is another general challenge, because assisting students to interact with knowledge is a critical factor in an online learning setting. Altmann *et al.* (2022) suggest that experienced e-tutors are better equipped to help students engage with knowledge in an online learning environment. They can provide timely and meaningful feedback, create interactive and collaborative learning activities, and foster a sense of community among students. In contrast, inexperienced e-tutors may struggle to effectively manage the virtual classroom and may not be able to provide the necessary guidance and support to students. Therefore, it is important to ensure that e-tutors are adequately trained and have the necessary experience to facilitate virtual learning environments (Youde, 2019).

Carless (2022) postulates that inadequate feedback is another challenge of e-tutoring, even though feedback loops are excellent online teaching options that help establish strong ties with students, even when learning is not synchronous. Carless (2022) further suggests that feedback is a critical component of online teaching, as it provides students with a sense of direction and helps them to identify areas for improvement. Feedback loops can help to establish a sense of community and trust between e-tutors and students, even in asynchronous learning environments. However, providing effective feedback in online learning can be challenging, due to the lack of face-to-face interaction and the need for e-tutors to rely on technology to deliver feedback (Cook *et al.*, 2021). In this case, e-tutors are expected to provide clear justification for their comments as well as recommendations for how students can improve their learning outcomes (De Metz & Bezuidenhout, 2018). This procedure allows students to consider criticisms, resulting in an iterative cycle that focuses on each student's development (Sauti, 2021). Online examinations, as active learning tools, are important components of online education solutions as they enable e-tutors to assess students' performance accurately, thus giving them immediate and detailed comments (Garcia, Falkner & Vivian, 2018).

5. Research Method

This study investigates the perspectives or evaluations of students on the effectiveness of e-tutoring in an online environment, using the Department of Financial Accounting with large student numbers at Unisa as a case study. This study was conducted to propose strategies to enhance e-tutoring in the department, as Unisa is the largest ODeL institution in South Africa. The integrated e-tutor project aims to decrease dropouts, increase completion rates and enhance student support. The study adopted a descriptive quantitative research strategy to provide answers to the problems of this study. According to Bloomfield and Fisher (2019), the descriptive quantitative research design can provide an in-depth examination of data and aid in the development of a thorough understanding of the study problem. The study was guided by two research objectives, which are to investigate the students' evaluations of the effectiveness of e-tutoring and the challenges that hinder the successful application of e-tutoring in the Department of Financial Accounting. An online survey was formulated, which was sent through the e-mail addresses of students. A total of 3,837 questionnaires were completed by students who indicated their willingness to participate in the study. The questionnaires were gathered and analysed using Statistical Package for Social Sciences (SPSS). In the analytical section, both descriptive and inferential statistics were applied. Descriptive statistics facilitated summarising the set of data associated with the population of the study. It focused on describing and summarising all quantitative data to identify trends and patterns revealing the relationships among variables. The inferential statistics made reasonable predictions, generalisations and conclusions about the population from the sample. This also involved conducting further statistical tests to establish how variables interrelate among themselves. Validity was attained by ensuring that the research instruments used in the study effectively measured what they intended to measure. To further maintain validity,

the questionnaire items were carefully designed based on existing literature and consultation with experts in the field of e-tutoring. The researchers conducted a pilot study to assess the clarity and appropriateness of the questionnaire items, making necessary adjustments to enhance validity. Reliability was attained in this study by ensuring consistency and stability in the measurement of variables. The researchers employed techniques such as test-retest reliability, where a subset of participants completed the questionnaire twice, with a time interval in between, to assess the stability of responses. Additionally, internal consistency reliability measures, such as Cronbach's alpha, were employed to assess the reliability of the questionnaire items. It was found out that all the constructs measured in the study were 0.858 Cronbach alpha coefficients, indicating that they have relatively high internal consistency and above the threshold of 0.7 according to Di lrio (2005), Hinton *et al.* (2004) and Cohen (1988). Ethical standards observed in the study included obtaining informed consent from the participants. Prior to their participation, the students were provided with clear information about the purpose of the study, procedures, its potential risks and benefits. Students were informed that participation was voluntary, while they could withdraw from the study at any time. They were assured that their decisions would not affect their relationship with the institution. Anonymity of responses was also ensured, as the researchers took precautions to remove any personally identifiable information from the collected data. The study did not include personal information in the questionnaire. For this reason, it was not determined if students' participation in the e-tutor project influences their results (pass and retention rates). The study adhered to ethical guidelines and principles to ensure the well-being and rights of the participants, while also maintaining the integrity and validity of the research findings. The researcher further interpreted the results to ensure that they conform to the focus of the study, as well as provide tangible evidence at which the problem of the study could be resolved. Furthermore, the study corroborated the findings with that of the literature review, to provide solutions to the problems of the study.

6. Presentation of Research Results

This section presents the results obtained from the online questionnaires that were sent to financial accounting students who were registered in undergraduate modules. The responses used in this study are from 3,837 students who participated in the study. In the first section of the results presentation, the biographical information of the respondents was presented, while the perspectives of the students on e-tutoring usage and the challenges of using e-tutoring as a medium of teaching and learning were presented in the second and third section.

6.1 Presentation of Biographical Information

This section presents the results obtained from the online questionnaires that were sent to accounting students who used e-tutors in various studies. In this section, descriptive statistics such as the status of the student who uses e-tutoring services, ages of students who use e-tutoring services and users of e-tutoring services were presented. Figure 2 presents the status of the 2,160 participants who use e-tutoring services.

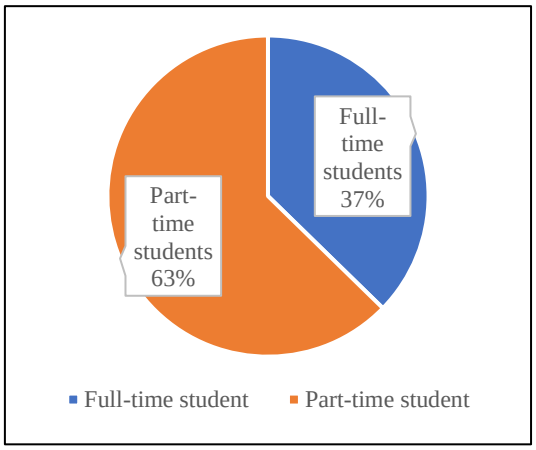

Figure 2: Status of students who used e-tutoring services

Figure 2 shows that 63% (1,361) of the students participated in the study part-time whilst working during the day, while 37% (799) are studying full-time. In the next section, more information will be provided on students' usage of e-tutoring services.

Figure 3 presents the ages of students who indicated that they use e-tutoring services provided by the department. The data confirms that the majority of students who used e-tutoring services fall within the age range of 26 to 35, with a count of 1,081. Following that, the age group of 18 to 25 has the next highest count of 621 students. The numbers gradually decrease as the age ranges increase, with 340 students in the 36 to 45 age group, 104 students in the 46 to 55 age group and 14 students who are 56 years old or older. The data, as presented in Figure 3, portrays that e-tutoring usage is particularly popular among students in the 26 to 35 age range, which could suggest that individuals within this age group actively seek out additional support and resources to enhance their learning experiences. It should be noted that the number of students decreases as the age groups progress, potentially indicating that older students may be less likely to utilise e-tutoring services or have different preferences for academic support.

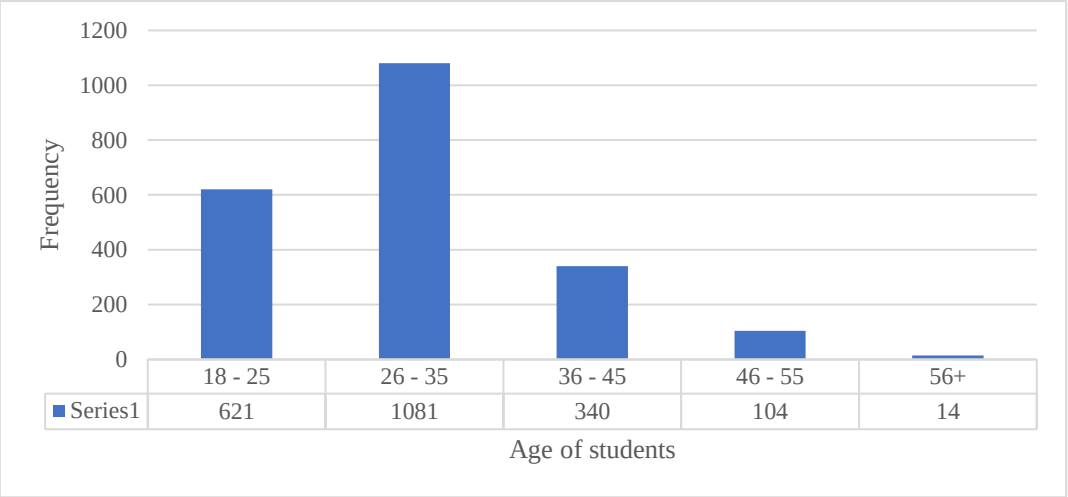

Figure 3: Ages of students who use e-tutoring services

Figure 4 presents the usage of e-tutoring by students in the Financial Accounting Department.

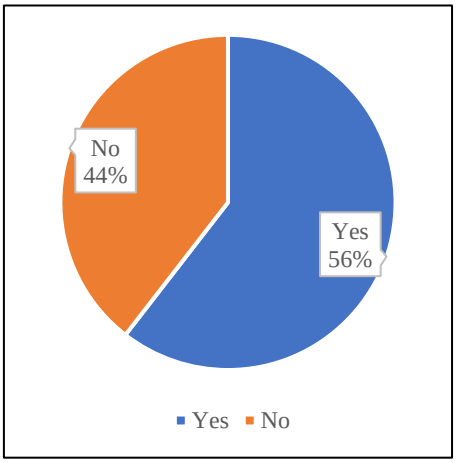

Figure 4: Usage of e-tutoring services

Figure 4 portrays that from the total of 3,837 students who participated in the study, it was revealed that e-tutoring services have been utilised by a significant number of students, with 56% (2,160) of students indicating that they have used these services. This high count reflects the perceived value and positive uptake of e-tutoring as an effective form of academic support. However, 44% (1,677) of students do not use the e-tutoring services, suggesting the need for further exploration into the reasons behind this. It is important to ensure that e-tutoring services are accessible and promoted to cater for the needs of all students, while also considering alternative forms of academic support that may be preferred by some students.

6.2 Usage of e-Tutoring Services by Students in the Department of Financial Accounting

This section presents the results related to the usage of e-tutoring as a method of teaching and learning at the Department of Financial Accounting at Unisa. Table 1 presents the KMO and Bartlett's test.

Table 1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.966
Bartlett's Test of Sphericity	Approx. Chi-Square	2.804
	Df	136
	Sig.	.000

Table 1 presents the KMO, Bartlett's test and the descriptive statistics. In Table 1, factor analysis is used to identify the important factors concerning students' perspectives of those who use e-tutors. Kaiser-Meyer-Olkin's measure of sampling adequacy reflects a score of 0.966, which is well above the recommended value of 0.7 (Feng *et al.*, 2017). Bartlett's test of sphericity is significant at $p < 0.05$ levels. It is concluded that the correlation matrix is not an identity matrix.

Table 2 shows all the factors (can be referred to as components) extractable from the analysis along with their eigen values and only two factors were considered. The study hypothesised that the seventeen questions considered form one common scale and the factor analysis indicates that this might not be true, as two factors were extracted.

Table 2: Total variance explained

	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	**Total**	**% of Variance**	**Cum. %**	**Total**	**% of Variance**	**Cum. %**	**Total**	**% of Variance**	**Cum. %**
1 Strategies	10.106	59.447	59.447	10.106	59.447	59.447	7.026	41.329	41.329
2 Age	1.163	6.843	66.290	1.163	6.843	66.290	4.243	24.960	66.290
3 Accounting in High School	.708	4.166	70.456						
4 ModuleSpecific	.624	3.668	74.125						
5 SolveProblems	.589	3.464	77.589						
6 HelpSpecific	.487	2.866	80.455						
7 Content Interesting	.437	2.573	83.027						
8 E-tutorSolveProb	.397	2.338	85.365						
9 MoreDiffTopics	.346	2.034	87.399						
10 VeryHelpful	.320	1.880	89.279						
11 ModMoreInterest	.305	1.797	91.076						
12 EssentialSuccess	.288	1.696	92.771						
13 AddressesNeeds	.269	1.583	94.354						
14 EffectiveUse	.263	1.550	95.904						
15 MorethanDiscuss	.242	1.422	97.326						
16 InteractInterest	.239	1.406	98.732						
17 AdditionalInfo	.215	1.268	100.00						
Extraction Method: Principal Component Analysis.									

The extraction method used was principal component analysis factoring with varimax rotation. The varimax method was chosen because it was assumed that the factors are independent of each other. For analysis and interpretation purposes, the study was only concerned with Initial Eigen Values or Extracted Sums of Squared Loadings. In this case, two components contain 66.29% of the variation of the original variables, so the study considerably reduced the complexity of the data set by using these components, with only a 33.71% loss of information. Component 1 explains 59.447% of the variation and Component 2 explains 6.843%. The remaining fifteen components explain only 33.71%.

The idea of rotation is to reduce the number of factors on which the variables under investigation have high loadings. The Rotated Component Matrix displays the factor loadings for each variable and identifies the factor on which each variable is most heavily loaded. In Table 3, based on these factor loadings, the positive perspectives subsets loaded strongly on Component 1 and this is the "address needs" factor group. The "get assistance" factor is strongly loaded in Component 2. High usage of e-tutoring mainly hinges on addressing of learners needs and assistance. These pull-factors need to be maintained.

Table 3: Rotated component matrix

	Component	
	1 Address needs	2 Get assistance
Q8_EtutorSolveProb	.806	
Q9_MoreDiffTopics	.805	
Q10_VeryHelpful	.840	
Q11_ModMoreInterest	.791	
Q12_EssentialSuccess	.751	
Q13_AddressesNeeds	.728	
Q14_EffectiveUSe	.669	
Q15_MorethanDiscuss	.631	
Q17_AdditionalInfo	.646	
Q18_MonitorMyProgress	.638	
Q19_Motivates	.670	
Q20_HelpsOrganise	.632	
Q22_AnswerTimeously		.643
Q23_AssistWithTech		.830
Q24_AssistAdmin		.844
Q25_TutorRoleClear		.624
Q26_RoleClearToMe	.537	.535

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization

a. Rotation converged in 3 iterations

6.3 Challenges of e-Tutoring

This section presents the challenges of adopting e-tutoring, by the Department of Financial Accounting, as a method of teaching and learning. Table 4 presents the KMO and Bartlett's test.

Table 4: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.862
Bartlett's Test of Sphericity	Approx. Chi-Square	1.095
	Df	66
	Sig.	.000

Table 4 presents the KMO, Bartlett's test and the descriptive statistics. In Table 4, factor analysis is used to identify the important factors concerning students' evaluations of those who use e-tutors. Kaiser-Meyer-Olkin's measure of sampling adequacy reflects a score of 0.862, which is well above the recommended value of 0.7. Bartlett's test of sphericity is significant at $p < 0.05$ levels. It is concluded that the correlation matrix is not an identity matrix. Table 5 presents the Total Variance Explained.

Table 5: Total variance explained

	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.872	40.600	40.600	4.872	40.600	40.600	3.346	27.882	27.882
2	1.500	12.498	53.098	1.500	12.498	53.098	2.520	21.000	48.883
3	1.264	10.534	63.632	1.264	10.534	63.632	1.770	14.749	63.632
4	.911	7.589	71.221						
5	.600	4.996	76.217						
6	.575	4.790	81.007						
7	.557	4.645	85.652						
8	.443	3.690	89.342						
9	.420	3.503	92.845						
10	.359	2.993	95.838						
11	.318	2.654	98.493						
12	.181	1.507	100.000						

Extraction Method: Principal Component Analysis.

Table 5 shows all the factors or components extractable from the analysis, along with their eigen values, and only three factors were considered. The study hypothesised that the twelve questions considered form one common scale and the factor analysis indicates that this might not be true, as two factors were extracted. The extraction method used was principal component analysis factoring with varimax rotation. The varimax method was chosen because it was assumed that the factors are independent of each other. For analysis and interpretation purposes, the study was only concerned with Initial Eigen Values or Extracted Sums of Squared Loadings. In this case, three components contain 63.632% of the variation of the original variables, so the study considerably reduced the complexity of the data set by using these components, with only a 36.368% loss of information. Component 1 explains 40.6% of the variation, Component 2 explains 12.498% and Component 3 explains 10.534%. The remaining nine components explain only 36.368%. Table 6 presents the Rotated Component Matrix.

Table 6: Rotated component matrix

	Component		
	1. Communication challenges	2. Training needs	3. Internet-related costs
Q28_StruggleToInteract	.655		
Q29_StrugglesAnswer	.734		
Q30_DontGetAssistance	.658		
Q31_GetTraining		.834	
Q32_OnlineTraining		.897	
Q33_TrainTechTools		.873	
Q34_PostManyAnnounce	.630		
Q35_DuplicateAnnounce	.713		
Q36_Redundant	.627		
Q38_TakesMyTime	.650		
Q39_BadInternetConnect			.858
Q41_InternetCost			.865
Extraction Method: Principal Component Analysis Rotation Method: Varimax with Kaiser Normalization			
a. Rotation converged in 6 iterations			

The idea of rotation is to reduce the number of factors on which the variables under investigation have high loadings. The Rotated Component Matrix displays the factor loadings for each variable and identifies the factor on which each variable is most heavily loaded. In Table 6, based on these factor loadings, the positive perspective subsets loaded strongly on Component 1 and this is the "communication challenges" factor group. The "training needs" subset is strongly loaded in Component 2, while Component 3 is mainly comprised of the "internet-related costs" subset. The dominant factor is "communication challenges", which implies that a greater number are facing challenges when communicating with the respective lecturers. The second factor implies learners are experiencing "training needs". Adequate training is required to change learners' perspectives. The "internet-related costs" factor impacts learners, hence communication challenges. Addressing the factors will reduce learners' negative perspectives towards the mode of studying.

7. Discussion of Research Results

This study investigated accounting students' evaluations or perspectives of the effectiveness of e-tutoring in an online learning environment, where student numbers are large and e-tutors are employed to assist academics with more personal student support. The findings revealed that students agreed that the e-tutoring services provided by Unisa have assisted them in achieving their academic endeavours, by addressing their needs. E-tutors solved many of the queries, attended to more difficult topics and have been very helpful in their learning process. These findings are in line with findings by Sauti (2021) who noted that the main duties of e-tutors are to help students succeed, while also making sure that the online learning environment is managed in a way that fosters optimal learning conditions. Since the e-tutors in the Department of Financial Accounting play an important role to overcome the challenges of high student-lecturer ratio, findings further indicate that e-tutoring makes modules more interesting and fosters interactive discussions. Given how successful it has been in raising students' achievements and strengthening the practical comprehension of their course outcomes, Youde (2020) affirms that e-tutoring has become a learning aid. In the same direction, Barnová, Krásna and Gabrhelová (2019) confirm that HEIs all around the world are adjusting to adopt e-tutoring, to ensure that students are provided with the opportunity to receive individualised attention and prompt answers to their inquiries. Furthermore, findings affirm that e-tutors provide additional information, monitor students' progress, provide motivation, help in organising and assist in providing clear roles. According to Tan (2019), e-tutoring has made it possible for students to actively engage in social and academic activities on an online platform, which

has a positive effect on student development. According to Doukakis, Michalopoulou and Chira (2020), who support this claim, one of the most important benefits of e-tutoring is that it gives students, in a distance education setting, a helpful learning environment and fills a vacuum by providing students with online instructions and directives. Furthermore, the combined e-tutor model, as presented in Figure 1 provides that students meet certain learning expectations and achieve their academic goals (Goold, Coldwell & Craig, 2010). Finally, the students confirm that they get assistance by making use of e-tutoring services, which assists first-year lecturers where their students often encounter challenges with an unfamiliar e-learning setting. In this regard, students are provided clear goals and are assisted with technological and administration related issues.

Regarding the communication challenges of e-tutoring, feedback from the accounting students indicates that e-tutors struggle to create group interactions, struggle to answer module questions, do not provide assistance on financial accounting modules, post too many announcements and duplicate lecturers' announcements. Similarly, in a study by Adnan (2018), students highlighted that e-tutors often failed to provide timely and comprehensive feedback, which hindered their progress. Another study by Quang and Tri (2021) explored the challenges and opportunities of online learning during the Covid-19 pandemic, and findings indicate that communication challenges were a significant issue for both students and teachers. In this regard, communication challenges are a common issue in online learning and several studies have explored this topic (Almaiah, Al-Khasawneh, Althunibat, 2020; Hebebci, Bertiz & Alan, 2020; Khalil *et al.*, 2020). The challenges reported by the accounting students in the present study align with the findings of previous research. E-tutors must work to address these challenges, to ensure that students have a positive learning experience and are not hindered by communication barriers. Findings further depict that e-tutors should get training, online training and training on technical tools. Ismailov and Laurier (2022), as well as Van Leeuwen and Janssen (2019), propose that training is required in an endeavour to enhance the learning environment. Consistently, Kebritchi *et al.* (2017) and Youde (2019) agree that e-tutoring has difficulties due to a lack of experience, while e-tutors' lack of experience affects their capacity to enhance the teaching and learning process. In this regard, Altmann *et al.* (2022) opine that experience and the constant training of e-tutors play a vital role in supporting students to interact with knowledge in the online learning platform.

Furthermore, findings revealed that students encounter technology-related problems, such as bad internet and internet cost. Akhter *et al.* (2022), and Majola and Mudau (2022) state that the development of e-tutoring platforms in South Africa is still constrained by technological issues, despite recent advancements in cloud-based collaboration tools and video conferencing software. In the view of Tan (2019), unstable connections or a lack of quality equipment are the main technical issues encountered in e-tutoring. The technical issues, as documented by Rakoma (2018), include bad operating systems and browser compatibility issues, which cause severe frustration to the students. Adnan and Anwar (2020), and Kibuku *et al.* (2020) note that technology-related problems, such as bad internet connectivity and internet cost, are common challenges facing e-tutoring services and students who participate in online learning. E-tutors and universities can address this challenge by providing students with technical support and guidance, investing in improving internet connectivity, providing internet connectivity and devices to students who cannot afford them, and using simple and easy-to-use technologies that do not require high internet bandwidth. Pitsoane and Lethole (2022) recommend that e-tutors should be well-versed with new technological inventions, to be able to utilise them to their fullest extent, in an endeavour to address technological barriers. According to Maré and Mutezo (2021), the facilitation of technology integration, including technical support and administrative/peer support, should be provided by e-tutors to improve e-tutoring, to ensure that students achieve their academic targets. The subsequent section presents the contributions of the study.

8. Contributions of the Study

This study investigates the students' perspectives or evaluations of the effectiveness of e-tutoring in an online learning environment and the challenges in the implementation of e-tutoring. The study found that e-tutoring services provided by the university have helped students in achieving their academic goals, by addressing their needs and resolving their problems. The use of e-tutoring makes modules more interesting, enhances essential success, effective use of learning resources and fosters interactive discussions. However, the study also revealed communication challenges faced by e-tutors, which include struggling to create group interactions and answer module questions, posting too many announcements and taking up most of the student's study time. Due to large student numbers with undergraduate financial accounting modules, it is practically difficult to assist students on a one-on-one basis. It also seems that e-tutors do not always have the required knowledge on module content and technology to assist the groups of students. Challenges with technology, for both tutor and student, make e-tutors not as successful, as explained by other previous students. Moreover, technical issues,

such as bad internet connectivity and internet cost, have been a common challenge facing e-tutoring services and students who participate in online learning. The study recommends that e-tutors should get training, online training and training on technical tools, while universities should work to address technological issues to ensure a positive learning experience for students.

Furthermore, the study disagreed with the assumption that e-tutoring allows students to connect with other students, that e-tutors are too demanding and that they would prefer e-tutoring support to be provided on a different platform, such as Microsoft Teams. This could be a major finding of the study, because it challenges some commonly held assumptions about e-tutoring. The findings suggest that e-tutoring may not be as effective in fostering social connections between students, as previously thought, and that students may not find e-tutors to be overly demanding. Additionally, the finding that students did not prefer e-tutoring support to be provided on a different platform may indicate that the current platform used for e-tutoring is effective and well-suited to the students' needs. These findings provide important insights into the effectiveness of e-tutoring and the perspectives of students towards this form of support. They could help inform future research and the design of e-tutoring programmes that are more responsive to the needs and preferences of students.

9. Recommendations

The recommendations of this study are made to the students, e-tutors and educational institutions.

9.1 Recommendations to the Students

The following recommendations are made to the students.

- Take advantage of the benefits of e-tutoring: Although some students may not feel that e-tutoring helps them connect with other students, it can still be an effective way to receive academic support. E-tutoring can be more convenient and flexible than traditional in-person tutoring, and it can be a great way to get help when in need.
- Communicate with your e-tutors: If e-tutors are too demanding, students must communicate their concerns with e-tutors and let them understand. They may be able to adjust their expectations or provide additional support.
- Consider using different platforms for e-tutoring: Students should communicate their frustrations to their instructor or e-tutoring programme coordinator if they prefer to receive e-tutoring support on a different platform, other than the one currently being used, such as Microsoft Teams. They may be open to exploring different options that work better.
- Stay engaged and take advantage of all available resources: Students should ensure to participate in e-tutoring sessions and ask questions when they need help. They should also take advantage of all available resources, such as online resources and study materials. Additionally, they should consider forming study groups with other students to help connect with their peers and receive additional academic support.

9.2 Recommendations to the e-Tutors

The following are the recommendations for e-tutors.

- E-tutors should be approachable and create a friendly learning environment: Students should appreciate e-tutors who are approachable and who create a positive and supportive learning environment. Additionally, e-tutors should ensure that they are available to answer questions and provide support when needed.
- Avoid being too demanding: While it is important to challenge students, it is also important to avoid being too demanding. Students may feel overwhelmed if they are constantly pushed to their limits. E-tutors should strike a balance between challenging students and providing support.
- Use a variety of teaching methods: Students learn in different ways, therefore, e-tutors should use a variety of teaching methods to accommodate different learning styles. For example, some students may prefer visual aids while others may prefer hands-on activities.
- Provide support on a platform that students prefer: The study found that some students preferred to receive e-tutoring support on Microsoft Teams, rather than the current platform. E-tutors should be flexible and willing to provide support on the platform that students prefer.
- Encourage group discussions: Although some students did not find e-tutoring helpful in connecting with other students, e-tutors can still encourage group discussions and collaboration. This can help students to develop a deeper understanding of the material and learn from their peers.

- Provide constructive feedback: Students benefit from receiving feedback on their work. E-tutors should provide constructive feedback that is specific, actionable and helps students to improve their understanding of the material.

9.3 Recommendations to Educational Institutions

Based on the findings of the study, the following recommendations are made to institutions.

- Clear guidelines and expectations for e-tutors: Institutions should provide clear guidelines and expectations for e-tutors, including their roles and responsibilities, communication protocols and the level of support they should provide to students. This will ensure that e-tutors are aware of their responsibilities, and can provide consistent and effective support to students.
- Offer training and support for e-tutors: Institutions should offer training and support for e-tutors, to help them develop the necessary skills and competencies for online tutoring. This could include training in communication skills, online teaching strategies and the use of technology platforms.
- Use multiple platforms for e-tutoring support: Institutions should consider offering e-tutoring support on multiple platforms to accommodate students' preferences. This could include platforms such as Zoom, Microsoft Teams or Skype.
- Encourage student participation: Institutions should encourage students to participate in e-tutoring sessions and promote the benefits of online tutoring. This could include providing incentives for participation or highlighting success stories of students who have benefited from e-tutoring.
- Collect feedback from students: Institutions should collect regular feedback from students on their e-tutoring experiences, to identify areas for improvement and make necessary adjustments. This could include surveys or focus groups to gather feedback from students.

10. Conclusion

E-tutoring provides students with access to learning resources and it is intended that this method will help students grow in several ways, including self-reliance, practical information processing methods, teamwork, collaborative learning, communication skills and ownership of their learning. This study set out to obtain the perspectives of accounting students who use e-tutoring in their learning. To achieve this aim, the study adopted a quantitative study where online questionnaires were sent to students who use e-tutoring in their learning options. The findings of the study revealed that e-tutoring was perceived positively by the students, with most students finding it helpful in their learning and academic progress. The study also found that e-tutoring was effective in enhancing students' engagement and communication with their tutors. However, the study also identified some challenges that students faced in e-tutoring, such as technical difficulties, lack of personalised attention and difficulty in building connections with other students. Additionally, some students expressed a preference for using a different platform, such as Microsoft Teams, for e-tutoring. Based on these findings, recommendations were made to students, e-tutors and institutions. Students were advised to ensure that they have a reliable internet connection and the necessary equipment to participate in e-tutoring effectively. They were also encouraged to communicate with their e-tutors and ask questions when they encounter challenges. E-tutors were advised to provide personalised attention to students and use interactive techniques to engage and motivate students. Institutions were recommended to provide technical support to students and e-tutors, and to consider offering training for e-tutors to enhance their e-tutoring skills. The study highlights the importance of e-tutoring in ensuring that students receive a quality education. With the appropriate measures in place, e-tutoring can be an effective way to enhance student engagement, learning and academic success.

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Investigating the Impact of Technostress on Perceived Hybrid Learning Environment and Academic Performance

Asad Abbas[1,2], Guillermina Benavides Rincón[2], Liya Wang[3] and Mohammad Khubeb Siddiqui[4]

[1]Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Monterrey, Mexico
[2]School of Government and Public Transformation, Tecnologico de Monterrey, San Pedro Garza García, Mexico
[3]Center of Microbes, Development and Health, Institut Pasteur of Shanghai, Chinese Academy of Sciences, Shanghai, China
[4]IBM, Sydney, Australia

asad.abbas@tec.mx (corresponding author)

Abstract: For the betterment of society, education plays a significant role in helping human beings in both tangible and intangible manner. From time to time, various transformations came to the teaching and learning pedagogy. Moreover, it has been evaluated by respective available resources. During and post-COVID-19, we have seen a considerable inclination towards hybrid learning. So, as a researcher, we also need to evaluate whether it has been progressing well. The emergence of different waves of pandemics across the globe has forced higher education institutes to develop and implement new educational models and policies that help to improve the quality of education and learning. However, we also need to examine the impact of these new modalities. For this, Tecnologico de Monterrey, Mexico, has also implemented its novel hybrid educational model, ' HyFlex+Tec,' to continue and uplift academic activities. This model has proposed access to quality education during and post-pandemic crisis and offers the possibility of providing a more environmentally friendly educational model. This study aims to explore the role of technostress in the association between a hybrid learning environment and students' academic performance and to reflect on how this new mode of blended learning could promote 'green-based' learning in an era of climate emergency. For this, we deployed a Form-based online survey among students through the convenient sampling technique. In total, we received 94 registered responses. For statistical analysis of quantitative datasets, we used a free and open statistical application, i.e., Jamovi. After the regression-based examination, it has been noted that technostress fully mediates the relationship between the perceived hybrid learning environment and the academic performance of undergraduate students. The reason for the occurrence of technostress among students is the continuous change in modalities, where the adaptation of new digital tools (software and devices) in a short time affects academic performance, thereby causing a lack of participation in course activities. This research provides guidelines to the university and government policymakers to update or introduce new flexible degree programs (in-person and hybrid) to promote digital skills and the wellbeing of students.

Keywords: Educational innovation, e-Learning, Hybrid learning, HyFlex+Tec, COVID-19, Institutional policy

1. Introduction

During the emergence of COVID-19, the transition of in-person to online learning, and then post-shifting to hybrid learning, this disruption is compelling policymakers to conceive fresh strategies to enhance student engagement, ensure all-encompassing digital learning setups, and surmount the challenges inherent in this transition. In 2015, the United Nations set an agenda for the vision of 2030 and proposed 17 sustainable development goals (SDGs). SDG-4 is based on education to improve the quality of education at all levels. The last few years have witnessed how the COVID-19 pandemic affected global education. School closures occurred because of the pandemic; consequently, 86% of students were affected, with 147 million children unable to attend school and in-person classes (Abbas *et al.*, 2024; UN, 2022; UNESCO, 2022). The impact of COVID was significant on students' learning, such as their change in emotions during the online e-learning classes, and this leads to behavioral changes that are analyzed by AI-based deep learning models (Bhardwaj *et al.*, 2021; Bhaik *et al.*, 2022). In academia, e-learning is not a new concept; it happened before COVID-19 but got attention during COVID-19 due to continuing education and reduced learning loss due to the pandemic. During the pandemic, educational institutions, significantly higher education institutes (HEIs), initiated steps toward the continuation of education through online teaching (i.e., emergency remote teaching) (Portillo *et al.*, 2020). Rapidly transforming the mode of education from in-person to online learning negatively affects the objectives of educational activities regarding course content and academic performance (Hafeez, Naureen and Sultan, 2022; Sastre-Merino *et al.*, 2020). According to Martín-Núñez *et al.* (2022), the drawbacks of emergency remote teaching are a lack of interpersonal contact and adaptability. In a contrary study, Mexican private university

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students already have experienced digital adoption in terms of familiarity with digital resources (Aguilera-Hermida *et al.*, 2021).

During different waves of COVID-19, all HEIs closely monitored pandemic scenarios and government educational policies. Based on the latest pandemic scenario and national and international educational policies, most HEIs developed and adapted new educational approaches and models to continue academic activities. For example, all educational activities were halted during the first quarter 2020. Then, steadily, with time, academic activities were held online (i.e., e-learning). These policies and modalities impacted teachers', students', and parents' performance and emotions (Rodríguez-Galván *et al.*, 2022). The rapid change in the learning process (Wasif, Munir and Shad, 2011), which heavily relies on digital technologies, has led to several effects. Most noticeable is that the educational transformation to digital learning burdened learners (Iivari, Sharma and Ventä-Olkkonen, 2020). On the contrary, perceived advantages encompassed establishing a digital learning community, enhancing students' proficiency in digital learning, and maintaining connections during challenging periods (Li, 2022).

The COVID-19 pandemic significantly influenced the adoption of hybrid learning. It is worth noting, however, that distance education has been present since the 1700s, as Harting (2005) reported, citing the development of the correspondence school model, which subsequently progressed with integrating innovative technologies and resources. The introduction of the personal computer and, more specifically, the internet and related technologies have facilitated the proliferation and mass adoption of distance learning (Harting, 2005; Moore and Kearsley, 2011). Over the years, several authors have analyzed both the advantages and disadvantages of online and blended learning approaches for students and learners. O' Shea, Stone and Delahunty (2015) outlined the benefits of virtual learning, including the option to engage online and the flexibility and independence provided by web-based instruction. The authors report that despite being "virtual" students, they still experience a sense of community on their college campus due to a supportive learning atmosphere.

Nonetheless, several authors have also discussed different challenges blended and online learning models impose. Kozma (1994) identified the technological challenges learners face due to the rapid evolution of tools and software, which could lead to frustration in the learning process. Since the widespread adoption of blended and online learning content, researchers have tried to understand the benefits and challenges of this learning model. Song, *et al.* (2004) identified that some challenges for online learning were the lack of sense of community, time management by learners for online courses, confusion about course objectives and information overload, communication and assessment barriers and challenges, and students' different levels of digital literacy.

After the pandemic, things are moving toward normalization. The hybrid educational model is still a milestone toward normalizing and continuing educational activities. This model allows students to start their in-person academic activities partially. This model is also technology-driven, with in-person or online learning options. Several studies highlight that the change in the mode of education during COVID-19 (Samawi and Al-kreimeen, 2022) affected students' academic performance. Other reasons for technostress are adaptation to digital tools in a short time of isolation with no physical interaction with peers and teachers.

As a step toward normalization, Tecnologico de Monterrey (TEC) developed and implemented a new hybrid educational model called HyFlex+Tec (Abbas, Martín-Núñez and Iqbal, 2022; Galvis and Carvajal, 2022). After implementing the HyFlex+Tec educational model, the Tecnologico de Monterrey became the first HEI in Mexico to partially start in-person educational activities (Rodriguez-Paz *et al.*, 2021). HyFlex+Tec is based on a hybrid learning environment, offering students options for in-person and online degree courses (Lin, 2021). The concept of HyFlex+Tec is to invite professors to physically come to the classroom and give lectures using multimedia tools; 50% of students physically attend the talks, whereas the remaining 50% attend online (Ward, 2004). On a weekly rotation basis, students take their in-person or online classes. In this new hybrid learning environment, students continue their course activities.

Implementing blended learning education allows higher education institutions to take action towards environmental sustainability. Hall and Mooney (2010) state that the inefficient use of fossil fuels in commuting to campus and in the production and distribution of printed materials associated with face-to-face education provides a valuable argument for the sustainability of the hybrid education model.

1.1 Objective of the Study

This study aims to empirically explore students' opinions about the role of technostress in the relationship between the perceived hybrid learning environment and academic performance. We deployed an online survey

among Tecnologico de Monterrey undergraduate students in Mexico to achieve this objective. After data collection, we statistically analyzed quantitative data using open-source Jamovi software to test all proposed hypotheses and draw conclusions.

2. Background

The online learning concept is not new; it has been implemented in educational settings for decades (Harasim, 2000). The purpose of this was to promote education at all levels. The concept of hybrid education was initially started in the 1970s and 1980s, when firms trained their employees using video, and questions were sent to the instructor through email. Later, in academics, the concept of hybrid learning was introduced by Stanford University Interactive TV network to deliver Professors sessions, and students submit their work online for review. Later, in the 1980s and 1990s, the mode of instruction was transformed to digital media, where recorded video lectures were stored on CD-ROMs.

Meanwhile, Learning Management Systems (LMS) were introduced and implemented in the HEIs to manage and promote educational activities such as course registration, material, discussion, and so on (Tritsch, 2021). In 1998, web-based instructions were introduced, and all course materials were available online. Since 2000, the hybrid learning environment has continuously emerged and is considered flexible regarding availability (Güzer and Caner, 2014). The new term adopted for hybrid learning is HyFlex, where offered courses provide opportunities for both online and face-to-face, the medium of instruction to the students where traditional flipped classrooms were not providing flexibility (Binnewies and Wang, 2019). The concept of the HyFlex mode is to encourage students to engage and continue their education during the pandemic (Miller, Sellnow and Strawser, 2020).

The critical contributions of the paper are as follows:

- Evaluating the Hybrid learning model, post-pandemic.
- Identifying the technostress as a risk factor in hybrid learning.
- Analysis reveals that academicians and students suffer from emotional and mental stress.
- Academicians/students prefer to interact in person rather than online or hybrid.

3. Relevant Literature Review and Hypotheses Development

3.1 Perceived Hybrid Learning Environment

Education continues to go through different transformation stages after the pandemic crisis. Most of the HEIs around the world are now implementing the hybrid model. The hybrid education model provides students a hybrid learning environment combining physical and digital interactive environments to enhance engagement and promote shared learning during classes (Cook and Holley, 2022). The hybrid learning environment primarily combines in-person and online modalities that provide a meaningful learning experience and is considered less complicated (Bozkurt, 2022; Mcdonagh, 2023) than the online or in-person educational model. Hybrid learning offers a study environment with an active engagement approach to get better outcomes by utilizing computers and the internet. However, the abrupt introduction of remote education due to the COVID-19 pandemic created anxiety among students due to their unfamiliarity with new software, as well as among educators regarding how to manage lecture activities (O'Ceallaigh, Connolly, and O Brien, 2023; Rosi, Abdurrahman and Wahyuni, 2022). Hodges, *et al.* (2020) note that the rapid shift from in-person classes to entirely online or hybrid models in response to disruptive events should be referred to as Emergency Remote Teaching (ERT), which has distinct characteristics and effects compared to traditional online learning (OL). The sudden shift to online education during the pandemic presented difficulties, including inadequate preparation for learners. Though some had prior experience with online classes, the complete transition to full-time online learning was challenging for some individuals. Many students had to return to their homes, facing challenges caused by the digital divide in internet connectivity. They also experienced a sudden loss of social interaction with both peers and instructors. Furthermore, the instructors' varying levels of familiarity and training with online teaching affected the quality of learning. Finally, the pandemic placed an enormous burden on educators and students, resulting in significant disruptions to their daily lives inside and outside the university (Hodges *et al.*, 2020).

However, online education allows HEIs to reach a broader, more diverse student population, transcending geographical boundaries and time constraints (Allen and Seaman, 2013). This benefits students who may not have access to traditional on-campus programs, improving their educational opportunities and potential career prospects. Online and hybrid teaching models have provided students with greater flexibility in course delivery.

Learners can now balance their academic interests with their professional and personal responsibilities (Hodges *et al.*, 2020).

3.2 Technostress

Incorporating technology into Higher Education Institutions (HEIs) has yielded various advantages. Technology-assisted learning systems have simplified access to information, enabling students to participate in customized and self-directed learning experiences (Bates, 2019). The potential for collaborative education has grown with digital platforms and resources, encouraging student involvement in virtual team projects and global knowledge exchange (Gikas and Grant, 2013). Moreover, technology has proven advantageous to academia by aiding administrative tasks, enhancing student communication, and introducing innovative teaching techniques, including blended learning and flipped classrooms (Kaputa, Loučanová and Tejerina-Gaite, 2022). The integration of technology in higher education holds the potential to improve educational outcomes and equip students with necessary digital skills.

However, it is imperative to acknowledge the negative impact of technology overuse in higher education institutions on students and faculty. Extensive usage of digital devices and platforms leads to technostress, characterized by information overload, perpetual connectedness, and digital exhaustion (Ragu-Nathan *et al.*, 2008). Following the pandemic, introducing new educational practices (such as hybrid learning environments) proves excessively challenging (Skulmowski and Rey, 2020). Technology integration forces students to adapt to software and communication tools. As a result, individuals experience technological fatigue and stress during learning (Shen and Kuang, 2021). Such strain and fatigue caused by technology are known as "*technostress*" (Cao, Xu and Ali, 2023). Introducing new technologies in hybrid learning considerably burdens students with information, communication, and social overload (Olabode, Abayomi and Sunguh, 2019), causing a detrimental impact on their academic progress due to technostress. Higher education institutions are therefore advised to prioritize educating individuals on digital literacy and encouraging the cautious use of technology to manage technostress effectively. Efforts should be made to devise techniques that can mitigate undesirable effects, optimizing the benefits of technology in the education field while minimizing any possible disadvantages (Ribble, 2015).

3.3 Academic Performance

In the hybrid learning environment setting, students must adapt to learning technologies proactively and dynamically (Behzad *et al.,* 2022). In the pandemic scenario, education is transforming quickly, and no one expects prompt changes, which may hinder acceptance and adaptation. Adapting new norms, such as a hybrid learning environment, provides students with a platform and contemporary experience to access in-person and online modalities (Rodriguez-Paz *et al.*, 2021). The shift from in-person to online and online to in-person is also associated with academic performance (Bülow, 2022; Siron, Wibowo and Narmaditya, 2020). On the contrary, increasing technostress during the pandemic due to overload and using new applications and digital competencies becomes a challenge for students (Olabode, Abayomi and Sunguh, 2019; Olivares *et al.*, 2021). Therefore, academic performance is associated with the hybrid learning environment, and technostress mediates such a relationship.

3.4 Mediating Role of Technostress Between Hybrid Learning Environment and Academic Performance

Technostress plays a significant role in the performance evaluation of hybrid learning; that is why 'Hyflex+Tec' has been proposed. I suppose the technostress mediates in both actors, i.e., academician and student performance, because of associated parameters. For instance, overload of delivering lectures and excess of perceiving talks, negative emotions due to sitting for long hours at the screen, less social life, an adaptation of AI-based learning (Cao, Xu and Ali, 2023; Regan *et al.*, 2012; Rodríguez-Galván *et al.*, 2022) which is itself sometimes challenge for academician those are not hands-on ICT (Sharma and Gupta, 2023). In summary, it has both direct and indirect impacts.

3.5 Research Problem

H1: A perceived hybrid learning environment is associated with academic performance.

H2: A perceived hybrid learning environment is associated with technostress.

H3: Technostress is associated with academic performance.

H4: Technostress mediates the relationship between the perceived hybrid learning environment and academic performance.

3.6 Need of Study

Proposing new theories should not always be correct. Every solution has its advantages and limitations. Similarly, during the COVID-19 pandemic, fully online learning was initially preferred due to the lockdown because no other options were available. Later, the hybrid learning trend started when COVID-19 began to normalize slowly and steadily. It comes under general practice after every implementation; there must be rigorous evaluation to explore the accuracy and sensitivity of the proposed solution because, practically, the ground situation is much different due to several unseen parameters. Due to this, we have taken the survey to perform the regression analysis, and we found that technostress is a crucial factor among students. It impacts health in terms of anxiety, high blood pressure, depression, sedentary lifestyle, etc., which leads to other non-communicable diseases. Not only this but this technostress is also correlated to privacy and data breaching of sensitive information.

4. Research Design and Methods

4.1 Research Design

This empirical study highlights the perception of hybrid learning environments through the HyFlex+Tec model in Tecnologico de Monterrey. Furthermore, investigating the impact of technostress in the hybrid learning environment of the education setting of HEIs. For a better understanding of the impact of technostress in a hybrid setting, we designed and online distributed a Google Form among undergraduate students through a convenient sampling approach. Empirical findings provide in-depth insights into the mediating role of technostress within a hybrid learning environment and its effects on students' academic performance.

4.2 Participants and Procedure

The participants of this study were final year undergraduate students currently enrolled in four schools of Tecnologico de Monterrey, i.e., (1) School of Architecture, Arts and Design, (2) School of Government and Public Transformation, (3) School of Business, and (4) School of Science and Engineering. All participants do not have prior experience of e-learning or hybrid learning. During the first and second quarters of 2021, the online survey was distributed through a convenient sampling approach. In this period, students gradually moved from hybrid to in-person learning mode. So, all students have an experience of the hybrid learning environment. For data collection, we requested anonymous professors to distribute the survey link during their lecture sessions conveniently. After the cutoff date of the online survey, we received 94 complete responses out of 127.

4.3 Measurements

The online survey contains a set of questions related to (1) demographic information, (2) perceived hybrid learning environment, (3) technostress, and (4) academic performance.

1. **Demographics information:** contains questions about gender, age, specialization, and scholarship of undergraduate students.
2. **Perceived hybrid learning environment:** The first construct we adapted four times from the published work of Butz and Stupnisky (2016) contains a 5-point Likert scale with a reliability value of α=0.659.

- I can bridge the gap to connect with online – and on-campus students.
- Interaction with my online campus classmates enables me to form meaningful relationships.
- I can overcome barriers that prevent me from building friendships with online, on-campus students.
- I can develop social relationships with my online campus classmates.

3. **Technostress:** For the second construct, we adapted six items from the work of Galvin, *et al.* (2021) and measured with a 5-point Likert scale, with a reliability value of α=0.725.

- A hybrid learning environment (HyFlex +Tec) creates problems I would otherwise experience.
- I feel pressured due to the hybrid learning environment (HyFlex +Tec).
- The capabilities provided by a hybrid learning environment are reliable.
- A hybrid learning environment (HyFlex +Tec) behaves highly consistently.
- A hybrid learning environment (HyFlex +Tec) enables others to have access to me.
- A hybrid learning environment (HyFlex +Tec) enables me to be in touch with others.

4. **Academic performance:** We adapted four items from Trockel, Barnes and Egget (2000) work for the third construct. These items were measured with a 5-point Likert scale, with a reliability value of α=0.725.

- In a hybrid learning environment (HyFlex +Tec), I often (online-on-campus) meet my academic needs.
- I often manage time and meet responsibilities in a hybrid learning environment (HyFlex +Tec).
- I often feel anxious or worried in a hybrid learning environment (HyFlex +Tec).
- In a hybrid learning environment (HyFlex +Tec), I often feel overwhelmed by the time pressure.

Cronbach alpha value of all constructs was per Cronbach's (1951) and Kaiser's (1974) set criteria of data reliability, that is, $\alpha>0.6$

4.4 Statistical Analysis

After data collection, we applied the data cleaning and pre-processing steps for better regression analysis. As the data was collected, we assigned labels to all the variables and numeric codes to each response. After data curation, we analyzed the empirical data using the Jamovi software application. Firstly, we applied descriptive statistics to obtain the summary of demographic information by frequency and percentage. Secondly, we performed Pearson's correlation to test the association between variables. Thirdly, we applied factorial analysis to test the goodness fit of the model. Finally, we used a mediation test to confirm the influence of the mediator (technostress) between the independent (perceived hybrid learning environment) and dependent (academic performance) variables. The following section discusses the results of the descriptive statistics, correlation, confirmatory factor analysis, and mediation test.

5. Analyzed Results

5.1 Common Method Bias

Before formal analysis, we applied the common method bias to ensure that the data was free from discrimination. To verify data bias, we combined all 18 items of the three variables and applied principal component analysis, selecting "None" as the rotation method and setting the number of components to 1. We get a 48.6% variance, which is less than 50%, meaning that the data is not biased (Fuller *et al.*, 2016).

5.2 Demographics of the Participants

In Table 1, we present the demographics of the participants based on frequency and percentage: 48 (51.1%) out of 94 students were female, and the remaining 46 (48.9%) were male. 35 (37.2%) of the students were aged between 18 and 21, and 45 (62.8%) were 22 years and above. Most students specialized in social science and management, 34 (36.2%), and 60 (63.8%) specialized in IT and engineering. We did not receive any response from students majoring in natural sciences. 47 (50%) students held full scholarships, and the remaining 47 (50%) self-financed their studies.

Table 1: Demographics of the participants based on frequency and percentage

	Frequency	Percentage (%)
Gender		
Female	48	51.1%
Male	46	48.9%
Age		
18 and 21 years	35	37.2%
22 years and above	45	62.8%
Specialization		
IT and Engineering	34	36.2%
Social Sciences and Management	60	63.8%
Scholarship		
No	47	50%
Yes	47	50%

Source: Own calculation

5.3 Correlation Analysis

In Table 2, Pearson's correlation analysis results show the significant association between all three variables, i.e., perceived hybrid learning environment, technostress, and academic performance. The perceived hybrid learning environment has a positive significant correlation with academic performance (r=0.723, p<.001), whereas technostress is also significantly associated with academic performance (r=0.664, p<.001).

Table 2: Correlation analysis results

	PHLE	TS	AP
PHLE	–		
TS	0.815***	–	
AP	0.723***	0.664***	–

Note; PHLE=Perceived hybrid learning environment; TS=Technostress; AP=Academic performance; Level of significance ***p<0.001

Source: Own calculation

5.4 Confirmatory Factor Analysis (CFA)

The factorial analysis technique is helpful to test the proposed research model. So, for the goodness of fit test, we applied the factorial analysis technique known as confirmatory factor analysis (CFA). The CFA test aims to propose and validate a research model through exact fit and fit measures. The based value of "test for exact fit," i.e., χ^2/df=1.89, is within the acceptable range, i.e., χ^2/df<3.00. The base value of "*fit measures*" is within the set reasonable fit range, i.e., CFI=0.896, TLI=0.872, RMSEA= 0.0971, and RMSEA 90% CI (Lower=0.0720, Upper=0.122). So, the value of "*test for exact fit*" and "*fit measures*" was in accordance with Abbas, *et al.* (2021) and Xia and Yang (2019) set criteria for goodness of fit statistics for the measurement of a model.

5.5 Hypotheses Testing

In this section, we explain our analyzed regression results, which include the total, indirect, and direct effects.

In Table 3, the analyzed regression results show that a perceived hybrid learning environment is associated with academic performance. In Table 3, the results support **H1**: (β=0.644, p<.001). Similarly, in Table 4, β=0.723 (p<.001), thus supporting **H2**: Perceived hybrid learning environment is associated with technostress. Given the analyzed results in table 5, **H3** (β=0.701, p<.001) and **H4** (β=0.410, p<0.065) are also supported. Technostress is associated with academic performance and mediates the relationship between a perceived hybrid learning environment and academic performance. The value of 95% confidence interval (CI) and absence of zero between lower and upper bounds confirm that full mediation exists.

Table 3: Total effects predicting: Academic performance

				95% C.I.				
Name	Effect	Estimate	SE	Low	Upper	β	Z	p
PHLE	PHLE	0.841	0.0982	0.649	1.034	0.644	8.57	p<.001

Note. PHLE=Perceived hybrid learning environment; C.I.=Confidence Interval; β=Beta; Level of significance= *p<0.05, **p<0.01, ***p<0.001

Source: Own calculation

Table 4: Dependent variable: Technostress

				95% C.I.				
Name	Effect	Estimate	SE	Low	Upper	β	Z	p
PHLE	PHLE	0.951	0.094	0.767	1.134	0.723	10.14	p<.001

Note. PHLE=Perceived hybrid learning environment; C.I.=Confidence Interval; β=Beta; Level of significance=p

Source: Own calculation

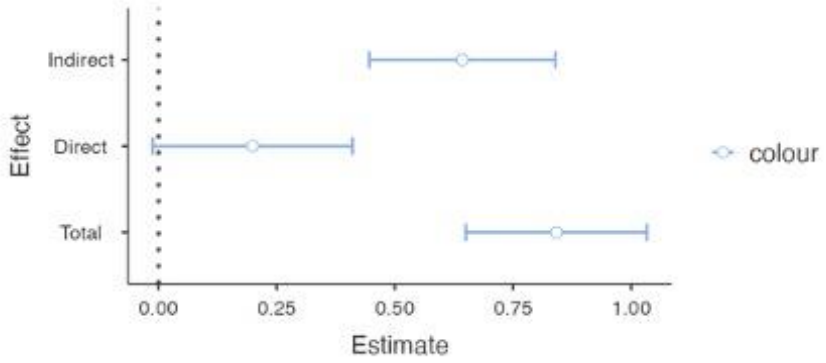
Table 5: Full model predicting: Academic performance

				95% C.I.				
Name	Effect	Estimate	SE	Low	Upper	β	Z	p
TS	TS	0.676	0.0819	0.515	0.836	0.701	8.25	<.001
PHLE	PHLE	0.199	0.1077	-0.012	0.648	0.410	1.85	0.065

Note. PHLE=Perceived hybrid learning environment; C.I.=Confidence Interval; β=Beta; Level of significance=p

Source: Own calculation

The estimation plot shows that the total effect has a higher estimate. After introducing the mediator, the indirect impact is lesser than the direct effect, which indicates complete mediation (see Figure. 1).



Source: Own compilation

Figure. 1: Estimate plot (Total, direct and indirect effect)

6. Discussion

In the discussion section, we discuss the proposed hypotheses and the analyzed findings of this empirical study. The results thoroughly explore the mediating role of technostress among perceived hybrid learning environments and students' academic performance. Furthermore, this section thoroughly discusses our empirical findings with the support of existing literature.

First, this study confirms that a perceived hybrid learning environment is associated with academic performance. Rodriguez-Paz, *et al.* (2021) argued that successfully implementing a hybrid learning environment supports students to accept new norms during the pandemic and ensures the promotion and continuation of quality education at all levels. During COVID-19, the shift in the learning mode resulted in benefits and challenges among students (Li, 2022). In the Mexican context, students at a private university have previous experience with and access to digital resources. In some cases, HEIs support their students by providing them with internet access and digital devices (Aguilera-Hermida *et al.*, 2021) for the continuation of study and improvement of performance.

Although many students had prior experience with online learning, the sudden transition from face-to-face teaching to entirely online and hybrid learning imposed new challenges on both learners and educators. Wang, Tan and Li (2020) similarly suggest that mismatches between students' characteristics, needs, abilities, and technological and educational contexts can result in technostress. This can occur when there is a mismatch between the student's characteristics and the learning environment, potentially resulting in frustration, anxiety, or decreased learning outcomes (Wang, Tan and Li, 2020). Similarly, faculty members are also affected. Multiple studies indicate that the abrupt transition to online education and the increased reliance on technology for teaching, communication, and administrative tasks due to the pandemic have led to greater levels of technostress. The proposition is that while the use of technology and blended learning was not unfamiliar to either faculty or students, the sudden and complete shift from face-to-face education to online and hybrid learning within a limited timeline proved to be a challenging experience for learners and faculty alike, particularly in instances where there was a mismatch between a person and their educational environment, with no other available learning model as an option (Wang, Tan and Li, 2020; Boyer-Davis, 2020).

The second finding confirms the associations between the perceived hybrid learning environment, technostress, and students' academic performance. According to Alexa, *et al.* (2022), COVID-19 affects the learning process, student focus, load, and communication between teachers and peers. So, the change in modality during the pandemic and the implementation of hybrid educational models in educational settings also exert emotional effects. One of the factors of such impacts is technostress. Technostress is associated with the heavy use of IT or information technologies in specific settings (Tarafdar *et al.*, 2007).

Lastly, technostress mediates the association between the perceived hybrid learning environment and students' academic performance. Technostress is a mediator. Olabode, Abayomi and Sunguh (2019) mentioned that technostress occurs due to failure to cope with emotional and psychological discomfort with the high possibility of regularly engaging with digital technologies. Handayani and Sulastri (2022) argued that technostress is associated with the inability to use new technologies, which impacts the health and performance of the users. Therefore, students primarily engage with and switch between in-person and online learning in the hybrid learning environment. This may affect motivation, technical issues, and a lack of interaction with peers and teachers. Adapting to the hybrid learning environment (Lorenzo-Lledó *et al.*, 2021) causes anxiety and stress in their daily routine and affects their academic performance. The significance of this study is not to make the teaching methods more complex so that they have an adverse impact on mental and physical growth. Christian, Purwanto and Wibowo (2020) explores the results obtained by the analysis using SPSS, which shows that online and hybrid learning increases the stress level for teachers and students by adding an extra load.

7. Conclusions

The evaluation of hybrid learning is a serious concern. This study will help educationists update or bring new reformations to the current model to excel in the current approach. Due to this, the proposed results obtained from regression analysis concluded that technostress fully mediates the relationship between the perceived hybrid learning environment and students' academic performance. Technostress mediates due to the continuous change in modalities, which burdens students as they must learn and adapt to new digital tools to participate in course-based activities. The other cause of technostress is the hybrid learning environment, where students attend classes in person and online. This shift in modalities causes technostress, affecting students' academic performance. However, it also has limitations in that the collected data is from one university campus, but this will open the gate for future researchers to extend our work and deploy an online survey to all 26 Tecnologico de Monterrey campuses or other academic institutions. This will enhance the understanding related to the acceptance of hybrid educational models and their effects on student's academic performance.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Asad Abbas: Conceptualization, literature review, research design, survey design, data collection, data curation, formal data analysis, validation, writing—final draft, revisions and editing.

Guillermina Benavides Rincón: Literature review, data collection, writing—review, revisions, and editing.

Liya Wang: Writing—review and comments.

Mohammad Khubeb Siddiqui: Literature review, writing—review, comments, revisions, and editing.

All authors read and approved the final manuscript.

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