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Learner Characteristics and Learners' Inclination towards Particular Learning Environments

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Abstract: In addition to a face-to-face classroom learning environment, today's learners in higher education are likely to have also experienced a blended learning or an online learning environment. These learning environments not only differ in their delivery modes, but also learning activities, class interactions, assessment approaches, etc. Learners tend to have differing perceptions about the effectiveness of different learning environments. This study therefore investigates whether the reasons learners like or dislike a learning environment reveal learner characteristics that may explain why some learners are more inclined towards a particular learning environment. This study also examines whether learner demographics influence learner characteristics and their preference for a particular learning environment. Using an exploratory sequential mixed methods research design, this study first conducted several focus group discussions and then administered an online questionnaire survey to collect input from students at a local university. Analyses derived four learner characteristics (i.e. desire for direct support, digital readiness, learning independence, and online hesitancy) based on the reasons why the students liked or disliked face-to-face classroom learning, blended learning, or online learning environments. A cluster analysis further distinguished the students into three groups (i.e. classroom learners, insecure learners, and online learners) based on the four learner characteristics. Analyses also found that learners' demographics largely had no effect on learners' characteristics and their preference for a particular learning environment. The findings suggest that learner characteristics may provide a clue to why certain learners have a preference for a face-to-face classroom learning, a blended learning, or an online learning environment. A better understanding of the relationship between learner characteristics and learners' inclination towards a particular learning environment can be helpful to educational institutions and academics to design a range of engaging learning activities for learners with different characteristics.

Keywords: Learner characteristics, Learner demographics, Learning activities, Learning environments, Learning needs

1. Introduction

Teaching and learning in today's higher education can occur through various delivery modes. Besides the conventional face-to-face classroom learning mode, blended learning and online learning have become two increasingly popular alternatives for learners and educational institutions. However, teaching and learning in a blended learning or an online learning environment is different from that of a face-to-face classroom learning environment (Nortvig, Petersen and Balle, 2018; Thai, De Wever and Valcke, 2020). Some learners may be more comfortable with face-to-face classroom learning, while others may prefer online learning (Kauffman, 2015).

Different learners learn differently (Jamiah, Mahmud and Muhayyang, 2016), and learner characteristics affect how they learn (Kauffman, 2015). Past studies have attempted to distinguish learner characteristics in different ways. For example, competences, culture, personality traits, learning goals (Abyaa, Idrissi and Bennani, 2019); ethnic background, intellectual capital, cognitive relevance of prior knowledge (Maringe and Sing, 2014); and educational experience, learning approaches, self-esteem, motivation, flexibility, social background (Thomas and May, 2010). As learner characteristics differ, their learning strategies may vary (Abyaa, Idrissi and Bennani, 2019). Because of their individual differences, learners may also display different behaviours and have different expectations in their learning (Barker, 2012).

The current trend towards blended learning and online learning in higher education makes it increasingly crucial for higher education to explore learner characteristics at greater depth. Even though a vast number of learner characteristic variables have been proposed, Drachsler and Kirschner (2012) assert that defining and measuring learner characteristics is still an intricate endeavour. Furthermore, many past studies in this context mainly focused on online learning. Only a few were about blended learning or flipped classrooms (e.g. Balaban, Gilleskie and Tran, 2016; Kintu, Zhu and Kagambe, 2017; Roehling et al., 2017), or a comparison between face-to-face classroom learning and online learning (e.g. Fendler, Ruff and Shrikhande, 2016; Zacharis, 2011). There has not been much investigation of all three learning environments in the same study.

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To increase student engagement, it is important for lecturers to have an understanding of and adapt to the learning needs of learners (Bengtsen and Barnett, 2017). A learning environment that recognises individual student learning needs and interests would more effectively engage the students (Hockings, 2011). However, as student diversity is multidimensional, designing a learning environment to meet the diverse learning needs of all students from different backgrounds can be challenging (Hockings, Brett and Terentjevs, 2012).

In view of the research gaps in the relationship between learner characteristics and learning environments in past studies, it is timely now to re-examine the learner characteristics that are more current and relevant to today's face-to-face classroom learning, blended learning, and online learning environments. Academics would be able to better deliver positive learning experiences for individual students by first understanding the characteristics and motivation of the students (Vanslambrouck et al., 2018).

A casual conversation with some university students about their individual preferences for a learning environment inspired this study. The students basically gave different reasons why they liked or disliked a particular learning environment. This study is based on the premise that the reasons learners like or dislike a learning environment provide insights into the role of learner characteristics in explaining why learners have a preference for a particular learning environment over others. This study therefore aims to answer two research questions: (1) whether the reasons learners like or dislike a learning environment reveal learner characteristics that may help explain why some learners are more inclined towards a particular learning environment; and (2) whether learner demographics influence learner characteristics and their preference for a particular learning environment. However, this study does not imply that placing learners in their preferred learning environment is a prerequisite for them to perform well in learning.

The following sections review learner characteristics and the research gaps that exist in past studies, introduce the research methods, present the data analyses and findings, and conclude the paper with a discussion of implications for practice, research limitations, and future research directions.

2. Literature review

2.1 Learner Characteristics

Considering that students are more diverse in large classes (Maringe and Sing, 2014), Abyaa, Idrissi and Bennani (2019) stress that the one-size-fits-all style of teaching and learning may have a deterrent effect on student learning effectiveness. When designing an inclusive pedagogy, Hockings (2010) suggests considering a range of individual differences; e.g. social classes, ethnic backgrounds, full-time or part-time students, work and life experiences, learning approaches, and the effect of these differences on learning. Knowing about such learner characteristics can help academics adjust their teaching strategies and activities for more effective learning, and provide better support for their students (Ghorbani and Montazer, 2015; Law, Geng and Li, 2019).

Past studies have not shown a clear consensus over the characteristics that can be used to best describe the diverse learners. Some researchers have attempted to categorise the wide-ranging characteristics of learners. For example, Thomas and May (2010) propose four dimensions: educational (e.g. skills, educational experience, learning approaches); dispositional (e.g. self-esteem, motivation, attitudes); circumstantial (e.g. age, flexibility, disability); and cultural (e.g. values, ethnicity, social background). Abyaa, Idrissi and Bennani (2019) highlight six categories of learners' characteristics: learner profile (e.g. age, gender); knowledge characteristics (e.g. knowledge level, competences); cognitive characteristics (e.g. learning styles, working memory capacity); social characteristics (e.g. social interactions, culture); personality traits; and motivation characteristics (e.g. interests, learning goals).

Although past studies were generally in agreement that learner characteristics are multi-dimensional, some studies considered only the socio-demographic variables. Some examples of such studies include Balaban, Gilleskie and Tran's (2016) study of the impact of flipped classrooms on student performance; Firmin et al.'s (2014) study of student success in massive open online courses (MOOCs); and Wang, Shannon and Ross's (2013) study of the levels of self-regulated learning and self-efficacy of students in online learning. However, a consideration of only the socio-demographic variables provides a far too simplistic view of the interactions between learner characteristics and learning environments.

Some studies have attempted to add a few other variables besides socio-demographics. Examples of these other variables include enrolment goals and motivations for MOOCs (Kizilcec, Sanagustín and Maldonado, 2017); student motivation and patterns of orientation (Mertens, Stöter and Zawacki-Richter, 2014); and willingness to work in groups, to seek new production information, and to try new products (Karamanos and Gibbs, 2012). However, it remains uncertain the extent to which these additional variables are able to account for learners' preference for face-to-face classroom learning, blended learning, or online learning environments.

To measure learner characteristics, some studies attempted to adapt existing scales that were initially developed for a different research context. Examples of these existing scales include learning goal orientation and proactive personality (Kickul and Kickul, 2006); computer-mediated communication anxiety (Wombacher et al., 2017); motivation and self-regulation (List and Nadasen, 2017); and intrinsic motivation, computer attitude, computer anxiety (Stiller and Bachmaier, 2017). Although it is a good attempt to use existing scales that have been validated, exactly how specific and relevant these scales are to expounding how learners perform in different learning environments may require further investigation.

In addition, some variables of learner characteristics in past studies may be considered outdated in view of current trends in technology use. For example, average hours spent using a computer or the Internet (Simmering, Posey and Piccoli, 2009); computer facilities, Internet usage (Yang and Tsai, 2008); and Internet use, prior use of web applications (Karamanos and Gibbs, 2012). Increased accessibility to and greater familiarity with the Web and digital technology may have already made technology a non-issue for students in their consideration of a learning environment.

2.2 Learning Styles

Some past studies posit that learners differ in their learning styles. The concept of learning styles suggests that learners can be categorised into certain learning styles based on their preferred approach to information processing and understanding, and that when learning delivery is purposefully designed to match one's learning style, better learning performance can be expected (Drachsler and Krischner, 2012; Riener and Willingham, 2010). However, education researchers have refuted this concept as fundamentally flawed (Drachsler and Krischner, 2012; Newton and Miah, 2017; Riener and Willingham, 2010). Besides the fact that human cognitive activities entail not just one but multiple senses such as sight, hearing, or touch, there is no evidence to suggest that learners can learn better with a learning design which matches their learning style (Newton, 2015). It is also questionable to categorise learners into just one of a few learning styles when the validity of the instruments has not been established (Kirschner and van Merriënboer, 2013). Without taking the learning context and content into consideration, to mainly classify learners based on their learning styles may misinform learners that they can only learn effectively when a learning activity matches their learning style (Newton, 2015; Newton and Miah, 2017).

3. Research Methods

An exploratory sequential mixed methods research design was adopted for this study (Creswell and Creswell, 2018). First, this study collected qualitative data through focus group discussions to identify the variables for the development of a survey instrument. This instrument was then deployed in an online questionnaire survey to collect quantitative data for subsequent statistical analysis.

3.1 Focus Group Discussions

Several focus group discussions were conducted to collect input from university students on their reasons for liking or disliking face-to-face classroom learning, blended learning, or online learning environments. Students at a local university voluntarily participated in a total of five focus group discussions. Each discussion involved five randomly recruited participants from the diploma, bachelor's, or master's level. Their responses were coded and analysed using a qualitative software to reveal 26 common reasons, ranging across such themes as learning motivation, peer interaction, self-learning initiative, and learning attitude.

3.2 Online Questionnaire Survey

An online questionnaire survey was administered to collect data in preparation for a cluster analysis. A section of the survey instrument asked one question for each of the 26 reasons that were identified from the focus group discussions. All items were measured using a five-point Likert-type scale, 5 being "strongly agree" and 1 being "strongly disagree." Another section asked several demographic questions regarding gender, age, programme, education level, semester currently in, student status, and prior work experience.

Multiple announcements on the university's learning management systems (LMS) invited students to voluntarily participate in the survey. The data collection lasted about two weeks and received a total of 125 responses. A check was performed for multivariate outliers. Following the rule that a response is considered an outlier if the probability of its squared Mahalanobis distance is equal or less than 0.001 (Tabachnick and Fidell, 2019), 8 of the 125 responses were removed. Thus, 117 valid responses were used for later data analysis.

Of the 117 respondents, whose average age was 21.25 (SD=3.16), 52 (44.4.%) were female and 65 (55.6%) male. 94 of them (80.3%) were doing business-related studies and 23 (19.7%) computer-related studies. All of the respondents were full-time students. However, 28 (23.9%) of them were working part-time. A high percentage of them (76.1%) had prior work experience, while the remaining 23.9% did not. Table 2 provides a summary of the respondents' demographics.

4. Data analysis and Findings

4.1 Factor Analysis

In preparation for a cluster analysis, which aims to separate the respondents into groups based on their responses to the items which measure the 26 reasons why learners like or dislike the different learning environments, a factor analysis was first performed to reduce these items into a smaller number of factors (DiStefano, Zhu and Mîndrilă, 2009). Steinbach, Ertöz and Kumar (2004) highlight the need to reduce the number of variables for a cluster analysis as a large number may unwantedly produce marginal groups.

Both the KMO (>0.5) and Barlett's tests (p<0.05) were satisfactory for the factor analysis. To decide the deletion of items, two criteria were used: (1) items loaded <0.5 on any one of the factors, or (2) items cross-loaded >0.5 on two or more factors (Hair et al., 2014).

The first iteration extracted five factors, but one item had a low factor loading. After removing the item, there existed a simple structure of five factors. A following reliability analysis showed that all the factors had good Cronbach α (>0.8), except the fifth factor (.575). The fifth factor comprised two items. Because of the low factor reliability, both items were removed in the second iteration. A further third and fourth interaction removed two additional items that had a low factor loading. The final factor structure consisted of 21 items loaded on four factors. These factors were labelled *desire for direct support*, *digital readiness*, *learning independence*, and *online hesitancy,* respectively. The scores of these factors were saved for the subsequent cluster analysis.

Parallel analysis and Velicer's Minimum Average Partial (MAP) tests were conducted to further confirm the number of factors. Although the parallel analysis test suggested two factors, the revised MAP test (Velicer, Eaton and Fava, 2000) suggested four factors. Having considered the possibility that parallel analysis may under-estimate the number of factors when the first factor has a large eigenvalue (Beauducel, 2001) and taking into consideration the unidimensionality of the factors, it was decided to adopt a 4-factor model as suggested by the revised MAP test. Table 1 provides a summary of these factors.

Table 1: Factor analysis results

Items	Mean	SD	Desire for direct support	Digital readiness	Learning indepen-dence	Online hesitancy
I can learn better under direct supervision of lecturers.	3.87	.896	.853			
I like to get immediate response from lecturers.	4.20	.833	.783			
I like to meet others face-to-face in class.	4.00	.861	.783			
I prefer to ask lecturers directly whenever I have a doubt.	3.82	.943	.761			
I need regular guidance of lecturers in my learning.	3.68	.918	.758			
I like to use the physical facilities provided by the university.	3.63	.867	.671			
I like to have face-to-face interaction with others.	3.86	.870	.595			
I find it more attentive listening to lecturers in class.	3.69	1.078	.560			

Items	Mean	SD	Desire for direct support	Digital readiness	Learning indepen-dence	Online hesitancy
I am comfortable with using digital technologies.	3.75	.899		.902		
I feel comfortable interacting with others online.	3.45	1.087		.862		
I like the flexibility of where I want to learn.	3.76	.906		.612		
I like to seek new information.	4.02	.743		.558		
I like to review learning materials at my own pace.	3.58	.958		.506		
I am disciplined enough to learn on my own.	3.52	1.022			.895	
I am clear about my learning goals.	3.74	.853			.735	
I am keen to learn on my own.	3.49	1.014			.723	
I am motivated to learn on my own.	3.44	1.021			.620	
I find it tedious to download learning materials online.	3.21	1.055				.938
I feel lonely learning alone.	2.99	1.148				.629
I am easily distracted by activities that are not related to my learning.	3.36	1.062				.624
I find online learning materials not as interactive as face-to-face lectures.	3.53	1.022				.553
% of variance explained			29.202	25.647	6.263	5.189
Eigenvalue			6.132	5.386	1.315	1.090
Cronbach α			.890	.835	.876	.799

Note: KMO (.835); Bartlett's test (<.001); extraction method: Principal Components Analysis; rotation method: Promax

4.2 Cluster Analysis

To identify the clusters that are discrete, Oberski (2016) differentiates two types of model-based clustering approaches, i.e. latent profile analysis (or Gaussian finite mixture model) for continuous variables and latent class analysis (or binomial finite mixture model) for categorical variables. As this study used the factor scores from the factor analysis, a latent profile analysis was performed using R and the mclust package.

To determine the best data-fitting model and the number of clusters, the model-based clustering approach compares different models of parameterisations and number of clusters. The best model is the one with the highest Bayesian Information Criterion (BIC) value among the models (Boehmke and Greenwell, 2019; Fraley and Raftery, 2007). Besides the BIC value, the integrated complete-data likelihood (ICL) value is also a useful criterion (Scrucca et al., 2016).

Figure 1 depicts the fitted models and their BIC values from the mclust analysis. The three-cluster VVI model had the highest BIC value (-1271.545). The best ICL criterion (-1289.299) also provided the support for a VVI model of three clusters. A VVI model indicates that the three clusters contain different number of cases and each has a different shape. In addition, the clusters have a diagonal distribution with an orientation parallel to the axes (Boehmke and Greenwell, 2019).

The three clusters comprised 81 (71%), 6 (5%), and 30 (24%) of the total 117 respondents, respectively. Considering the learner characteristics (and their relative means) that each of the three clusters is particularly associated with, the clusters are labelled classroom learners, insecure learners, and online learners, respectively. Figure 2 depicts the means of desire for direct support, digital readiness, learning independence, and online hesitancy of each group. The classroom learners show relatively higher means than the insecure learners and online learners in desire for direct support and online hesitancy, but lower means than the online learners in digital readiness and learning independence. The insecure learners show relatively lower means than the classroom learners and online learners in desire for direct support, digital readiness, and learning independence, but a higher mean than the online learners in online hesitancy. A direct opposite to the classroom learners, the online learners show relatively higher means than the classroom learners and insecure learners in digital readiness and learning independence, but lower means than the classroom learners in desire for direct support and online hesitancy.

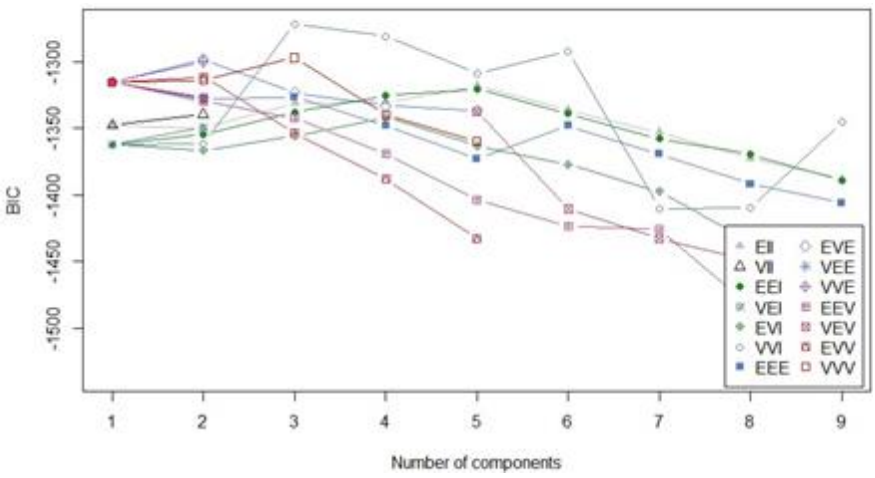
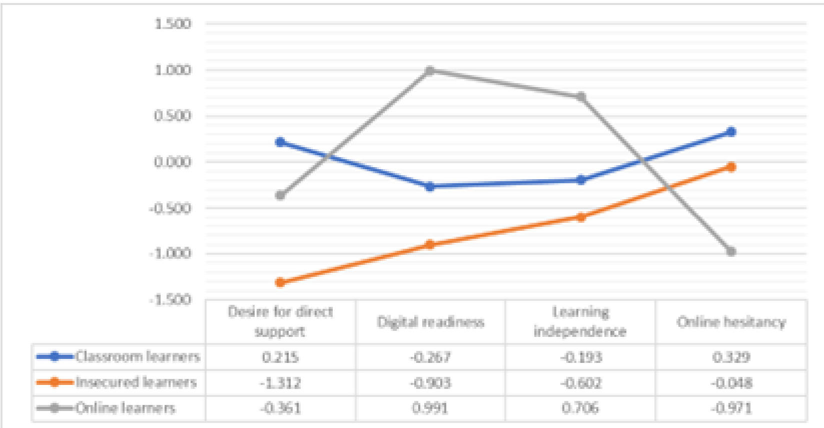


Figure 1: The BIC values and models



	Desire for direct support	Digital readiness	Learning independence	Online hesitancy
Classroom learners	0.215	-0.267	-0.193	0.329
Insecured learners	-1.312	-0.903	-0.602	-0.048
Online learners	-0.361	0.991	0.706	-0.971

Figure 2: Means of learner characteristic

Figure 3 depicts the result of a classification analysis. The respondents were allocated to the individual groups at an uncertainty rate of less than 95%, providing the evidence of high membership probability of at least 95% for each respondent.

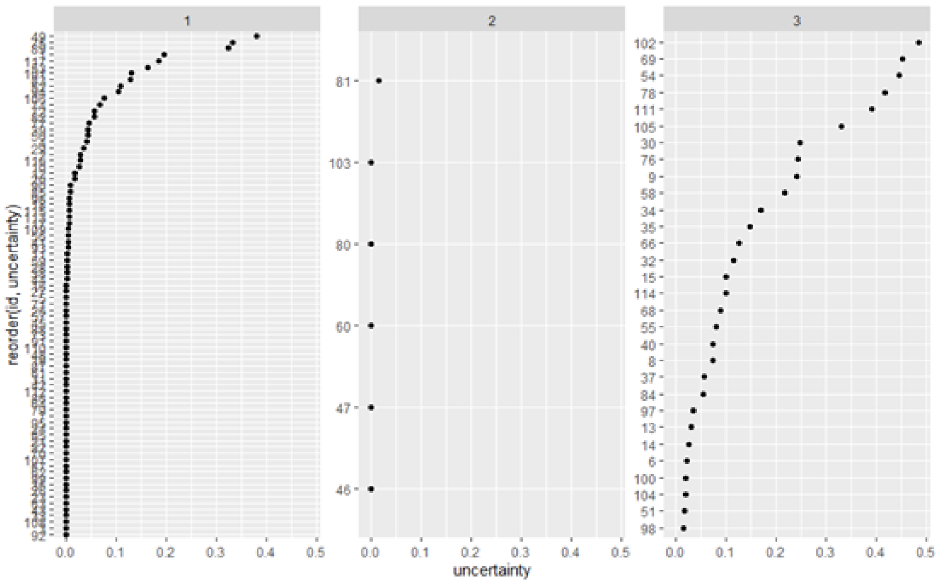


Figure 3: Classification analysis

Table 2 provides a summary of the respondents' demographics, categorised by classroom learners, insecure learners, and online learners. The respondents were spread across the three groups and their numbers differed in terms of gender, programme, education level, semester, student status, and work experience.

Table 2: Respondents' demographics

Respondents' demographics	Full sample (n=117)	Classroom learners (n=81)	Insecure learners (n=6)	Online learners (n=30)
Age (mean)	21.25 (SD=3.16)	21.14 (SD=3.07)	21.00 (SD=2.10)	21.60 (SD=3.61)
Gender				
Female	52 (44.4%)	39 (48.1%)	2 (48.1%)	11 (36.7%)
Male	65 (55.6%)	42 (51.9%)	4 (51.9%)	19 (63.3%)
Programme				
Accounting and Finance	18 (15.4%)	12 (14.8%)	1 (16.7%)	5 (16.7%)
Business Administration	19 (16.2%)	13 (16.0%)	2 (33.3%)	4 (13.3%)
Business Information Systems	9 (7.7%)	6 (7.4%)	--	3 (10.0%)
Computing	14 (12.0%)	10 (12.3%)	--	4 (13.3%)
Logistics Management	21 (17.9%)	15 (18.5%)	1 (16.7%)	5 (16.7%)
Management	16 (13.7%)	10 (12.3%)	1 (16.7%)	5 (16.7%)
Marketing	10 (8.6%)	8 (9.8%)	1 (16.7%)	1 (3.3%)
MBA	10 (8.5%)	7 (8.6%)	--	3 (10.0%)
Education level				
Diploma	44 (37.6%)	28 (34.6%)	3 (50.0%)	13 (43.3%)
Bachelor's degree	62 (53.0%)	46 (56.8%)	3 (50.0%)	13 (43.3%)
Master's degree	11 (9.4%)	7 (8.6%)	--	4 (13.3%)
Semester				
1st semester	28 (23.9%)	22 (27.2%)	2 (33.3%)	4 (13.3%)
2nd semester	27 (23.1%)	19 (23.5%)	2 (33.3%)	6 (20.0%)
3rd semester	38 (32.5%)	27 (33.3%)	2 (33.3%)	9 (30.0%)
4th semester	8 (6.8%)	5 (6.2%)	--	3 (10.0%)
5th semester	6 (5.1%)	4 (4.9%)	--	2 (6.7%)
6th semester or later	10 (8.5%)	4 (4.9%)	--	6 (20.0%)
Student status				
Full-time student and not working part-time	89 (76.1%)	66 (81.5%)	6 (100.0%)	17 (56.7%)
Full-time student and working part-time	28 (23.9%)	15 (18.5%)	--	13 (43.3%)
Work experience				
No	28 (23.9%)	21 (25.9%)	3 (50.0%)	4 (13.3%)
Yes	89 (76.1%)	60 (74.1%)	3 (50.0%)	26 (86.7%)

4.3 ANOVA and Independent Sample t-Ttsts

A One-way ANOVA test showed that learner characteristics were statistically significantly different for at least one of the groups. Three follow-up independent sample t-tests showed that there were significant statistical differences in the learner characteristics between any two groups. Table 3 summarises the results of the tests.

Table 3: ANOVA and independent sample t-tests

Learner characteristics	All groups	Classroom learners vs insecure learners	Classroom learners vs online learners	Insecure learners vs online learners
Desire for direct support	$F_{2, 114}$=9.688 P<.001***	$t_{80.044}$=13.740 P<.001***	t_{109}=2.561 P=.012*	$t_{29.009}$=-6.697 P<.001***
Digital readiness	$F_{2, 114}$=32.654 P<.001***	$t_{81.828}$=5.944 P<.001***	$t_{85.840}$=9.220 P<.001***	$t_{29.723}$=19.010 P<.001***
Learning independence	$F_{2, 114}$=14.468 P<.001***	$t_{61.898}$=2.989 P=004**	t_{109}=5.000 P<.001***	$t_{33.961}$=-9.730 P<.001***

Learner characteristics	All groups	Classroom learners vs insecure learners	Classroom learners vs online learners	Insecure learners vs online learners
Online hesitancy	$F_{2, 114}$=32.114 P<.001***	$t_{80.627}$=4.136 P<.001***	$t_{99.119}$=10.401 P<.001***	$t_{29.339}$=11.281 P<.001***
*Note: ***significant at the 0.001 level; **significant at the 0.01 level, *significant at the 0.05 level*				

Subsequent one-way ANOVA tests showed that there were no significant statistical differences between learner characteristics and the respondents' demographic background, except for between desire for direct support and education as well as between digital readiness and student status. Table 4 summarises the results of the tests. A correlation analysis also showed that there were no significant correlations between age and learner characteristics at the 0.05 level.

Table 4: ANOVA tests

Learner characteristics	Gender	Programme	Education level	Semester	Student status	Work experience
Desire for direct support	$F_{1, 115}$=2.491 P=.117	$F_{8, 108}$=.870 P=.544	$F_{2, 114}$=3.866 P=.024*	$F_{5, 111}$=.823 P=.536	$F_{1, 115}$=.068 P=.794	$F_{1, 115}$=.310 P=.579
Digital readiness	$F_{1, 115}$=.001 P=.978	$F_{8, 108}$=1.763 P=.092	$F_{2, 114}$=1.634 P=.200	$F_{5, 111}$=.659 P=.655	$F_{1, 115}$=5.044 P=.027*	$F_{1, 115}$=1.327 P=.252
Learning independence	$F_{1, 115}$=.139 P=.710	$F_{8, 108}$=.925 P=.499	$F_{2, 114}$=2.009 P=.139	$F_{5, 111}$=.353 P=.879	$F_{1, 115}$=1.023 P=.314	$F_{1, 115}$=1.148 P=.286
Online hesitancy	$F_{1, 115}$=.061 P=.806	$F_{8, 108}$=.653 P=.731	$F_{2, 114}$=1.146 P=.322	$F_{5, 111}$=1.621 P=.160	$F_{1, 115}$=.059 P=.808	$F_{1, 115}$=1.610 P=.207
*Note: *significant at the 0.05 level*						

Fisher's exact tests showed that there was no statistical evidence to suggest an association between the respondents' demographic background and the groups, except student status (P=.013). Table 5 summarises the results of the Fisher's exact tests.

Table 5: Fisher's exact tests

Respondents' demographics	Groups	
	Value	P-value
Gender	1.464	.545
Programme	7.319	.987
Education level	2.388	.642
Semester	9.125	.448
Student status	8.297	.013*
Work experience	4.224	.117
*Note: *significant at the 0.05 level*		

5. Discussion

To better understand the characteristics that can help explain why some learners are more inclined towards a particular learning environment, this study proposes that a good starting point is to simply ask the learners the reasons they like or dislike a learning environment. The findings indicate that these reasons have indeed provided the basis for the derivation of four learner characteristics, lending support to the study's assertion that an understanding of learners' like or dislike of a learning environment is useful in uncovering learner characteristics.

The four learner characteristics help explain the principal differences in the respondents' preference of learning environments, and divide the respondents into three groups, i.e. classroom learners, online learners, and insecure learners. It appears that the classroom learners and online learners are the two major groups. The respondents in both these groups have rather distinct characteristics in their preference for a face-to-face classroom learning or an online learning environment. The insecure learners are a minority group, making up only about 5% of the total respondents.

The classroom learners have higher levels of desire for direct support and online hesitancy, as compared to the online learners. As the largest of the three groups, over 80% of the respondents in this group are full-time students who do not work part-time. It may be that these students do not need to juggle studying and working, and thus find the conventional university life more enjoyable, preferring to interact with their lecturers and peers face-to-face rather than online. The classroom learners appear to have less confidence about learning online. This finding is consistent with that of Stiller and Köster (2016), which found that students who dropped out from an online training course were more likely to have greater computer anxiety.

In contrast to the classroom learners, the online learners have higher levels of digital readiness and learning independence. About one-third the size of the classroom learners, close to 45% of the respondents in this group are full-time students who work part-time. It is reasonable to presume that these students value the flexibility of learning online. The online learners appear to be technologically savvy in such activities as searching for information or interacting with others online and have better preparedness for self-directed learning. This finding concurs with that of Tratnik, Urh and Jereb (2019), which reported that online students were more independent than classroom students.

Relative to the classroom learners and online learners, the insecure learners have the lowest levels of desire for direct support, digital readiness, and learning independence. Although the insecure learners have a low degree of learning independence, coupled with a low level of readiness to use technology, it seems that they do not have a strong desire for obtaining direct support from their lecturers or peers. Although this is a minority group, this finding is significant because it shows that there may be students who face challenges in their studies and are in need of additional academic assistance, but do not realise that they should be reaching out for such assistance.

This finding also points to a plausible assumption that the respondents are in favour of either face-to-face classroom learning or online learning. A cohort made up of predominantly classroom learners and online learners may be well-served by a blended learning environment, a hybrid mode of learning delivery that brings together the best of face-to-face classroom learning and online learning environments. A blended learning environment can still fulfil the needs of classroom learners for direct face-to-face interactions with their lecturers and peers, and that of online learners for greater learning flexibility.

Past studies have reported no effect of demographic background on learner performance in different learning environments (Fendler, Ruff and Shrikhande, 2016; Kintu, Zhu and Kagambe, 2017; Roehling et al., 2017). This study finds that only student status, but not the other demographic factors, may influence learners' preference of learning environment. In addition, learners' demographics do not appear to have widely influenced the characteristics of learners either, with the exception of education level and the desire for direct support, as well as student status and the level of digital readiness. Although this study cannot conclusively infer a link between a specific education level with a greater or lesser desire for direct support, or a specific student status with a higher or lower degree of digital readiness, it still points to a prospective future research direction.

6. Conclusion

In conclusion, although different learner characteristics have made learners diverse, this study has succeeded in identifying the characteristics that help distinguish three learner groups. The findings reinforce the notion that, considering the diversity of students in terms of learner characteristics, learning design should begin with an understanding of such elements as student learning needs, learning capabilities, and learning gaps; and their effect on teaching pedagogy (Gordon, Reid and Petocz, 2010). A learning environment that takes into consideration the characteristics of learners would greatly support and engage learners to enhance their overall learning experience and performance (Ghorbani and Montazer, 2015; Kintu and Zhu, 2016).

6.1 Implications for Practice

Given the differences in such features as learning delivery, class interaction, and learning feedback between face-to-face classroom learning, blended learning, and online learning environments (Thai, de Wever and Valcke, 2020), educational institutions and academics must understand the issues and challenges that learners of various characteristics face in their learning in order to engage them more effectively. Academics and educational institutions should not assume that all learners in a given learning environment have the same level of prior experience or expectations (Simon et al., 2020), readiness (e.g., technology literacy and competency) (Robinson, 2019), or skill sets (e.g., time management, self-regulation) (Coman et al., 2020; Tseng, Yi and Yeh, 2019). Instead, it may be necessary to teach learners certain skills to better prepare them for a certain learning environment and to use different pedagogical approaches to design learning activities that are better suited to meet the varying learning needs of diverse learners.

To meet intended learning outcomes, Ramsden (2003) underscores the importance of designing learning within specific contexts. Previous education experiences, coupled with such elements as teaching, curriculum, and assessment designs, can affect one's orientation to studying, and subsequently one's perception of task requirements, learning approaches, and learning outcomes. Thus, to achieve intended learning outcomes, learning contexts need to be carefully created to foster learning. The findings support Ramsden's (2003) advice on learning contexts by adding insights about differences in learner characteristics. These insights can be useful for educational institutions and academics to better create learning contexts that help learners transit successfully from one learning environment to another.

It is vital to emphasise that although learners may have a preference for a particular learning environment, this does not necessarily mean that learners cannot perform well when studying in a less preferred learning environment. When studying in a learning environment that they do not initially like, some learners may gradually change their perception of that learning environment after having recognised its advantages, and eventually find ways to overcome its limitations. Lee et al. (2021) reported that, in a study of students' online course satisfaction during the Covid-19 pandemic, learners were able to adapt to cope well in a transition from face-to-face classroom learning to online learning.

Certain characteristics of learners may also change over time because of such factors as their stage in life, external environment, or skills development. For example, when a learner has graduated from university and started to work full-time, when a learner's daily schedule no longer allows much time or location flexibility, or when a learner has developed study skills and has become more adept at self-directed learning or has attained a higher level of digital literacy. These changes in learners' characteristics will eventually affect their perception and attitude towards different learning environments.

6.2 Research Limitations and Future Research Directions

Two research limitations and two future research directions should be highlighted. First, the participants in this study were from the same university. Therefore, the findings may not be generalisable to a wider context. Future research may conduct a similar study in different educational institutions for results comparison. Second, a majority of the participants in this study were full-time students who do not work part-time. Their perception of time, location, and learning flexibility may be different from that of learners who study part-time and work full-time. Future research may conduct a similar study in different higher education settings for a more a wide-ranging understanding of this topic.

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Microlearning in the Education of Future Teachers: Monitoring and Evaluating Students' Activity in a Microlearning Course

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Abstract: Microlearning has become a promising modern and effective approach to the education of various groups in recent years. In order to be able to further develop microlearning and consider student individualities it is necessary to map their passage through a course in detail. The article presents the conclusions of a research carried out at the Faculty of Education of the University of Ostrava. The aim of the research was to find out whether there are differences in approaches of studying a microlearning course. A microlearning course focused on teaching future teachers was created for the purposes of the research. The aim of the course was to present to students the possibilities of using digital technologies in the educational process. The research was conducted in the winter semester of the academic year 2021/2022. A total of 378 students participated in the study in the first phase (precourse survey) and subsequently 156 students in the second phase (analysis of course participants' behavior). Student activity was monitored during the study through learning analytics tools. Time of study, the number of realized events, the number of registrations, etc. were recorded for each student with these tools. The obtained data were analyzed using cluster analysis. Total of six different approaches that led to the successful completion of a microlearning course were described based on this analysis. The approaches can be used to describe a successful strategy to go through a microlearning course including the extreme ones. An interesting fact is that the choice of strategy is not influenced by the student's gender. The only parameter where significant differences were found was the number of days to finish the microlearning course. In addition, the article describes the behavior of students in the course, the types of learning materials, devices from which they logged in the course and list of the most used course components. This part of the data was recorded via heatmaps. A detailed description of students' study strategies within microlearning courses can improve the effectiveness of microlearning also in connection with the personalized passage and thus improve the quality and efficiency of the educational process of future teachers.

Keywords: Online learning, Microlearning, e-Learning, Learning analytics, Future teachers

1. Introduction

Active teachers, pupils, and students notice new trends that can have a positive impact on the education process. It can be assumed that those involved in education want to teach and be taught using modern approaches that reflect the latest trends, including teaching aids and technology. When integrating modern educational resources, such as digital technology, into the education process, they are often rejected by teachers and parents, which may be caused by various factors (lack of information, bad experience, fear or prejudices against digital technology, lack of support from the school). To change this attitude and to make the teacher want to use it in their courses (or transform them – or part of them – into e-learning courses), digital technology needs to be used in a way that makes the education process more effective.

One way to catch the attention of those who support the integration of digital technology into the education process as well as those who are against it is to further develop e-learning and adapt it to meet the demands of today's world. This does not necessarily mean finding a new method or education model that will result in better knowledge and retention and skill acquisition, but rather trying to look for more effective teaching methods, e.g., shortening the time required to learn new information, improving the activation and motivation of students, as well as their attention span. Those are the key factors in today's world.

In today's technology-centered world where the majority of children and adults check notifications on their smartphones every 30 minutes (Gausby, 2015), keeping students' attention is a difficult task. According to

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Sternberg R. J. and Sternberg K. (2011), it is the attention that has a direct impact on long-term memory, improving students' knowledge retention and building links between new information and their existing knowledge base. According to Microsoft Research (Gausby, 2015), one of the biggest factors that impacts the ability to concentrate is technological development, which, since 2000, has led to a decreased attention span (from 12 to 8.25 on average) in the age group of 18 – 55+. Research conducted by Bunce, Flens and Neiles (2010) shows that students do not pay attention for 10-20 minutes during a lecture. This time is spread out during the entire lecture, alternating between periods of paying and not paying attention (those cycles become shorter and shorter as the lecture progresses). This study also suggests that students are more focused if a teacher uses nontraditional methods, such as demonstration or groupwork. This result confirms well-established findings that students are more engaged and attentive when they are doing something other than listening to the teacher lecture. The same applies to online lectures that are often conducted through video conferencing platforms. Regardless of the duration of a lecture, the engagement time has been determined to be 6 minutes at most (Lagerstrom, Johanes, and Ponsukcharoen, 2015). Engagement time can be improved by implementing interactive elements (questions, quizzes, etc.). Geri, Winer and Zaks (2017) argue that the average engagement time can be increased by more than 20 %. The aforementioned studies show that students would prefer the education content to be divided into small segments, which they could go through at their own pace. They would also prefer interactive elements such as questions, quizzes, fill in blank questions, etc. This concept is used by the following two models: Programmed Instruction Educational Model (Molenda, 2008) and Mastery Learning (Joyce, Weil and Calhoun, 2017). Both models are based on the idea that the student manages their own learning, which is then examined by a test. If unsuccessful, the student can repeat the unit and retake the test.

A decrease in attention span may be caused partly by today's stressful world, which also affects education. Technology forces us to multitask, i.e., to divide our attention between learning and our smartphone, which is online all the time. Speed is important also in education, for a variety of reasons. People do not want to spend a lot of time studying. They want to study in an effective manner (at their own pace, if possible), anytime and anywhere. Because of the COVID-19 pandemic, it can be assumed that online learning will become much more popular in the future. Multiple studies on online learning during the pandemic have already been published (Mulla et al., 2020; Naddeo, Califano and Fiorillo, 2021). Today, quickly finding the information one is looking for appears to be more popular than studying a comprehensive course, in which students encounter information they already know from start to finish (Miller, 2019). The same is true of the professional world where companies do not want to spend much time educating and training their employees – they would prefer it if they educated themselves on-the-go, and were able to adapt to market changes and customer needs (Martins, Zerbini and Medina, 2019).

When discussing students' requirements on the structure and quality of the education process, one must not forget the teachers. According to the survey conducted by the British Department of Education (Walker, Worth and Den, 2019), teachers' working hours have not been reduced (they still work approximately 1,700 hours a year), despite the implementation of educational technology. When combined with the average class size (21 pupils in primary school and 23 pupils in secondary school) and curriculum size, teachers' workload is too high. Regarding innovating the education process, one needs to consider teachers' workload and therefore all the proposed changes should be aimed at making the education process as time efficient as possible.

Current trends in using digital technology for educational purposes, expectations of students, teachers' workload, and the demands of today's world have encouraged the authors to explore the use of digital technology in education that would reflect the current trends. In their research, the authors focused on e-learning, with which they have a wealth of experience as it is used at their workplace, both in formal and nonformal education. The authors' the research was aimed at the courses available in the Moodle Learning Management System (Moodle LMS), which, as the authors have discovered, students do not study continuously but rather all at once at the end of the semester/course (Polasek and Javorcik, 2020). That is why the authors set out to transform the courses, so they could be studied continuously, anytime and anywhere.

Microlearning appears to be a worthy successor to e-learning, which meets the demands of today's world (it needs to be available anytime and anywhere, not overwhelmed with information, be interactive, offer diverse learning objects, allow students to study at their own pace, etc.). In their research, the authors focused on the impact of microlearning in different variations on different target groups. The research should provide answers to the following questions:

Q1: What is the level of students' digital technology skills, especially considering they are studying to become teachers?

Q2: Can different approaches to studying a microlearning course be identified?

Q2.1: Are there significant differences between men and women in their approach to studying a microlearning course?

Q3: Which parts of a microlearning course are most/least used by students?

The authors used two different research methods to answer the aforementioned questions. A questionnaire survey, which is a quantitative research method, was used to determine the level of students' digital technology knowledge and skills (Lee, Jahnke and Austin, 2021), while learning analytics was used to record students' behavior in a microlearning course (Song, 2018).

2. Types of Microlearning

From a global perspective, microlearning is not a new term. However, in the Czech educational system it is not as common as mobile learning. According to Buchem and Hamelmann (2010), the rise of microlearning was heavily influenced by technological and economic changes, which were so significant that they increased the demand for new educational concepts and strategies that would be different than the ones used today. The most significant is the fact that learning is no longer tied to a particular time and place as it can occur anytime, anywhere, and during almost any activity.

Microlearning is a comprehensive approach to education based on using web content in activities that are short in time (Singh, 2014). Giurgiu (2017) adds that that these short activities should be independent but should also build on each other (which is essential as it allows the learner to put information into context). The authors often refer to these short learning units as microlearning units (MLU) or short information units (SIU).

Microlearning is closely associated with the following concepts (Buchem and Hamelmann, 2010):

- MicroContent – defines the ideal duration and form
- Web 2.0 – MLUs can be created, aggregated, and used (repeatedly)
- Social software – an integral part of students' lives; it makes it easier for them to communicate while studying
- eLearning 2.0 – using Web 2.0 technology for educational purposes
- Personal Learning Environment – creating and using micro content in informal learning
- Informal learning – short MLUs can be integrated into everyday activities
- Work-based learning – using MLUs for employee education

From a theoretical perspective, microlearning was described by Hug (2005, 2012) and others (Lindner, 2007; Mathy and Feldman, 2012; Souza and Amaral, 2014). Hug (2005, 2012) defines the following MicroLearning characteristics:

- Time: relatively easy, short
- Content: small units
- Form: fragments, episodes
- Focus: separate, integrated activities, maintain attention
- Mediality: various media – printed, online multimedia
- Learning method: repetition, constructivism, connectivism, etc.

Bersin (2017) argues that microlearning has evolved from eLearning. If we are to accept this notion, we need to compare microlearning and e-learning and define the differences between them. The main difference is in the course layout and the duration of its individual parts, through which educational content is presented to students.

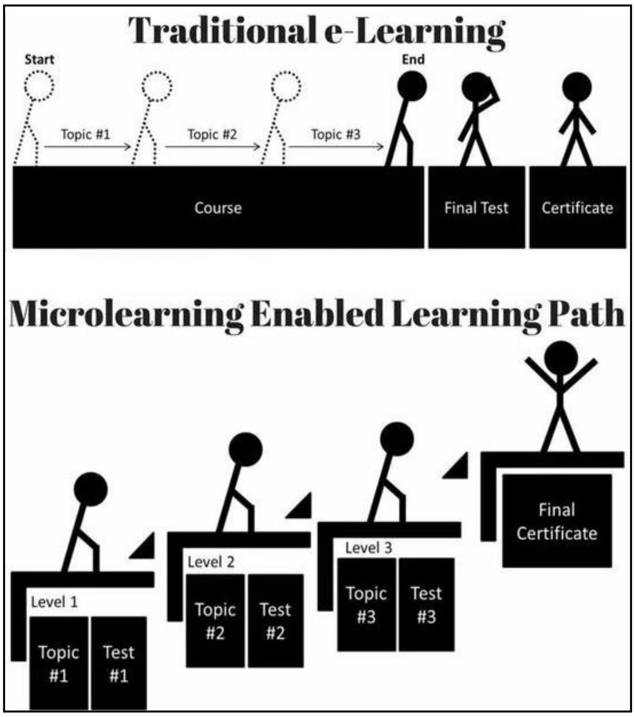

Figure 1: Graphic comparison of eLearning and microlearning (Bersin, 2017)

The individual levels (Level 1, Level 2, etc.), as seen in the picture above, are represented by the so-called microlearning units, which can be represented by any learning object (text, presentation, video, audio, animation, infographics, etc.). According to literature (Buchem and Hamelmann, 2010; Lindner, 2006; Hug, Lindner and Bruck, 2006), it takes 2 to 15 minutes to learn the content.

As far as the time and content scope is concerned, learning objects can be divided into Micro level, Meso level and Macro level (Hug, 2005). The individual levels (including examples) are described in the following table.

Table 1: Relation of micro learning, meso learning and macro learning to different areas (Hug, 2005)

	Example 1 Linguistics	**Example 2 Language instruction**	**Example 3 Educational content**	**Example 4 Course structure**	**Example 5 Classification of competencies**	**Example 6 Sociology**
Micro level	Individual letters	Words, phrases, sentences	Educational objects, micro content	Educational objects	Students' or teachers' competencies	Individualized learning
Meso level	Words, combination of signs and numbers, sentences	Situations, episodes	Sub-topics, content-limited topics	Topics, lessons	Lecture proposal	Group instruction or organized learning
Macro level	Texts, conversation	Socio-cultural specifics, complex semantics	Topics, subjects	Courses, structure of educational plans	Proposing learning plans	Generational learning, social learning

The term "microcontent" is inherently linked to microlearning (Souza and Torres, 2015). Even though it was originally associated only with Web (Dizon and Tang, 2017; Clark and Paivio, 1991), Lindner (2007) describes microcontent as "all kinds of micro-chunked digital content: very small texts, pictures and graphics, and combinations thereof; links; short low-resolution audio or video clips", and introduces the term "micromedia" (stressing the use of different content mediality). There are also other forms of microcontent, such as podcasts or microblogging (Lindner, 2007; Salomonsen, 2018).

Many authors have written about microlearning (both directly and indirectly). They have focused on the following topics:

- Nursing education (Bian et al., 2014)
- Medical training and health professions (Simons, Foerster, Bruck, Motiwalla and Jonker, 2015)
- Language training (Fang, 2018)
- Engineering topics (Zheng et al., 2019)
- Programming skills (Skalka and Drlik, 2019)

Research showed that microlearning helps improve students' motivation, participation in instruction and performance.

Jahnke et al. (2020) provide an extensive overview of microlearning research. This study also outlines how microlearning will evolve in the future, particularly when used along with mobile learning. There are already 25 platforms that allow microlearning content to be mediated through mobile technology (e.g., EdX, Lynda.com or Skillshare).

Recent psychology findings on memory, learning or capturing and maintaining students' attention also prove the effectiveness of microlearning. The so-called Miller's magical number, which argues that the number of objects an average human can hold in short-term memory is 7 ± 2 (Miller, 1956), can serve as an example. If we consider the learning theory and Miller's magical number, a short attention span when it comes to learning, the need to revise information stored in short-term memory, their retention (in order to learn), and today's fast-paced world, microlearning appears to be the clear choice. Since they reflect the existing knowledge on attention span, the learning process characteristics and memory stages, MicroLearning Units (MLU) may be an appropriate alternative (Morris et al., 2005; Salomonsen, 2018; Schmidt, 2007; Wissman, Rawson and Pyc, 2012).

In general, a learner's attention span corresponds to their age. If the attention span increases, it leads to so-called information overload, i.e., isolated and unconnected knowledge which leads to not understanding the presented curriculum (Skoda and Doulik, 2011).

3. Design of Microlearning Course

A microlearning course with the aforementioned characteristics was created to verify the authors' assumptions and answer the research questions. To maintain scientific objectivity, the authors selected the course "Information Technology in Education". The goal of this course is to show the students (future teachers) how to use digital technology in education. The course is mandatory for all future teachers studying at the Pedagogical faculty of the University of Ostrava. Hence, the course was taken by students with different digital technology knowledge and skills, with the conditions being the same for everyone.

The microlearning course consisted of 5 chapters:

1. Working with text and creating worksheets
2. Working with images and graphics
3. Multimedia
4. Online tools and sharing
5. Mobile technology and applications

Each chapter was designed to show the students how beneficial digital technology can be if used properly and with a specific educational purpose. The chapters included MLUs in the form of short text, videos, video tutorials and other interactive elements. A H5P module (HTML5 Package) was used to create the interactive elements. At the end of each chapter, the students were required to design and create a product that could be used in instruction (according to their specialization). In doing so, the students put the newly acquired information to good use. The Moodle LMS was chosen for course creation and administration.

4. Methods

Research occurred during one semester from September to December 2020. 378 teacher students from the Pedagogical Faculty of the University of Ostrava participated in the research study. The students studied in programs aimed at different subjects (Czech language, music, arts, computer science, mathematics, etc.). Before the start of the semester, each participant received an email with course specifications (requirements, assignment submission guidelines, etc.). The email also included information about research participation. The students were then enrolled in the microlearning course. Those who did not agree to participate in the research study were enrolled in the same course, but were not asked questions or monitored.

The research study was divided into two stages. In the first stage, after logging into the microlearning course, the students filled out a precourse survey that consisted of 23 questions aimed at demographic information (e.g., gender, grade, age, etc.), their specialization, attitude toward digital technology and its use in the education process and subjective evaluation of their digital technology skills (e.g. text processing, working with images, creation of video tutorials, tests or online courses). This part of the study was aimed at determining, through self-assessment, the students' existing digital technology knowledge and skills, particularly with respect to their future role as teachers. The authors assume that the students are able to accurately assess their digital literacy (Porat, Blau and Barak, 2018). Based on the survey data, the microlearning course was adapted to better suit the students' needs. Selected topics were expanded while others were simplified, to allow the students to pay more attention to the chapters they needed to improve in. However, no chapter was left out.

The second stage was aimed at the participants' behavior. Since the authors were interested in identifying different approaches to tackling the microlearning course, the second stage included only those participants who successfully completed the course – the research sample was selected using stratified sampling by gender (N = 156 students). The goal of this stage was to determine the behavior of microlearning course participants through web analytics. The results allowed the authors to identify different approaches of microlearning course participants. The website analytics tool Smartlook was used to monitor the behavior of course participants (https://www.smartlook.com/).

The following parameters were monitored:

- Learning days (time between the first and last login)
- Number of events (number of clicks, text written and other student input)
- Total number of visits
- Length of each visit
- Type of device (smartphone, tablet, desktop computer)
- Course components used by students

Cluster analysis was used to analyze the collected, aggregated and standardized data to determine groups of students with similar behavior.

5. Data Analysis

The first stage of research – the precourse survey – was conducted in September 2020, before the start of the semester. Of the total 469 students enrolled in the course Information Technology in Education, 378 participated in the precourse survey (80.6 %).

Table 2: Pre-course survey – research sample

n		Age	
Female	**Male**	**Avg.**	**SD**
262 (69.31 %)	116 (30.69 %)	23.71	7.661
378			

In the first part of the questionnaire, the respondents were asked to assess their attitude toward digital technology and their digital skills. The majority of respondents reported a positive attitude toward digital technology, with the average score on a five-point scale (1-positive, 5-negative) being $\bar{x} = 2.25$ ($\tilde{x} = 2$). The answers the students gave when asked to evaluate their own knowledge and skills on a five-point scale (1-excellent knowledge, 5-lack of knowledge) prove that they have not yet mastered all the skills and knowledge a teacher should possess. Based on their answers, the respondents believed they were the most skilled at text processing, creating presentations, information seeking and email management. On the other hand, they were less confident about their skills required to create educational animations and video tutorials or create and manage websites and e-courses. Tables 3 and 4 provide a detailed summary.

Table 3: Student self-assessment of their digital skills – basic use of digital technology

Basic use of digital technology	$\bar{x}$	$\tilde{x}$	Absolute frequency					Relative frequency [%]				
			1	2	3	4	5	1	2	3	4	5
Text processing	1.992	2	102	192	71	11	2	26.98	50.79	18.78	2.91	0.53
Data processing	2.791	3	35	113	146	64	20	9.26	29.89	38.62	16.93	5.29
Use of images	2.280	2	78	166	90	38	6	20.63	43.91	23.81	10.05	1.59
Use of photography	2.526	2	67	129	109	62	11	17.72	34.13	28.84	16.40	2.91
Sound recording and editing	3.368	3	22	56	120	121	39	5.82	14.81	31.74	32.01	15.61
Creating presentations	1.915	2	138	163	57	11	9	36.51	43.12	15.08	2.91	2.38
Creating animations	3.566	4	11	61	111	93	102	2.91	16.14	29.37	24.60	26.98
Creating video tutorials	3.791	4	16	38	89	101	134	4.23	10.05	23.54	26.72	35.45
Use of applications or educational purposes	2.780	3	45	118	125	55	35	11.90	31.22	33.07	14.55	9.26

Table 4: Student self-assessment of their digital skills – online environment

Online environment	$\bar{x}$	$\tilde{x}$	Absolute frequency					Relative frequency [%]				
			1	2	3	4	5	1	2	3	4	5
Information seeking	1.479	1	231	127	11	4	5	61.11	33.60	2.91	1.06	1.32
Email management	1.563	1	215	132	17	9	5	56.88	34.92	4.49	2.38	1.32
Use of cloud services	2.757	3	50	117	118	61	32	13.23	30.95	31.22	16.14	8.47
Creating online forms	3.061	3	36	97	107	84	54	9.52	25.66	28.31	22.22	14.29
Creating online documents	2.976	3	41	106	106	71	54	10.85	28.04	28.04	18.78	14.29
Creating online tests	3.270	3	25	84	109	84	76	6.61	22.22	28.84	22.22	20.11
Creating websites	3.746	4	18	37	100	91	132	4.76	9.79	26.46	24.08	34.92
Creating e-courses	3.921	4	9	31	90	99	149	2.38	8.20	23.81	26.19	39.42

The majority of respondents (n=318; 84.13 %) reported they intended to improve the aforementioned skills. The remaining respondents either stated that they were satisfied with their level of skills and knowledge (n=23; 6.08 %) or that they had yet to discover their own potential (n=37; 9.79 %).

The second part of the questionnaire was aimed at learning the students' opinions on the integration of digital technology into the education process. The participating future teachers have a positive attitude toward integrating digital technology into instruction ($\tilde{x} = 2$; 1-positive attitude, 5-negative attitude).

The results show that future teachers intend to use digital technology in their classes – 342 respondents (90.58 %) intend to use digital technology in their classes, with the majority of respondents reporting that they are not stressed at all or only slightly stressed (n=238, 62.96 %) about using it. As far as teaching stages are concerned, the students intend to use digital technology during the motivation (n=304) and application (n=242) stages. 136 respondents selected the motivation stage as the only option out of the five presented (motivation, exposition, retention, diagnostic and application) while 30 respondents selected all five options.

The majority of respondents would use digital technology to present the curriculum (n=331, 87.57 %); 126 of them would use it exclusively for this purpose. The remaining respondents chose different combinations of the available options (to present the curriculum, for modeling/simulation, testing, to record students' grades/performance). 58 respondents chose all available options.

A closer look at the collected data shows that the students approached the microlearning course differently. The average learning time was 59.15 days (time between the first login and the final assessment given by the tutor). During this period, the actual time spent studying was also measured (i.e., the time the students were logged into the course – which was 3.31 hours on average). During this period, the students performed 813.77 actions (events) in 56.99 logins on average. The average length of one login was 3.31 minutes. The standard deviation values for monitored characteristics (Table 5) indicate large differences between students' strategies in terms of how they approach the course.

Table 5: Aggregate data acquired by recording student activity in the microlearning course

	Learning days	Number of events	Time (hours)	Number of logins	Number of events per day	Length / login	Length / event	Time per day (minutes)	Number of logins per day
Avg.	59.15	813.77	3.31	56.99	16.17	236.68	23.06	4.05	1.16
SD	30.14	902.78	2.76	36.36	15.19	204.40	52.17	3.07	1.00
Median	61.00	608.00	2.74	49.00	11.04	197.64	14.89	3.10	0.90

If one were to divide the research sample by gender, one would find further differences in approaching the course. Due to the nature of the data, a Mann-Whitney U-test was used to determine statistically significant differences in behavior in the microlearning course between male and female students. Of all the data recorded by the web analytics tool, the only statistically significant difference was in the time spent studying (p-value 0.014), with men studying longer (more days) than women. Even though there were differences in other monitored data, none of them were statistically significant. The results, including the calculated p-values, are presented in Table 6.

Table 6: Behavior of students in the microlearning course by gender

Monitored data	Avg. women (N=102)	Avg. men (N=54)	P-value
Learning days	53.422	68.87	**0,0135**
Number of days	709.71	1008.4	0.40868
Total learning time (seconds)	11.140	13.408	0.997
Number of logins	53.842	62.889	0.52673
Number of events per day	15.554	17.334	0.33165
Length/login (seconds)	255.88	200.77	0.22155
Length/event (seconds)	22.499	24.123	0.39916
Time per day (seconds)	253.89	222.44	0.1794
Number of logins per day	1.1331	1.2167	0.60296

Cluster analysis was used to provide a more accurate picture of the collected data, allowing the authors to identify common features across the research sample. Using cluster analysis (Euclidean distance in particular), clusters with common features were identified (the results are presented in Table 7).

Table 7: Characteristics of identified clusters determined through Euclidean distance

Cluster	n	Learning days	Number of events	Time	Number of logins	Number of events per day	Length /login	Length / event	Time per day	Number of logins per day
1	18	63.17	1002.00	5.09	90.00	16.33	3.60	20.33	5.00	1.47
2	61	70.33	663.01	2.55	52.44	9.55	3.04	15.63	2.23	0.76
3	18	25.39	372.00	1.32	26.83	22.70	3.96	43.91	4.69	1.46

Cluster	n	Learning days	Number of events	Time	Number of logins	Number of events per day	Length /login	Length / event	Time per day	Number of logins per day
4	12	108.08	1827.00	7.87	110.50	18.87	4.15	17.26	4.90	1.15
5	23	42.13	482.13	2.26	35.74	12.85	6.47	39.89	4.37	0.91
6	19	28.53	591.00	2.66	43.89	29.62	3.83	15.47	7.15	2.18

Using cluster analysis, the authors identified 6 groups of students (based on how they approached the course). Cluster 1 students (n=18) logged into the course often and their time spent studying was above average. Their number of logins per day was also above average. Cluster 2 (n=61) includes the largest number of students. This group of students spent the shortest amount of time studying per day. Their other values were average. Cluster 3 is a perfect example of cramming. This group spent the shortest overall time studying; they tried to perform as many actions (events) per day as possible. This group's goal was to complete the course in the shortest time possible. Cluster 4 students spent the most time studying, performed the most actions (events) and studied the course the longest. It can be assumed that this group included students with low digital literacy and students who did not find this type of learning appealing. Cluster 5 students approached the course in a similar way to Cluster 3 students, the only difference being that they did not log into the course as many times a day, but tried to accomplish as much as possible during one visit. Cluster 6 is another example of cramming. When compared to Cluster 3, this group's approach was even more extreme, with a higher total number of logins, time spent studying and number of events per day. This group's goal was to minimize the time spent studying.

The website analytics tool heatmap was used to determine which parts of the course the students used the most often. It provided information about the number of clicks on the particular parts of chapters. The data on student activity in the individual course chapters are presented in Table 8.

Table 8: Student activity in the individual chapters of the microlearning course

	No. of displays	No. of clicks	Type of device	
			Computer / laptop	Smartphone / tablet
Introduction	769	651	726	43
Topic 1	1,836	1,196	1,806	30
Topic 2	1,185	876	1,168	17
Topic 3	634	392	618	16
Topic 4	891	493	878	13
Topic 5	1,173	550	1,134	39

The table shows that the most visited chapters were Topic 1 (Working with text and creating worksheets), Topic 2 (Working with images and graphics) and Topic 5 (Mobile technology and applications). Working with text and creating worksheets chapter also had the most clicks. The individual chapters differed in the total number of clicks, which was caused by the fact that the students did not always use all the available study materials. As far as educational materials are concerned, the students preferred videos and video tutorials to text materials. The amount of used educational materials in the chapter was influenced by its thematic focus. When working with common apps (e.g., MS Word, MS PowerPoint or Google cloud tools), the students did not use many materials. In these chapters, they chose educational materials aimed at using those tools for educational purposes. When working with less common apps, however, the students used the majority of available materials, including additional information and external links.

Heatmaps were also used to determine the type of device the students accessed the course from. The majority of students accessed the course from a desktop computer/laptop. Only a minority of students accessed it from a mobile device (a smartphone or a tablet).

6. Discussion

The presented results allow the authors to answer the aforementioned research questions. Those were:

Research question 1: What is the level of students' digital technology skills, especially considering they are studying to become teachers?

Conducted before the start of the microlearning course, the pre-course survey showed that the students were confident about some of their skills (text processing, creating presentations, information seeking, and email management) and less confident about others, which a future teacher should have (creating video tutorials or creating online tests). The results prove that to make the education process more modern and effective, future teachers need to constantly develop their knowledge and skills on the use of digital technology in education. According to the authors, students' input knowledge needs to be monitored constantly. When compared with a similarly focused study on the digital literacy of elementary school students, the results are similar (despite the significant age difference among respondents). The fact that university and elementary school students have a similar level of digital literacy may be caused by the high (and ever-growing) digital literacy of young students. The ITFitness survey results support this argument (Kucera and Jakab, 2020).

Research question 2: Can different approaches to studying a microlearning course be identified?

Data acquired through web analytics showed statistically significant deviations, which means there were different approaches to studying the microlearning course, and with different results. If we focus on the differences between men and women in how they approach the course, we will learn that the only statistically significant difference was in the time spent studying, with men studying longer (more days) than women ($p=0.01$). Data from previously published studies reveal several reasons why men take longer to complete the course than women. Women tend to login into the Moodle LMS more often and can organize their online learning more efficiently. On the other hand, men tend to find the Moodle LMS difficult to navigate (García-Martín and García-Sánchez, 2017). Moreover, women are also more productive in an online environment than men (Caspi, Chajut and Saporta, 2008). However, it needs to be said that their cultural background may also have an impact on the differences (and their extent) between men and women (Li and Kirkup, 2007). Even though it took men more days to complete the course, they did not spend more time doing so ($p=0.997$). They only spread it out over more days.

Using cluster analysis, the authors identified 6 groups of students (based on how they approached the course). There were students who used a cramming strategy, there were students who studied continuously and then there were students who completed the course, but it took more effort and time. Since there are multiple ways to successfully complete a microlearning course, there might be a connection between the student's learning style and their strategy in regard to working their way through the course. The course components (types of educational materials) used by the student might be an important guide (Ocepek et al., 2013).

Research question 3: Which parts of a microlearning course are most/least used by students?

The website analytics tool heatmap was used to determine which chapters and their parts the students accessed the most often and which had the most clicks. The most visited chapters were those aimed at working with text and creating worksheets, working with images and graphics and mobile technology and applications. It is unclear whether this activity was caused by students' interest or the chapter's difficulty level. The number of events (clicks) corresponds to the number of used materials. Regarding chapters with a higher number of clicks, it can be assumed that some students either kept coming back to the same educational materials or needed to go through more materials to be able to complete the course. As far as particular parts of the individual chapters are concerned, the heatmap data show that the students preferred the multimedia content (video, animations and interactive elements). The fact that in e-learning students tend to prefer multimedia to text supports this argument (Lam et al., 2014). Text materials were used sporadically, especially in chapters aimed at less traditional tools that the students were not familiar with, and which required more studying (i.e., they needed to consult more materials). The popularity of video, multimedia and other interactive elements is documented in other published studies written by authors with different cultural backgrounds (Afacan Adanir et al. , 2020; Muthuprasad et al., 2021).

The assumption that in e-learning and microlearning students mostly used mobile devices to access the course content was not confirmed. The majority of students accessed the course from a desktop computer/laptop. Only a minority of students accessed it from a mobile device (smartphone or tablet). The results of this study contradict the results of other studies published both in the Czech Republic and other countries where the use of mobile devices for educational purposes is more pronounced (Klimova, 2017, Muthuprasad et al., 2021).

Research could be made more accurate by using Eye-Tracking, which would allow the authors to monitor students' attitude toward individual materials and compar

e it with similarly focused studies (Conley, Earnshaw and McWatters, 2020; Copeland and Gedeon, 2014).

7. Conclusion

Future teachers have different input knowledge and skills. Such education should aim to produce teachers with identical input knowledge, which would allow them to use digital technology in an effective and useful way, regardless of the subject.

One of the ways to achieve this goal is to incorporate microlearning into the education of future teachers. The authors chose microlearning because its positive impact on learning has been described in recently published studies, and the sheer volume of available materials that they wanted to include in the microlearning course. The main goal of the study was to prove the students use different learning approaches and to identify the parts of the course that are accessed more often than others. By analyzing data acquired through web analytics, the authors identified 6 groups of students (based on how they approached the course). These groups differed in terms of how long (how many days) it took them to complete the course, the number of events, total learning time or the number of logins. Using these factors, the authors described each of the six groups.

It is interesting that aside from the time spent studying, there was no statistically significant difference in behavior in the microlearning course between male and female students, with men studying longer (more days) than women. The website analytics tool heatmap was used to determine which parts of the course the students used the most often. As far as educational materials are concerned, the students preferred videos and video tutorials to text materials. The amount of used educational materials in the chapter was influenced by its thematic focus. When studying topics they were not familiar with, the students used the majority of available materials. Students used mobile devices to access the course much less often than the authors expected.

The authors feel that findings of the study may contribute to incorporating microlearning into the education of future teachers and to revealing appropriate strategies in navigating this type of course. Based on the presented results, such courses can be adapted to those strategies and therefore make students' learning more effective. This study also opens new possibilities for further research.

With respect to the aforementioned findings, in future research the authors would like to focus on students' learning styles and their impact on learning new information in microlearning courses. Designing a personalized version of the microlearning course for every student based on their learning style (which would meet the conditions of learning style variability according to the VARK test or Kolb's experiential learning cycle) appears to be an appropriate idea.

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Electronic Flipped Classrooms as a Solution to Educational Problems Caused by COVID 19: A Case Study of a Research Course in Iran Higher Education

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Abstract: A review of the related literature shows that flipped learning has greatly affected the students' academic progress. However, despite a large number of studies on different forms of electronic learning, electronic flipped classrooms and traditional electronic(virtual) learning have not been compared to date. This study was an attempt to investigate the impact of traditional electronic, text flipped, and video flipped learning on improving the graduate students' theory and practical knowledge of research methodology. To meet the goal, the researchers employed a quasi-experimental research method, which is quantitative. The researcher selected three intact classes consisting of 48 postgraduate students majoring in social sciences and communication sciences and exposed each class to one form of electronic learning. The findings showed that flipped classrooms were more effective than traditional electronic learning, and text flipped learning was more effective than video flipped classes. The findings can be used by universities as well as university teachers to use electronic flipped classes as an alternative form of electronic learning It can be concluded that the universities need to encourage flipped classrooms in graduate and postgraduate courses as far as the universities can offer face-to-face classes.

Keywords: COVID 19, Electronic learning, Flipped learning,Flipped classrooms

1. Introduction

Universities and colleges are places where many students study and live near each other. There are also cultural hubs where students, teachers, and staff gather together from different nations around the world. Very recently, the foundations of this ecosystem have been significantly influenced by the rapid spread of the coronavirus (COVID-19) outbreak. Therefore, a kind of uncertainty was created in the higher education system of most countries affected by COVID-19. Over the last months, education officials felt obliged to cancel classes and close the doors to campuses across all cities in Iran as well as across the world in response to the growing coronavirus outbreak. Moreover, the higher education ministry of Iran has switched classes to electronic learning, and students studying at almost all universities in Iran and elsewhere were asked and indeed forced to return home to complete their studies. The researchers of this study, while teaching their students, felt that virtual flipped classrooms might turn out to be more effective than traditional virtual classes, which are mostly teacher-oriented.

Since a couple of years ago, there has been a plethora of research into active learning (Al-Ammary, 2015; Arnold-Garza,2014; Gündüz andAkkoyunlu, 2019). The most dominantly used model of lecturing at universities is still a model of "show and tell, with students as passive recipients of information" (Vliet, Winnips, and Brouwer., 2015, p. 1). Gündüz and Akkoyunlu (2019) stated that technological changes in the 21st century have created new demand for learning settings. The 21st-century features such as notebook computers, tablets, and mobile phones are part of our daily lives and have become more ubiquitous. Recently, flipped-classroom (also called flipped-lecture or flipped class) pedagogy has become very popular. FC as defined by Gündüz and Akkoyunlu (2019) is an approach that blends face-to-face interaction in the classroom with independent study outside of it, often through watching prepared video content.

Flipped learning models and the impact of each model on the students' academic uptake have been studied to a great extent (Chen, et al., 2018; Chen, Chao, and Hungl, 2018; Chen, et al, 2017; Hao, 2016; Seery, 2015a). Similarly, many flipped learning models have been developed, and currently, databases and theoretical as well as experimental studies on their pedagogical values still continue (Al-Ammary, 2015; Arnold-Garza,2014; Bergmannand Sams, 2014; Betihavas, et al.,2016; Davies, et al, 2013; Halili and Zainuddin, 2015; Hassan, 2015;

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Hoffman, 2014; Tan et al, 2017). A number of systematic review papers have been published topics on the use of flipped learning in higher education. For example, Tan et al. (2017) and Betihavas et al. (2016) systematically reviewed the papers on the role of flipped classrooms in nursing education. Similarly, Chen, Lui, et al. (2017) reviewed the published papers on the use of flipped classrooms in medical education. Moreover, in the context of engineering education, another review was undertaken by Karabulut-Ilgu, Jaramillo Cherrez., and Jahren (2018). Despite these reviews and the empirical studies, there is a lack of studies that investigates the effectiveness of different types of flipped classrooms (text, papers and book chapters), video, and traditional online learning. During the Pandemic, electronic learning has become an important focus of both educational policy makers and instructors in almost all countries and flipped classroom has been emphasized by teachers and educational decision-makers (Giannakos et al. 2018), it seems necessary to address this research gap in higher education context in Iran. Therefore, the researchers tried to investigate the impact of electronic flipped classrooms as an alternative to traditional face-to-face classes at Allameh Tabataba'i University in Tehran, Iran.

1.1 Aims and Research Questions

This paper aimed at investigating the impact of flipped learning on graduate students' knowledge of theories and practice of research methodology. The researchers tried to investigate whether electronic flipped learning and electronic non-flipped learning have the same impact on improving the students' knowledge of research methods (theories and practice). The study also tries to investigate whether video and text electronic flipped classrooms have the same impact on improving the students' knowledge of research methodology. Finally, it attempts to see whether flipped learning has the same impact on the students' performance in the theories and practice sections of the research methodology test. More specifically, the following research questions were raised:

- Does the teachers' use of electronic flipped classrooms affect the graduate students' knowledge of research methodology?
- Does the teachers' use of electronic flipped classrooms affect the graduate students' practice of research methodology?
- Do two types of electronic flipped classrooms, video flipped and text flipped, have the same effect on the students' performance in the knowledge and practice section of the research methodology?

2. Review of the Literature

2.1 Theoretical Background

Flipped learning is deeply rooted in several learning theories. The first underlying theory of flipped classroom is the revised Bloom's taxonomy. As Eppard and Rochdi (2017) have argued, the main assumption of the revised version of Bloom's Taxonomy which is relevant to flipped classroom is that "the transmission of information, which is the basis for learning, is obtained independently and outside of class; while the assimilation of information, which requires greater critical reasoning occurs during class under the guidance of an instructor or mentor" (p.35). the second underlying theory of flipped classrooms is deeply rooted in constructivism. Vygotsky (1978) viewed learning as a process that occurs when the others, who are more competent in the skills which are to be learned, help the learners. Vygotsky also believes that learning is optimized by collaboration within the learner's Zone of Proximal Development (ZPD). Vygotsky (1978) defines ZDP as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through solving problems under adult guidance, or in collaboration with more capable peers"(p.68). In other words, learning successfully take place when students work either with a peer or a more skilled adult/teacher to solve problems that are just beyond their actual abilities. Hence, when the students are using the FC techniques, they are assigned problem-solving tasks they learned through watching the video or reading the texts outside of the classroom. Students either work in groups or in groups under the supervision of the teachers to solve the problems.

2.2 Definitions of Flipped Classroom (FC)

Although the use of flipped classrooms in higher education has turned out to positively contribute to the students' academic achievement, there are few evidence-based research studies that indicate that flipped classrooms might not always turn out to be effective because of the associated challenges with students' familiarity with the technology needed for practicing flipped learning., A small but growing interest in undertaking studies on flipped learning environments in university classrooms has been reported (Brewer and Movahedazarhouligh, 2016; Fraga and Harmon, 2015; Lee, et al, 2016; Love, et al, 2014; Vliet, et al, 2015). For example, Filiz and Benzet (2018) suggested: that "the learner-centered approach forgoes unnecessary teacher-talk time during class by scaffolding learning from pre-class assignments, and expanding or deepening learning in class" (p.72). This instructional activity through which technology is used to reverse the traditional role of classroom time is referred to as the flipped or inverted classroom (Warden, 2016). Similarly, Fraga and Harmon (2015) stated that teachers are taking advantage of "flipped classroom" models. They highlighted that in the FC model, what generally occurs in the classrooms, such as demonstrations and lectures, occurs at home or out of class. The main assumption underlying the use of FC is to "allow more efficient and effective use of the instructor's time during class to provide the necessary scaffolding, and guidance students need when engaged in applying newly learned information" (Fraga, et al, 2015, p. 18). These classes are generally reported to have resulted in significant effects in terms of learners' achievement, satisfaction, and participation (Kim, 2014; Kim, Jeon, and Choi, 2014; Kim and Kim, 2014; Mehring, 2016).

2.3 Empirical Studies on Flipped Learning

To gain a comprehensive understanding of the flipped classroom in a university context, Al-Samarraie, Shamsuddin, and Alzahrani (2019) conducted a literature review study. They guided the study by interpreting the previous research findings based on the domain of utilization, opportunities, challenges, and extensions to the conventional flipped classroom model. The findings revealed that the use of flipped classrooms in different disciplines is mainly advocated to promote students' engagement, attitude, metacognition, understanding, performance, and achievement, as well as other learning outcomes. In a review article, Seery (2015b) surveyed the related studies with regard to the rationale for using the flipped classrooms and, how educators implemented and evaluated the flipped classroom approach. The findings revealed that the flipped classrooms are highly popular with teachers and students and they adopt them to increase the students' engagement, flipped classrooms are used to develop an active learning environment and allow time for developing a deeper understanding of the field

Love, et al (2014) compared the conventional instructional practices with the flipped classroom teaching model in an applied linear algebra course. They reported that students who received instruction through the flipped classroom model outperformed the students in the conventional instruction model. They also found that students positively reacted to the flipped learning model. The findings of previous studies (e.g., Amresh, Carberry, and Femiani ,2013; Cabı, 2018; Casadonte , 2018; Chen, et al., 2018; Velegol, Zappe, and Mahoney, . 2015) revealed that students' performance scores improved even when students sometimes found the flipped classroom intimidating and overwhelming. This might somehow be associated with students' positive perceptions of the format of flipped classrooms which allowed them to read more material and perform better in quizzes and exams (Chien and Hsieh 2018). Therefore, it can be inferred that the structure of the teaching syllabus and materials for teaching engineering courses can greatly benefit from the flipped classroom format since it can help students take a very active approach in doing the group activities, negotiating and discussing materials, and researching the used online teaching resources to justify the answers and to solve the problems.

It has also been claimed that a flipped classroom can be used to develop students' motivation, problem-solving skills, and engagement (Panuwatwanich 2017). This led to a common perception that the majority of the participants in the previous studies view flipped learning as a valuable addition to the traditional teaching methods (Mitchell, 2017).

Similarly, Vliet, et al (2015) investigated the effects of flipped classes on motivation and learning strategies in higher education. They employed a controlled, pre-test, and post-test approach. They collected the data by administering a validated Motivated Strategies for Learning Questionnaire (MSLQ). The results showed that flipped-class pedagogy enhanced the MSLQ components of task value, critical thinking, and peer learning. However, the effects of flipped classes did not exist. They suggested that the repeated use of flipped classes in a curriculum can make effects on metacognition and collaborative-learning strategies sustainable.

Very recently, Gündüz and Akkoyunlu(2019) determined the challenges and benefits of the flipped classroom in higher education. They employed a questionnaire consisting of open-ended questions to delve into the participants' views of flipped learning. The results of their study indicated that through implementing flipped learning students can have a chance to experience greater instructional flexibility during both online and in-class sessions. Although the participants of their study argued that they felt more responsible for their own learning, some of them were dissatisfied with poor Internet access outside of the classroom and expressed disappointment with the lack of immediate feedback while watching videos and listening to podcasts.

Sung (2015) investigated the effect of flipped classrooms containing twelve university students attending an elective course. Before the instruction, the learners previewed lesson materials such as readings and videos and were involved in various online activities on a Learning Management System (LMS) platform. Then, they completed collaborative class activities such as sharing their thoughts on paper, discussing questions regarding weekly online readings and implementing the final project of planning an assessment proposal. The outcomes of the analysis of both informal and formal course assessments and student work indicated that they were positive with flipped instruction despite early integration problems. The results also indicated that FCI is a good choice for modification, at least in existing English language teaching.

Adedoja (2016) examined Nigerian pre-service teachers' attitudes toward flipped instruction and the challenges they faced while teaching. The study used both conventional instruction and flipped instruction by developing the questionnaire and Focus Group Discussion. The results revealed that the attitude of pre-service teachers was completely positive regarding flipped instruction. Nouri (2016) conducted a study on the Swedish learners' attitude toward flipped learning in research methods by administrating the questionnaire. The results showed that the sum of the participants stated a positive attitude towards flipped classrooms as a result of improved motivation, engagement, and more effective learning.

As the findings of the related studies suggest that the FC model can be an effective instructional approach, the researchers feel that it might prove to be useful in higher education, while the universities are not offering face-to-face educational services to the students. Most particularly, the researchers found that teacher-oriented electronic classes might be different from flipped classes as an interactive learning approach. Although flipped learning has attracted the attention of researchers in higher education, the number of studies on the use of flipped learning in graduate courses is scanty.

3. Methodology

The researchers employed a quasi-experimental research method to investigate the impact of flipped learning on improving graduate students' knowledge and practice of research methodology. As research methodology is an obligatory course for MA students and the content of the course does not vary across all Masters of Arts (MA) majors, the researcher selected it as the variable of the study. Moreover, all the participants had passed basic research methodology courses in the undergraduate curriculum as an obligatory course. Three weeks after the spread of COVID 19 in Iran, the researchers selected three intact classes at Allameh Tabataba'i University (intact classes A, and C), and Khazar Higher Education institute (intact class B). The intact classes were selected among the faculties of social sciences and communication sciences and humanities. At the outset of the study, a research test consisting of open-ended questions and multiple-choice items was developed by the researcher and administered to 75 Masters of Arts (MA) students, to check the homogeneity of the intact classes. To make sure that the students in three different classes are homogenous, the students who scored +1 Standard deviation above and below the mean were excluded from the final analysis, but not excluded from the intact classes. The participants' recruited for the final analysis were 48 (15 in Class A, 16 in Class B, and 17 in class C). All participants were adults and their age range varied between 24 and below 35. All participants were Iranian. 62.5 % (n=30) of the participants were male and 27.5% (n=13) of them were female. The three classes were in communication with each other. They were all taking advanced research courses at the mentioned universities. The researchers negotiated the syllabus and selected the same content areas for the three classes.

Intact classes A, B, and C were assigned to Electronic Flipped 1(text), Electronic-Flipped 2, and non-flipped electronic learning conditions. Teaching processes were explained to each intact group and they all agreed with the instructor's instructional plan. In the three intact groups, the researcher used the BigBlueButton software as an online learning system (See the screen in Appendix). BigBlueButton enables the teachers to share their audio, slides, chat, video, and desktop with students. Built-in polling makes it easy to engage students, and recording the lectures means that the teachers can make them available for later review. One of the experimental intact classes received flipped learning intervention through watching videos, one group received articles and book chapters, and one group received only electronic teaching. In the electronic non-flipped classroom, the teacher used Big-Blue-Button, through which he delivered the contents of the syllabus to the students online. The class was mostly teacher-oriented, but the students had the chance to speak and ask questions if needed. However, in the video flipped classroom, the researcher audio-recorded each session and sent it to the students as a video file through the Big-Blue-Button, four days before the class schedule. The students were required to download the file at home, watch it, and do the assignments at home. In the following session, the teacher and the students joined an online classroom and discussed the main topics of the video file through interactive activities, i.e., the teacher just asked questions and managed the interactions among the students and in some cases, he added to the students' comments. However, in the text flipped classrooms (papers and book chapters), the teacher added book chapters and papers to the Big-Blue-Button space. The students were encouraged to download the assigned files and read them as much as they needed and to take notes. In the following session, like the video flipped learning, teachers and students negotiated and discussed the syllabus. The students were encouraged to comment on the topics raised by the teachers and the students. On the 14^{th} session, the researchers developed the research methodology post-test and administered it to the selected intact classes. The participants in each class were coded numerically, and their scores on the knowledge and practice sections of the research methodology posttest were reported and submitted to appropriate data analysis techniques. The test was administered online to the Three Intact Classes

4. Data Collection Procedure

The researchers developed two research methodology tests to collect the required data: pre-test and post-test. Each test is described in detail, as follows:

4.1 Pretest

The pre-test consisted of 20 multiple choice items (each correct answer=1 point) and 10 open-ended questions (each item=1 point). The questions evoked the participants' knowledge about sampling, research designs, hypotheses, research paradigms, data collection strategies, research ethics, and different parts of a paper. The reliability of the test was estimated through Kurder and Richardson -21 (KR-21). The test enjoyed an acceptable level of reliability (0.84).

4.2 Posttest

The posttest consisted of two sections: knowledge and practice. The knowledge section consisted of 30 multiple-choice items and 10 open-ended questions. However, the practice section consisted of different tasks such as developing research questions and hypothesis, evaluating a paper in terms of method, discussion, introduction, and conclusions, criticizing the review of literature section, writing in-text citations, writing a sample abstract and introduction, and writing a review paper. This section was evaluated holistically by two researchers. The mean of the scores given by two researchers was reported as each student's final score on the posttest research practice section. The reliability of the research knowledge test was estimating through KR-21, while the reliability of the practice section was estimated through inter-rater reliability. Both sections enjoyed an acceptable level of reliability (0.87 and 0.90).

5. Ethical Permission

In order to follow the research ethics, the researchers negotiated types of flipped classrooms with the students in each class. They explained the purpose of the study to all participants. The participants were asked to sign the informed consent form. The participants were assured that the same content of research methodology is taught to all groups. The teachers also assured the participants that they would give the chance to students to have access to some recorded files containing the research methodology syllabus after the post-test if they did not learn the content of the course well.

6. Data Analysis

The researchers analyzed the data in different ways. KR-21 was employed for analyzing the reliability of the placement test and the theory section of the achievement test. Pearson correlation was used to estimate the correlation coefficient between two sets of scores as the index of inter-rater reliability of the groups' scores on the practice section of the achievement test. Also, the researchers employed one-way ANOVA to answer research questions 1 and 2. Moreover, the researchers calculated the effect sizes for different types of flipped classrooms (Video vs., Text) to answer the third research question.

7. Results

In this section, the main findings are presented. At first, the pre-test findings are presented. Then, the findings of the three research questions are presented sequentially. First, the participants' scores on the pre-test were submitted to a one-way ANOVA. Results are presented in Table 1.

Table 1: ANOVA for comparing the groups' scores on the pre-test

Groups	Mean	SD	df	Mean Square		F	P
				Between groups	Within groups		
Non-Flipped	9.14	1.4	2/46	5.91	2.13	2.77	0.09
Flipped 1(research)	9.50	1.5					
Flipped 2 (Video)	9.19	1.3					

The 15 participants in the control group had an average of 9.14 (SD = 1.4); the 16 participants in the Flipped Class 1 (paper and books) had an average of 9.4 (SD = 1.5), and the 17 participants in the Flipped Class 2 (Video) had a mean of 9.9 (SD = 1.3). The difference between the groups, therefore, was not significant, F (2, 46) = 2.77, p=.09. That is, the three intact classes were homogenous in terms of research knowledge.

7.1 Results for the Research Question 1

The first research question aimed at investigating whether or not teachers' use of electronic flipped classroom affect the graduate students' knowledge of research methodology. In order to answer this question, the three groups' scores on research methodology achievement test (theory section), after checking the assumptions of ANOVA test including homogeneity of variances and normal distributions were submitted to a one-way ANOVA test. Results are presented in Table 2.

Table 2: The groups' scores on the knowledge section of research methodology test

Groups	Mean	Sd	df	Mean Square		F	P
				Between groups	Within groups		
Non-flipped	23	1.6	2/45	412	2.44	168.5	0.001
Flipped 1(Video)	28.6	1.7					
Flipped 2 (text)	33.2	1.6					

The 15 participants in the traditional virtual class had an average of 23 (SD = 1.6); the 16 participants in the Flipped Class 1 (video) had an average of 28.6 (SD = 1.7), and the 17 participants in the Flipped Class 2 (papers and books) had a mean of 33.2 (SD = 1.6). The difference between the groups, therefore, was significant, F (2, 45) = 168.5, p=.001. That is, the three intact classes did not have the same performance on research knowledge section. Moreover, the results of the post-hoc test (Bonferroni) showed that the difference between the students in flipped2 classroom (papers and books) outperformed the students in flipped 1(video) class, and the students in flipped1 outperformed the students in the traditional virtual classroom. That is, the difference between the mean scores of the students in the traditional virtual classroom and flipped 1 was statistically significant favoring the fliped1 classroom (p=0.001). Also, the difference between the mean scores of the students in flipped1 classroom and flipped2 classroom was statistically significant favoring the fliped2 classroom (p=0.001). Results can be seen in Table 3.

Table 3: Multiple comparisons between the three intact classes' scores on the knowledge section of the research test (Bonferroni test)

(I)	(J) groups	Mean Difference (I-J)	Std. Error	Sig.
Non-flipped	Video Flipped	-5.62	.56	.000
	Text Flipped	-10.17	.55	.000
Text flipped	Video flipped	4.55147*	.54	.000

7.2 Research Question 2

The second research question addressed the impact of different flipped classrooms on the graduate students' practice of research knowledge. To answer this question, the three intact groups' scores on the practice section of the research test were submitted to a one-way ANOVA test. Results are presented in Table 4.

Table 4: The groups' scores on the practice section of the research methodology test

Groups	mean	Sd	df	Mean Square		F	P
				Between groups	Within groups		
Non-flipped	20.6	2.19	2/45	1182.2	6.01	196.1	0.001

Groups	mean	Sd	df	Mean Square		F	P
				Between groups	Within groups		
Flipped 1(video)	33.4	1.4					
Flipped 2 (text)	37.7	1.15					

The 15 participants in the non-flipped virtual class had an average of 20.6 (SD = 2.19); the 16 participants in the Flipped Class 1 (video) had an average of 33.4 (SD = 1.4), and the 17 participants in the Flipped Class 2 (papers and books) had a mean of 37.7 (SD = 1.15). The difference between the groups, therefore, was significant, F (2, 45) = 1182.2, p=.001. That is, the three intact classes did not have the same performance on the practice section of the research test. Moreover, the results of the post-hoc test (Bonferroni) showed that the difference between the students in flipped2 classroom (papers and books) outperformed the students in flipped 1(video) class, and the students in flipped1 outperformed the students in the traditional virtual classroom. That is, the difference between the mean scores of the students in the traditional virtual classroom and flipped 1 was statistically significant favoring the flipped1 classroom (p=0.001). Also, the difference between the mean scores of the students in flipped1 classroom and flipped2 classroom was statistically significant favoring the fliped2 classroom (p=0.001). Results can be seen in Table 5.

Table 5: Multiple comparisons between the three intact classes' scores on the practice section of the research test (Bonferroni test)

(I)	(J) groups	Mean Difference (I-J)	Std. Error	Sig.
Non-flipped	Video-flipped	-10.63	.88	.001
	Text flipped	-17.19	.86	.001
Text Flip	Video-flipped	6.26	.85	.001

7.3 Research Question 3

The third research question aimed at investigating whether different types of flipped electronic classrooms had the same impact on the students' performance on the research methodology test. The effect sizes for each type of flipped classroom were estimated. The effect size of different types of flipped classrooms in the knowledge section of the research methodology was 2.7, while the effect size of different types of flipped classrooms in the practice section was 3.28. As the effect size of 1.4 is large (Cohen, et al, 2018), it can be argued that both video and text flipped classrooms have great effects on the students' performance in the knowledge and practice sections of the research methodology. However, the experimental effect of flipped classrooms on the practice section is larger than that of the knowledge section of the research methodology suggesting that flipped classrooms are more effective for the students' practice of research methodology.

8. Discussion

The main objective of the present study was to investigate whether the three types of electronic learning (traditional electronic, video flipped, and text flipped) have the same statistically significant impact on improving the graduate students' theory(knowledge) and practice of research methodology. The researcher, having estimated the initial homogeneity of the three intact groups, used three types of electronic learning modes to teach research methodology to the graduate students. Results showed that the students in both flipped electronic classrooms outperformed the students in the traditional electronic classroom, and the difference was statistically significant (p=0.001). That is, virtual flipped classes were found to be more effective than non-flipped virtual classes, in both the students' theory/knowledge and practice research methodology.

This finding is consistent with the results of some of the reviewed related studies (Baranovic, 2013; Grimsley ,2013; Gündüz and Buket Akkoyunlu, 2019). In line with Gündüz et. Al. (2019), it can be argued that the use of flipped learning allows students to be more active in the teaching and learning process, and it gives them more time for active student participation in the classroom. Moreover, classroom time is used more creatively and effectively. Another justification for this finding is that in flipped classrooms, students have a greater chance to experience greater flexibility during both in-class and online sessions. Another reason for the effectiveness of virtual flipped classrooms is, as Lage *et al*. (2000) believed, inverted classrooms engage students with different learning styles. It can also be argued that because the flipped-class approach helps students to regulate and direct their learning, they are more effective than non-flipped classrooms. In line with Mason et al. (2013), it can be argued that in the flipped classroom, the instructors have opportunities to cover more material and improve student participation in the classroom activities. Moreover, flipped classrooms are more effective than non-flipped ones because the students have the chance to pause or re-watch the video files and re-read the text files as many times as they like, while in the traditional virtual classes the students do not have such opportunities.

The results also showed that the students in the text flipped classroom outperformed the students in the video flipped classroom and the difference between the mean scores of both flipped classes on both knowledge and practice sections of the research methodology test were statistically significant, favoring the text flipped classes. That is, the students' mean scores of the text flipped classroom on both knowledge and practice sections of the research methodology achievement test exceeded the mean scores of the video flipped classroom. This finding is not consistent with some of the researchers who argued that students are able to take better notes by re-watching and pausing the videos, which them to understand the content (Awidia and Paynterba, 2019; Siegle 2014). However, it is consistent with the findings of Gündüz, et al (2019) who argued that some of their participants expressed disappointment with the "lack of immediate feedback while watching videos and with their poor Internet accessibility outside of the classroom" (p.11). The main reason for the inconsistency between the findings of this study and the reviewed studies is that: a) it took time for each student to download the video files due to the low speed of the internet in Iran and their listening related problems and issues such as the teacher's tone, accent, and speech speed rate, b) while reading the book chapters and papers, students have great opportunities to reflect on each unknown academic term and surf the net for having more information about the assigned topics.

With regard to the third research question, it was found that the experimental effects of both types of flipped classrooms were large. It was also found that the effect size of flipped classrooms for the practice section of the research methodology (3.28) exceeded the reported effect size (2.7) for the knowledge section of the research methodology. Therefore, it can be argued that both text ad video flipped classrooms enhanced the participants' scores on the practice section of the research methodology more significantly than the theory section. As this finding is quite new in this realm of study, there is no research in the review section to back up the finding. However, it could be inferred that in the flipped classes, the students have the chance to rehearse and discuss the materials with the teachers and their classmates. More particularly, in the text flipped classes, the students are exposed to sample research papers and book chapters. Therefore, they actually practice the theories of the research, and they get familiar with the genre of the research papers.

9. Conclusions

In line with the findings of the study, it could be concluded that, as the Coronavirus closed all face-to-face classes at universities all over the world, a radical shift from traditional learning to electronic learning is unavoidable. Among the flipped classrooms, because of the students' likely problems such as slow speed of internet, text flipped classes are more strongly recommended to faculties and educational administrators at both local and international universities. It can also be concluded that for practical courses such as research methodology, as a very needed course for graduate and postgraduate students, academic writing courses, etc., the use of text flipped classes is much more advantageous than the other types of electronic learning and video/audio flipped classes. As the context of the study, the students' and teachers' electronic learning literacy, and the nature of academic fields of the study might play a role as mediator variables, the other researchers are recommended to replicate the study using these variables. In this small-scale study, results suggested that text-flipped classes have strong potential to foster student learning. Therefore, universities can employ the findings and provide the students and teachers with required online learning platforms. As graduate students are active learners and they are required to write papers and projects for the courses they take, text flipped classrooms are strongly suggested to university instructors to help students acquire the needed skills to practice the theories learned in each classroom.

Despite the merits of this study, the researchers' faced some limitations such as lack of access to a large number of participants and the impossibility to deeply delve into the participants' perceptions about different types of electronic learning, Therefore, it is clear that further research is needed to explore this finding further at different scales, across different subject areas, and in different learning contexts through both qualitative and mixed-methods research designs.

Abbreviations

EFL= English as a Foreign Language

ESL= English as a Second Language

FC= flipped classroom

FCI= flipped classroom instruction

KR-21= Kurder and Richardson -21

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Information Technology Capability (ITC) Framework to Improve Learning Experience and Academic Achievement of Mathematics in Malaysia

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Abstract: Poor mathematics performance was generally reported from international assessments such as Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) among Malaysian students. Malaysia is ranked 52nd and 48th in the assessments for 2012 and 2018 respectively, while Singapore, Japan, South Korea, and even Vietnam have consistently performed well and held the top spots among the 78 countries evaluated in the PISA. Although numerous new technologies have been introduced, developed and implemented for education, incorporation of IT capability (ITC) to teach and learn Mathematics where still lacking commonly. Additionally, learning Mathematics in the traditional teaching contents could not accomplish desired learning outcomes because of dry contents and dull teachers. Therefore, this study is to design an appropriate ITC framework for improving learning experience and academic achievement of learning Mathematics. This study has adopted the development model of Analysis, Design, Development, Implementation and Evaluation (ADDIE) and Mayer (2010)'s cognitive theory for multimedia instructional content design. This study developed a new Multimedia Probability and Statistics system (MMPASS) for a subject of Probability and Statistics. The developed topics were concepts of discrete random variables and probability distribution function which were puzzled by students from preliminary study. An experiment was conducted with both control and experimental groups. The developed MMPASS blended multiple influential multimedia elements in the learning contents. A quantitative method and proportional stratified sampling were used to collect data. The blended topics were used by the experimental group whilst the control group was solely learning using the existing learning contents. Questionnaires were distributed to both groups after the lessons. 66 students participated in this survey. The collected data was then analysed and an ITC model was formed. Results of this study show that Perceived System Quality, Perceived Information Content Quality and Perceived System Performance as independent variables significantly improved learning experience. The findings also reveal that the performances of the experimental group have a higher mean score (9.65/10.00) compared to the control group (8.03/10.00), indicating the use of MMPASS improved students' learning performance in subjects that involve understanding of concepts. While there is a lack of established ITC framework and IT application for Mathematics education in Malaysia, this study has verified the use of ITC improving performance of learning Mathematics in Malaysia.

Keywords: IT capability, Students' interest, Learning experience, Multimedia learning context, Academic achievement of mathematics

1. Introduction

The important role of Mathematics grows in all areas such as Analytical, Science, Engineering, Finance Medicine and Computing Science. Basic arithmetic and estimation are very important in education, even in our daily life. For example, using algebra to study the symmetry in chemistry and calculus for molecular structure. Furthermore, Mathematics also provide ability to interpret (logical reasoning), analyse information, simplify and solve problem (Tan, 2012; Nagasaki, 2017; Adelabu, Makgato and Ramaligela, 2019). The most recent results of the Programme for International Student Assessment (PISA) 2018 revealed that Malaysian teenagers continue falling behind their regional and global peers (Table 1). Despite a slight improvement in PISA 2018 compared to PISA 2012, Malaysia remained in the lower segment of the rankings (Borzsonyi, n.d.; Kean Hin, 2020; Mahdzir, 2016) This problem should be a concern and increase the performance of the students in Mathematics across the nation.

Table 1: PISA mathematics scale by jurisdiction for 2015 and 2018

Year	2012		2015		2018	
Jurisdiction	Rank	Average Score	Rank	Average Score	Rank	Average Score
Singapore	2	573	1	564	2	569
Japan	7	536	5	532	6	527
South Korea	5	554	7	524	7	526
Vietnam	17	511	22	495	*	*
Malaysia	52	421	*	446	48	440

Note: *No data available. Source: https://pisadataexplorer.oecd.org/ide/idepisa/dataset.aspx

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Students' interest is one of the core factors for better learning experience as well as higher academic achievement. However, students have no interest to learn Mathematics subject and their participation are low because of uninteresting learning method (Siti, 2013; Yeh, et al., 2019). When mathematics concepts are not connected to real-world issues and are just seen as numbers, mathematics becomes boring (Chand S, 2021). Learning Mathematics needs to involve students' participation for understanding the boring concepts. Thus, the concepts of Mathematics should be related to real-life problems and presented in an interesting way. It is important to choose an appropriate information technology capability (ITC) in learning Mathematics which can promote students' interest effectively. This is due to the fact that, despite several new technologies being invented, introduced, and applied in the field of education, the inclusion of IT capability (ITC) to teach and study mathematics was still commonly lacking.

Multimedia learning is one of the effective learning approaches that was explored through ITC. In learning Mathematics, multimedia is very useful and productive because of its characteristics of interactivity, flexibility and incorporation of various media elements that can support and boost students' motivation, interest and confidence level (Pulasthi and Sellapan, 2016; Luiza, 2017; Ben, 2018).

Interactivity in multimedia content learning allows control over the lessons. Learners can change parameters, perceive their results or respond to a choice selection. Students regularly try to solve mathematical problems by substituting parameters to a standard formula/equation without reaching an understanding of the actual meaning. As stated in Mayer (2010)'s cognitive theory of multimedia learning, "it is essential to integrate both picture and definition methods to improve students' existing knowledge to enlarge it with the new facts". Hence, multimedia can visualise better mathematical ideas, formulas, theoretical names and issues (Dena, 2014; Sri, Kalaiarasi and Lew, 2018; Ben, 2018).

New technology has improved the effectiveness and efficiency of learning Mathematics (Lai D., 2021; Lai D., 2022). In this study, a learning framework was developed with integration of multimedia for Mathematics. A variety of multimedia elements were included in the developed ITC framework for learning mathematics. Three independent variables (IVs); (1) Perceived System Quality (IV1), (2) Perceived Information Content Quality (IV2) and (3) Perceived System Performance (IV3) and two dependent variables (DVs); (1) Academic Achievement (DV1) and (2) Learning Experience (DV2) were used to measure the ITC system's effectiveness. Students' performances were used to evaluate the framework's effectiveness. The results showed positive impacts in learning Mathematics.

The developed framework is aimed to improve the mathematics performance for Malaysia students. This aim is in line with the aspiration of Malaysia Education Blueprint 2013-2025, particularly the Education National Key Results Areas (NKRA) which is to improve the student outcomes in Malaysia's school system and to enable access to quality education for all students (Malaysia, n.d.). Students can learn Mathematics effectively with the developed IT application that incorporated the IT capabilities. While Mathematics being a fundamental knowledge for all disciplines, improving student outcomes in Mathematics could develop a more competitive workforce as Malaysia pushes towards becoming a high income and advanced nation by 2025 under the Twelve Malaysia Plan 2021-2025 (Yaakob, 2021; Zainuddin, 2021).

1.1 Problem Statement

In PISA 2015, Malaysia scored 446 marks in Mathematics and marked improvement over previous PISA (421 marks). Unfortunately, Malaysia was not featured in the 2015 PISA rankings although 9,660 students from 230 schools in Malaysia took part (Mahdzir, 2016). There were only 51% response rate from Malaysian schools, far below the benchmark response rate of 85% from other countries. Thus, the results were not valid for this low response rate. In PISA 2018, Malaysia scored 440 marks in Mathematics, despite a minor improvement over PISA 2012, Malaysia remained in the lowest mark category (below 450 marks) of the rankings in PISA 2018 (Borzsonyi, n.d.; Kean Hin, 2020; Mahdzir, 2016). In TIMSS 2015, Malaysia scored 465 marks where 25 marks more than the from previous TIMSS (2011) score. Even though the score improved, it is still "below average" than the global average score of TIMSS which is 500. Generally, the major issues in poor academic achievement of mathematics are students' lack of interest and confidence level to solve a mathematics problem (Filiz, 2013; Yeo, Tan and Lew, 2015; Sri, Kalaiarasi and Lew, 2018; Mohammad, Fitra and Hamsyah, 2018). Uninteresting learning method will cause low students' interest and participation (Siti, 2013). Besides, students have difficulties to understand the concepts of mathematics. Tan (2012) said that learning mathematics needs to involve students' understanding. Thus, the concepts of mathematics should be related to real life problems and presented in interesting way. Therefore, the lack of interest and confidence level cause poor learning experiences among the students. Furthermore, due to a lack of understanding of mathematics concepts, which is reflected in poor performance, Malaysia's workforce will be less competitive, limiting its ability to contribute to the country's goal of being a high-income, advanced nation by 2025. In contrast, good learning experiences contributes for better academic performance (Kelly, et al., 2010; Clark and Mayer, 2016). Previous studies (Khalid, 2009; Cemil, et al., 2010) showed the integration of IT in learning is quite low, although IT has been contributing positive impacts in Mathematics (Babettte and Tim, 2011; Filiz, 2013; Yeo, Tan and Lew, 2015; Sharon, 2017).

1.2 Significance of Research

This study was proposed from the poor Mathematics performance among Malaysian students in several programmes such as foundation, PISA and TIMSS. The developed framework is aimed to improve the mathematics performance for Malaysia students. Students can learn Mathematics effectively with the developed IT application that incorporated the IT capabilities. While Mathematics being a fundamental knowledge for all disciplines, improving student outcomes in Mathematics could develop better personnel to develop the country.

Furthermore, the developed framework is useful for Probability and Statistics subject, students, lecturers, researchers and system developers of Probability and Statistics. All the empirical insights in this study are useful for the theoretical development and future researchers.

1.3 Objective of Research

The overall aim of this research is to improve learning Mathematics by integrating an information technology capability (ITC) framework. The specific objectives are as follows:

- To design an appropriate ITC framework for learning Mathematics.
- To evaluate the relationship between ITC, learning experience and academic achievement of learning Mathematics.

2. Literature Review

The characteristics learning experience, multimedia learning and the adopted model to design and develop an effective ITC framework in this study are discussed.

2.1 Learning Experience With Technology

Vinesh and Jo (2012) and Yeo, Tan, and Lew (2015) found that technology can build learners' confidence level by reducing their anxiety. Technology can also help learners to grasp language more quickly by motivating them. Teaching and learning using e-audio and e-visual (e-AV) were tested improving learning experience (Siti, 2013). A total of 256 students from a high school in Indonesia participated in a quasi-experiment with two different teaching methods: one with entirely media instruction through e-AV Biology and the other with teaching method. After using e-AV Biology, the performance of the instructional media was evaluated. The mean scores of Biology were improved from 14.60 to 20.35. In terms of students' interest, the interest had improved significantly with mean scores from 3.84 and 4.06.

Users can learn through the interaction. Interaction is the process of engaging the experience for learners to achieve their personal goals (Patrick A. Müller, 2020; Dario Cottafava, 2019). The ability to solve new problems by applying the newly learned materials in reality is an example of interest or engaging process. This ability can be measured by a retention test. Interest or engagement process can be assessed by retention test (Kristian, 2006; Dick and Hollebrands, 2011; Mohammad, Fitra and Hamsyah, 2018). Interaction, course, program or any other experiences that an individual has in the process of learning is considered as learning experience. Furthermore, achievement of academic, users' perception of motivation, interest and confidence measure users' learning experience (Ertmer and Ottenbreit, 2010; Dena, 2014; Tan, 2012; Sri, Kalaiarasi and Lew, 2018). With this notation, in this study, learning experience is measured by academic achievement, interest, confidence level and users' perception of the system.

2.2 Multimedia Learning Context

Multimedia learning context comprises multimedia elements such as text, image, video, audio and animation which support learning experiences and showed positive impacts in learning (Paturusi, Yoshifumi and Usagawa, 2012; Haftamu, 2016; Ben, 2018; Mohammad, Fitra and Hamsyah, 2018; Reza, Zulela and Mohamad, 2019). One of the main capabilities is allowing students to visualise and manipulate the contents of learning in a different perspective such as animation based on analogy examples for Mathematics (Sharon, 2017). Students can learn by seeing, hearing, visualising and manipulating content using multimedia elements used in the animation. In addition, multimedia elements are influencing learners' attitudes towards learning. Thus, the developed ITC framework is an integration of impactful multimedia elements supporting educational principles.

According to cognitive theory, the more learning resources to be used, the less percentage of brain will be involved in retaining the memory (Mayer, 2010). The process of information in working memory can be reduced by using effective multimedia elements (Abbas, 2012; Li, Neo and Neo, 2013). This is due to the content delivery by auditory channel and visual channel in working memory is reduced. The processing of information can be heard through auditory channel and seen through visual channel. Mayer (2010) claimed that in multimedia learning, the process of information in our brain is more effective. Hence, the learning can be effectively achieved throughout the engagement of learners in cognitive processes of information in our brain by using effective multimedia elements.

The cognitive theory of multimedia learning was investigated by many researchers (Abbas, 2012; Jenny, 2014; Vinesh and Jo, 2012; Filiz, 2013). These studies presented the principles that learning process is more effective by minimising the processing load on the working memory (Abbas, 2012; Filiz, 2013). Meysun and Thair (2016) conducted a study using cognitive theory of multimedia learning. The study showed an improvement in the students' achievement. This study proved that when the multimedia elements were employed properly into the educational process can improve students' understandings and help students to achieve higher academic scores. Li, Neo and Neo (2013)'s study showed students learn better by choosing the cognitive theory of Mayer (2010)'s cognitive theory to design the learning goals. This study supported multimedia learning can raise up level of interest, retention rate and academic achievement of students. However, their study was to acquire students' perception towards a student-centred learning environment only which was not focusing on ICT that will be discovered by this study. As a result, in this study, the engagement of learners using cognitive theory via impactful multimedia learning is proposed for higher academic achievement.

2.3 Multimedia Learning Context Design and Development

Figure 1 shows the most popular model used for instructional design is the analysis, design, development, implementation and evaluation (ADDIE) model (Aldoobie, 2015; Branch, 2010). This model helps the instructional designer to create effective and efficient instructional design. ADDIE model is identified as an effective model to design a good instructional learning. The model name, ADDIE was formed by the first character of its five phases "(1) analysis, (2) design, (3) development, (4) implementation and (5) evaluation". The first phase of ADDIE model explains the instructional issues, objectives, identify learning environment and learners' existing skills and knowledge. The second phase contracts with learning objectives, media selection, assessment, instrument and content. The third phase is for developers or instructional designer design the story boards with integrate technologies. The fourth phase emphases on developing procedures. The final phase of ADDIE model ensures all the objectives are achieved throughout the learning process.

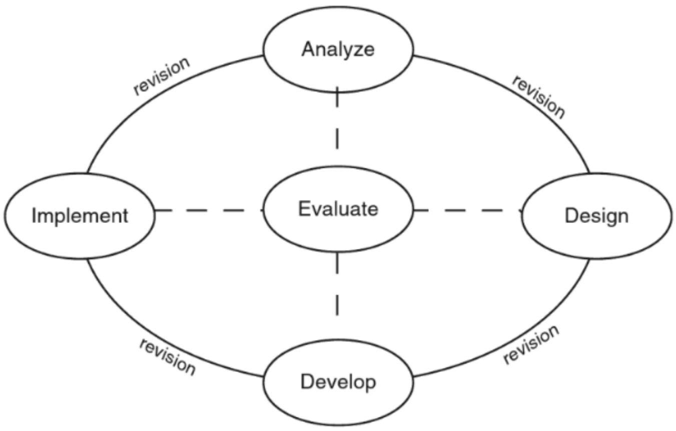

Figure 1: The ADDIE concepts

The effects of ADDIE instructional design using multimedia improving learning skills was evaluated by Azimi, Ahmadigol, and Rastegarour (2015). As a result of the study, the students who were trained using multimedia, scored higher mean scores as compared to students who were trained with traditional method. Therefore, ADDIE model was found effective for instructional design. In addition, Mohammad, Fitria and Hamsyah (2018) conducted a study of improving mathematical reasoning by integrating interactive multimedia in mathematical problem solving. The model used in the study were developed using ADDIE instructional design. The findings supported that students gained better problem solving skills and have a significant impact on their mathematical reasoning. As a conclusion, the literature review studies proved that the ADDIE model has a positive impact in the multimedia learning process. Therefore, ADDIE model has been adopted in the framework of this study.

2.4 Media Elements in Multimedia Instructional Content

The attitudes and behaviours of learners towards multimedia content learning are substantially influenced by the types of media elements. Table 2 shows various media elements that were commonly aided multimedia learning (Xiaohui and Mark, 2010; Siti, 2013; Nuraini, 2016).

Table 2: Various media elements and its purposes for multimedia learning

Media Elements	Purposes
Animation, simulation, video	Virtually explain, Animated PA
Button, help, image, link, search	Navigation
Diagram, process model or flowchart	Examples, representations
Chart, concept map, graph	Demonstration, relationship
Text	Explanation and narration

In this study, text, images, audio and animations were used to present the learning content. For instance, mixture of analogy, animation and formulas were used to elaborate the steps of processes.

2.4.1 Animated Pedagogical Agent

Animated pedagogical agent (PA) refers to an agent used to assist students in multimedia content learning (Yeo, Tan and Lew, 2015). Animated PA creates new learning experience that will stimulate students' engagement and interest in students' learning. Animated PA interacts and transmits information to students by either verbal or nonverbal behaviour (Kristijn, Ivaan and Dejan, 2012; Yeo, Tan and Lew, 2015). Kristijn, Ivaan and Dejan (2012) found that animated PA also increases confidence level of students and encourage them to put in more effort in order to succeed in their academic performance. In the current study, animated PA is integrated to deliver the learning content. The animated PA is developed using Adobe Photoshop and Adobe Animate CC. Action script 3.0 is used to code the program.

2.5 Guidelines and Protocols for Multimedia Instructional Content

The developers must define the presentation of learning contents based on multimedia cognitive theory. Design guidelines derived from the cognitive theory of multimedia learning could be used to engage cognitive processing and teaching approaches in mathematics education to enhance learning (Chiu and Churchill, 2015). Multimedia learning would provide for even more in-depth cognitive processing than standard text-based articles, resulting in improved knowledge, sharing, adoption, reputation, and relevance (Mirkovski, Gaskin, Hull and Lowry, 2019). There are three important cognitive processing capacity aspects that are able to achieve the learning objectives and which are extraneous processing, essential processing, and generative processing (Clark and Mayer, 2016). The objectives of multimedia learning are related to the three stages of cognitive processing in terms of essential, extraneous and generative. Table 3 presents the cognitive processing mapping to multimedia principles by Clark and Mayer (2016).

Table 3: Cognitive processing and multimedia principles

Cognitive Processing	Multimedia Principles
Managing Essential Processing	Modality, Pre-Training, Segmenting
Demoting Extraneous Processing	Coherence, Contiguity, Redundancy, Signalling, Spatial Contiguity, Temporal
Promoting Generative Processing	Image, Multimedia, Personalisation, Voice

Clark and Mayer (2016) suggested two keys to create a meaningful context in learning. The first key is to understand the audience or learners. The developers should take effort to understand the perspective of learners, prior knowledge and experience. Furthermore, exploring knowledge on the contents and interest are also very important. Secondly, listening to the audience during early stages of system design such as reviews. The last key is to adapt the audience into the development of framework. If the learners' experience come with identical prior experience means the developers work is straightforward. The developers need to connect to the audience even if the path given is not prescribed by the subject expert.

Designing an effective multimedia instructional content-based application, there are some basic principles should be considered (Kuba, et al., 2021; Mayer, 2017). Table 4 presents 8 basics principles by Clark and Mayer (2016).

Table 4: Multimedia principles

Multimedia Principles	Definitions
Multimedia Principles	Learners learn through words and graphics than words. Multimedia principles help to integrate words and graphics effectively.
Contiguity principle	Contiguity principle is the words to be aligned simultaneously to corresponding image.
Modality principle	Modality principle is to exhibit text in audio versus visual text on screen.
Redundancy principle	Redundancy principle is to explain the visuals with narrated audio or text on screen but not simultaneously.
Personalisation principle	Personalisation principle is emphasised on the use of a familiar way of expression such as the use of pedagogical agent.
Worked Examples	Solving problem by showing solution gradually and carefully from one stage to the next.
Practice	Unsolved exercises are designed to train learners to solve the rest of the task by reading the worked examples. By following the steps from worked examples, learners are able to solve the problem by themself.

Previous studies suggested few criteria to present the multimedia learning contents because learners must be attracted to the learning contents (Tsung, 2010; Vinesh and Jo, 2012; Leow and Neo, 2014; Obizoba, 2015; Meysun and Thair, 2016; Nuraini, 2016). Besides, unnecessary multimedia elements in instructional materials will distract the learners' interest.

Meysun and Thair (2016) conducted a study using cognitive theory of multimedia learning. The study shows an improvement in the students' achievement. Hence, the multimedia elements were employed properly into the educational process and improved students' understandings and helps students to achieve higher scores. Meysun and Thair (2016) presented guidelines to present texts, images, audios and video or animation based on principles of multimedia learning.

Nuraini (2016) discussed multimedia learning contents in individualised learning environment manner. The findings of this study showed that the learning contents were well-presented using multimedia learning contents based on the user acceptance test. The user acceptance measure module of contents, multimedia elements, navigations and usefulness.

The colour of background and text increase the readability of users and also boost their learning retention (Jiménez, et al., 2020; Mayer, 2017). The colour selection for developed framework used based on the colour codings. Table 5 shows the choice of colours and its characteristics proposed by Rick, Tara and Donna (2014).

Table 5: Choice of colours and characteristics

Colour Choice	Characteristics
Red	Red helps learner to remember the important points. Melissa (2015) suggested to write the key points in red colour.
Green	Green is a relaxing colour which can improve student concentration.
Blue	Blue provides a peaceful feeling, creativity and also improve learners' reading comprehension.
Yellow	Yellow can be used to highlight of contents. The learners are able to pay more attention using yellow. Melissa (2015) suggested to use this colour to highlight the contents and use it as borders on hand-outs.
Orange	Orange boosts learner's mood to feel comfortable and it improves the functions of brain.
Overlay Orange	Overlaying orange in white background can be used for autism students (Melissa, 2015).

The protocols and guidelines in Tables 2, 3, 4 and 5 were adopted in this study to improve multimedia instructional contents that found by Meysun and Thair (2016), Nuraini (2016), Clark and Mayer (2016) and Rick, Tara and Donna (2014). These protocols and guidelines are used during the process of framework development because it's successfully implemented and improved students' learning experience and performance of Mathematics in past studies. Therefore, the current study adopted Mayer (2010)'s cognitive theory, ADDIE model and keys to design a meaningful multimedia instructional content by Meysun and Thair (2016), Nuraini (2016), Clark and Mayer (2016) and Rick, Tara and Donna (2014).

3. Methodology

A procedural plan was used to acquire answers for research questions and objectives (Ranjit, 2011). It works on testing and makes a common description of method of certain relations. This study applied hypothesis testing on the developed framework in order to evaluate the relationships between information technology capability (ITC), learning experience and academic achievement of Mathematics. Two research questions were identified as

- What is the appropriate ITC framework for learning Mathematics?
- Are there any significant relationships between IT capability, learning experiences and academic achievement of Mathematics?

3.1 Research Procedures

Sekaran and Bougie (2016) suggested a sequential research procedure to execute the planning and designing phase. The suggested research procedures were adopted. Figure 2 represents the flow of research procedures (Sekaran and Bougie, 2016).

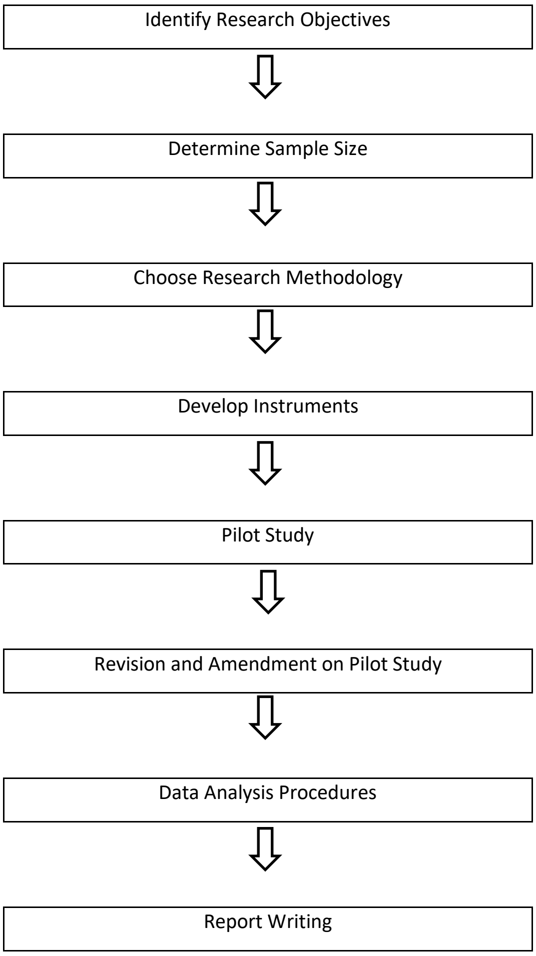

Figure 2: Flow of research procedures

3.2 Sampling Design and Demographic Analysis

Table 6 shows the summary of respondents' demographic profile. This study used Stratified sampling method to divide the students into experimental and control group. For proportional stratified sampling, gender, race and level of education can be used to split the sampling groups (Ranjit, 2011). Hence, the population was split into two groups by the students' academic achievement in overall (Cumulative Grade Points Average, CGPA) of their education level.

Table 6: Demographic profile of respondents (n = 66)

		Count	Percentage
Gender	Male	51	77.3
	Female	15	22.7
Age	Below 18	33	15.9
	18 and above	55	84.1
Most preferred Tools	Computer	58	87.9
	Scientific calculator	57	86.4
	Smartphone	56	84.8

3.3 Instrument

A questionnaire was used as an instrument. The use of questionnaire was to evaluate the students' perception towards the developed information technology capability (ITC). The questionnaire contains four main key variables namely "Learning Experience", "Perceived System Quality", "Perceived Information Content Quality" and "Perceived System Performance". All the variables use 5-point Likert scale.

3.3.1 Questionnaires design

Table 7 presents the type of questions, sources and measurement that were used in the questionnaire.

Table 7: Structure of questionnaire

Sections	Types of Questions	Sources	Measurement
Section A General information	Closed ended questions	Siti (2013), Jenny (2014) and Dena (2014)	Demographic information
Section B Students' perception	Closed ended questions using 5-point Likert-scale	Paturusi, Yoshifumi and Usagawa (2012), Siti (2013), Jenny (2014) and Dena (2014)	(1) Learning Experience (2) Perceived System Quality (3) Perceived Information Content Quality (4) Perceived System Performance
Section C - Students' suggestions and opinions	Open ended questions	Self-designed	Suggestions and opinions

3.4 Multimedia Elements of MMPASS

Table 8 shows the multimedia elements that have been integrated in Multimedia Probability and Statistics system (MMPASS) and its description (Xiaohui and Mark, 2010; Yeo, Tan and Lew, 2015; Sivapoorani, Lew and Tan, 2016; Clark and Mayer, 2016)

Table 8: Adopted multimedia elements

No	Multimedia Elements	Description
1	Text	Simple font type, colour coding (blue, green, red, and yellow).
2	Images	Pairing audio and images to illustrate practical examples.
3	Audio	Good quality audio, low speech rate and simple language.
4	Animation	Usage of animated PA and presenting complex mathematical concept by practical examples.

3.5 Examples of Animations

An animated pedagogical agent (PA) shows in Figure 3. This PA was designed and included in the developed MMPASS. The PA can be played as lecturer or tutor role. She speaks clearly, slowly and simple English. She teaches lecture contents and guides solving mathematical problems using animations, audio, text and images.

Figure 3: Animated pedagogical agent

Figure 4, Figure 5 and Figure 6 show three examples of animations by MMPASS to teach the concept of discrete and continuous random variable. Figure 4 (Example 1) illustrates and visualises discrete random variable. The animation illustrates and visualises the concept of a car parked in a parking lot in a given time by using texts, car images, car action, time narration and audio. Figure 5 (Example 2) shows discrete random variable. This figure illustrates and visualises the number of cars entering car wash by using texts, car images, car wash images, car action and audio. Figure 6 (Example 3) shows continuous random variable. This figure illustrates and visualises the time taken to complete a Mathematic test. Exam papers are used as image and arrow symbol is used to indicate the time left.

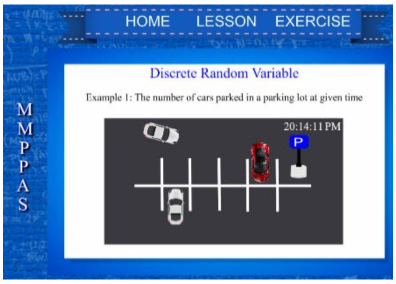

Figure 4: Discrete random variable 1

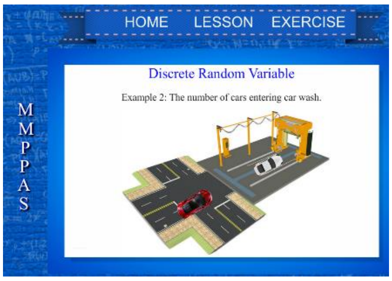

Figure 5: Discrete random variable 2

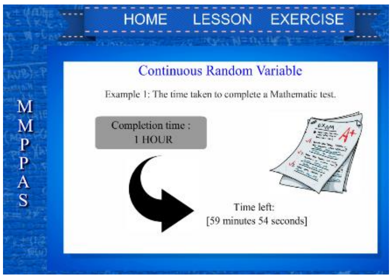

Figure 6: Continuous random variable

Figures 7, 8 and 9 are some examples of images and texts used in this study. Figure 7 illustrates and visualises the probability of coin tossing. Red colour is used to highlight the text and the coins. Figure 8 shows three types of questions to test if a student can identify a probability distribution function. The solution of each question is linked by a blue solution button. Figure 9 shows the solution for each question is linked in blue solution button. The green tick is used to indicate the audio explanation.

Figure 7: Probability of tossing coins

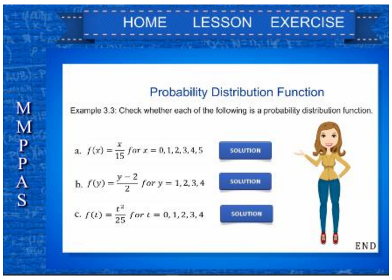

Figure 8: Example of probability distribution function

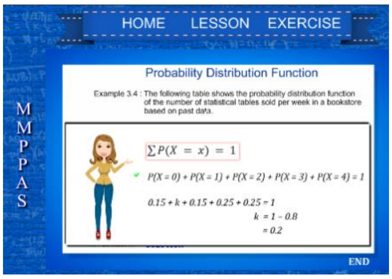

Figure 9: Solution of probability distribution function

3.6 Normality

In this study, skewness and kurtosis tests were used to test the normality of a distribution. Table 9 presents the values of skewness and kurtosis for this study.

Table 9: Skewness and kurtosis analysis

	Skewness	Kurtosis
Scores	-.897	-.460

The values of skewness and kurtosis are less than absolute value of one. Therefore, the analysed data are reasonably symmetric and considered as normal distribution.

3.7 Validity and Reliability

Validity and reliability are two important criteria in the questionnaire to ensure the developed instrument is error-free (Jenny, 2014; Sekaran and Bougie, 2016). A pilot survey was carried out on the developed questionnaire. The questionnaire was validated and reviewed by three information system and Mathematics experts. Then the questionnaire was revised based on the given comments and suggestions. These experts are senior lecturers from academic institution. Table 10 shows the values of Cronbach's alpha coefficient for the developed instrument.

Table 10: Reliability test

Items	Cronbach's Alpha
Learning Experience	0.846
Perceived System Quality	0.721
Perceived Information Content Quality	0.773
Perceived System Performance	0.708

Based on the accepted Cronbach's alpha which is greater than 0.70 this instrument is reliable (Sekaran and Bougie, 2016).

3.8 Survey

The survey was carried out with experimental and control group. The group without using ITC system is known as control and the group with ITC system is known as experimental. The control group learned the subject by a lecturer using traditional teaching method. Before the lecture commenced, a small briefing session was given to students about the ITC system and the purpose of this study. A quiz was given to both groups after the lecture session. The quiz's performances of the two groups of students were compared to verify the effectiveness of the developed ITC system. Students' perception was collected consequently using a questionnaire.

4. Results

This section initially, discusses the proposed ITC framework and followed by the overall findings of results using descriptive statistics, *t*-test and linear regression used in this study.

4.1 Data Analysis

Social Science Software Package (SPSS) analytic software was used to test the effectiveness of the information technology capability (ITC) framework and hypotheses. Independent *t*-Test and Linear regression test were used to analyse the students' performance and relationship between independent variables (IVs) and dependent variables (DVs) respectively.

4.2 ITC Framework

Figure 10 shows the developed ITC framework in this study. As shown, the ITC framework is a combination of multimedia elements in learning Mathematics. The multimedia elements were developed based on a set of multimedia instructional protocols and guidelines (Clark and Mayer, 2016; Meysun and Thair, 2016; Nuraini, 2016; Rick, Tara and Donna, 2014). The learning process is situated in the middle of the framework. The effectiveness of the ITC system was measured by three independent IVs and two DVs.

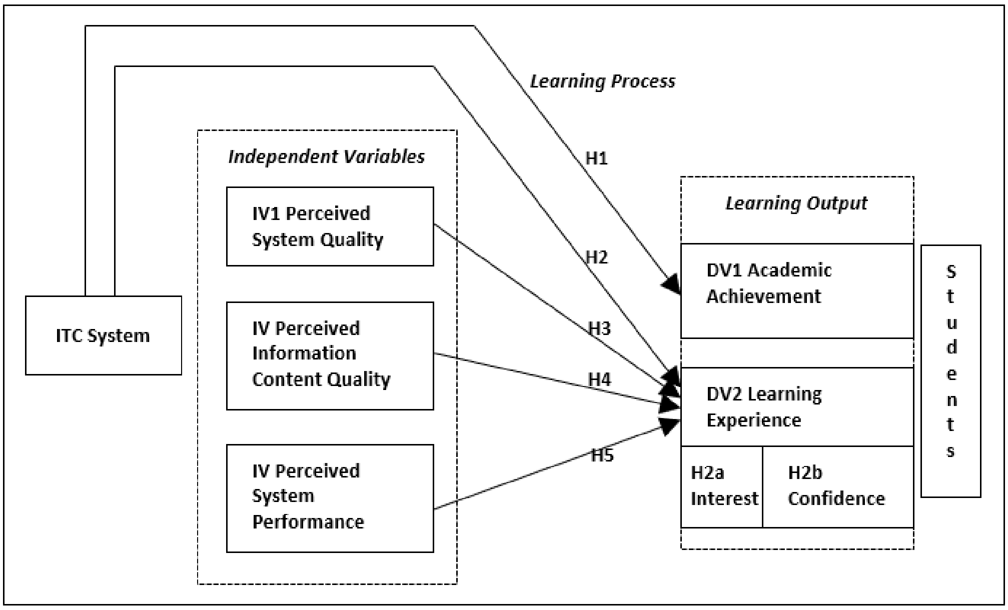

Figure 10: IT Capability (ITC) framework

Hypotheses

Hypothesis 1 (H1): "Students who use ITC system performs better in answering quiz than those who do not use the ITC system"

Hypothesis 2 (H2): "Students who use the ITC system, the better the students' learning experience"

Hypothesis 2a (H2a): "The higher the students' interest in learning, the better the students' learning experience is"

Hypothesis 2b (H2b): "The higher the students' interest in learning, the more students' confidence is"

Hypothesis 3 (H3): "The higher the perceived system quality, the better the students' learning experience is"

Hypothesis 4 (H4): "The higher the perceived information content quality is, the better the students' learning experience is"

Hypothesis 5 (H5): "The higher the perceived system performance is, the better the students' learning experience is"

4.3 Findings

Table 11 shows that the mean scores of quiz are 9.65 for experimental and 8.03 for control groups respectively. The experimental group has higher mean score compared to control group. The presented independent *t*-test result shows that there is a significant difference in mean scores between two groups as the *p*-value = 0.000 ($p<.05$). Therefore, it is proven that MMPASS is helpful in learning Probability and Statistics. Thus, the null hypothesis is rejected and H1 is accepted.

Table 11: Independent sample t-Test

	Group	n	Mean	SD	t-Test for Equality of Means		
					t	df	Sig. (2. tailed)
Scores	Control	33	8.03	1.447	5.703	64	0.000***
	Experimental	33	9.65	0.566			

***Significant at 0.05

Figure 11 and 12 presents the mean of scores in bar chart and boxplot of the mean scores of control and experimental groups respectively. The minimum and maximum values in experimental group with MMPASS are higher than the values control group. Meanwhile, the median value, lower quartiles value, upper quartiles value in experimental group with MMPASS are also higher than the values in control group.

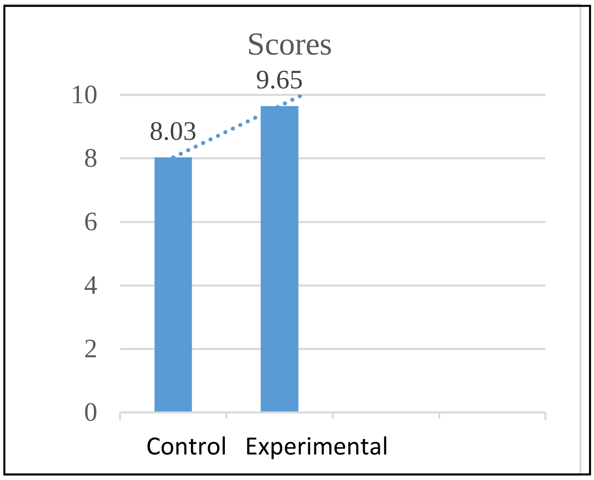

Figure 11: Scores in control and experimental groups

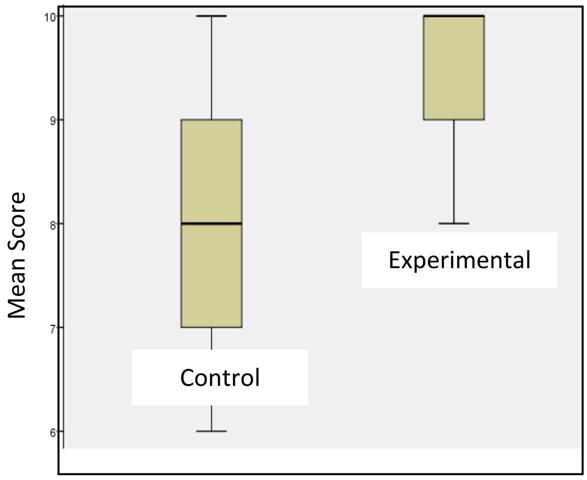

Figure 12: Box plot of mean scores in control and experimental groups

Table 12 shows a summary of hypotheses with measures of standardized beta coefficient, *p*-value and significance level.

Table 12: Summary of findings

	Hypothesis	Description
t-Test	H1	Mean scores of 9.65 and 8.03 from a total of 10 for the experimental group and the control group respectively. The mean scores are statistically significant with p-value = 0.000 (p<.05). With this, H1 is accepted.
Linear Regression	H2 H2a	Students' interest (p = 0.000) has a significant influence on students' learning experience by using ITC system as the p-value is found to be significant at 95% confidence interval. Based on the framework, students' interest in learning Mathematics has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.839). Thus, H2a is accepted.
	H2b	Students' interest (p = 0.000) has a significant influence on confidence level by using ITC system as the p-value is found to be significant at 95% confidence interval. Based on the framework, students' interest has a significant positive influence on students' confidence level to solve a set of Mathematics questions (standardised beta coefficient = 0.693). Thus, H2b is accepted.
	H3	Perceived system quality (IV2) (p = 0.002) has a significant influence on students' learning experience as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, perceived system quality (IV2) of ITC system has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.512). Thus, H3 is accepted.
	H4	Information content quality of (IV3) (p = 0.000) has a significant influence on learning experience (DV2)) as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, information content quality (IV3) of ITC has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.705). Thus, H4 is accepted.
	H5	Perceived system performance (IV4) (p = 0.002) has a significant influence on students' learning experience (DV2) as the p-value is found to be significant at 95% confidence interval. Based on the ITC framework, perceived system performance (IV4) of ITC has a significant positive influence on students' learning experience (DV2) (standardised beta coefficient = 0.513). Thus, H5 is accepted.

5. Discussion

The objective of this study is aimed to improve students' learning experiences and academic achievement of Mathematics by developing an information technology capability (ITC) framework, particularly in Probability and Statistics subject. Multimedia learning is found as an effective ITC for cognitive knowledge and learning from various literatures (Sivapoorani, Lew and Tan, 2016; Sivapoorani, Lew and Tan, 2020; Saidun, et al., 2019). Therefore, an ITC application integrated with impactful multimedia elements was developed for this study ensuring its effectiveness in learning Mathematics. Three independent variables, namely "Perceived System Quality (IV1), Perceived Information Content Quality (IV2) and Perceived System Performance (IV3)" have been identified from various literatures, used in the ITC system and empirically proven to improve students' ability to learn Probability and Statistics and "Learning Experience (DV2)". This study also shows that the usage of images, text, audio and animation throughout ITC system is appropriate to enhance the learning contents to be less verbal and more effective and efficient for learning Mathematics.

Students have a better learning experience in Mathematics by having better visualisation learning content. Students feel that the contents in developed IT capability (ITC) framework were presented in an attractive way which kept their attention throughout the lessons. Based on the developed ITC framework in Figure 10, the higher the ITC, the higher the academic achievement (DV1) and the better the learning experience (DV2) in learning Probability and Statistics. Relationships between ITC, learning experiences and performance of learning Mathematics are determined as IT tools enable ITCs, ITCs contribute better learning experiences and better learning experiences which eventually improve the performance of Mathematics.

The t-test result of quiz scores proved that students from experimental group achieved the highest score than students from control group (Table 12). Students feel that the contents in MMPASS are presented in an attractive way which kept their attention throughout the lessons. Students can easily understand the contents presented in MMPASS because the contents can be visualised easily with the inclusion of animations. This result aligned with the previous studies that pointed out the changes in students' learning experiences can contribute to the improvement of academic performance (Kelly, et al., 2010; Tan, 2012; Haftamu, 2016). Specifically, learning experience of students is improved with the integration of IT. The better visualisation of contents leads students to have better learning experience.

The standardized beta coefficient for interest and learning experience scored 0.839 (Table 12). 0.839 is the highest score among all the beta coefficients. This means interest is the most important independent variable affecting the learning experience. Apart from that, results from linear regression test shows that students' interest in learning has a significant positive influence on students' learning experience by using MMPASS (Table 12). Previous studies have proven that IT can improve students' proficiency by having better learning experiences (Siti, 2013; Paturusi, Yoshifumi and Usagawa, 2012; Mohammad, Fitra and Hamsyah, 2018). Students believed that using MMPASS can increase their interest in learning. In fact, students will be more engaged and active in learning, especially in Probability and Statistics subject. Multimedia elements such as texts, images, audios and animations play a crucial role in MMPASS as it helps to attract the students' attention.

Previous studies indicated that students' interest level in learning Mathematics has influenced their confidence level (Leow and Neo, 2014; Yeo, 2015). Thus, it is consistence with this study that MMPASS has improved their confidence level when they have more interest in learning. Students are able to think about the contents of the system and relate it with the quiz questions that can help them to answer more confidently. The standardized beta coefficient for interest and confidence scored 0.693 (Table 12). 0.693 is the third highest score among all coefficients. This means confidence is ranked below information content quality and learning experience which affecting the learning experience. Apart from the results, the linear regression test on this study shows that students' interest in learning has positive significant influence on their confidence level to solve Mathematics questions (Table 12).

According to Paturusi, Yoshifumi and Usagawa (2012), system quality is concerned with systems' errors, consistency of user interface, systems' response rate, user-friendliness and quality documentation. Siti (2013) stated that information support, service, presentation and navigation play a major role in system quality concepts. Perceived system quality of MMPASS has positive effects as it has significant path towards students' leaning experience. Most of the students believed that interactive features and user-friendliness in MMPASS attracted their interest towards Multimedia learning system. The standardized beta coefficient for perceived system quality and learning experience scored 0.512 (Table 12). 0.512 is the least score among all beta coefficients. This means perceived system quality is ranked after perceived system performance and learning experience which is affecting learning experience. A linear regression test demonstrates that perceived system quality has a significant positive impact on students' learning results, in addition to the findings (Table 12).

Information content quality is concerned with accuracy, relevancy of data and timeliness created by an information system (Siti, 2013). According to Paturusi, Yoshifumi and Usagawa (2012) and Azimi, Ahmadigol, and Rastegarour (2015) the delivery of information content should consider the type of information presented, better graphics, colour codes, not distracting or annoying, and the way of information is delivered. The results indicated that information content quality had significant effects on students' learning experience. Students agreed that the provided learning materials, visual examples, objectives of lessons, contents of learning materials, colour codes and design of text used in MMPASS are well structured and appropriate. The standardized beta coefficient for information content quality and learning experience scored 0.705 (Table 12). 0.705 is the second highest score among all beta coefficients which means the information content quality is ranked after interest and learning experience affecting learning experience. The linear regression test also demonstrates that perceived system performance has a significant positive impact on students' learning experiences (Table 12).

The standardized beta coefficient for perceived system performance and learning experience scored 0.611 (Table 12). 0.611 is the fourth highest score among all beta coefficients. This means the perceived system performance is ranked after interest and confidence affecting learning experience. The linear regression test also demonstrates that perceived system performance has a significant positive impact on students' learning experiences as well (Table 12). As a result, the performance of the MMPASS system is also a significant aspect of the students' learning experience in this study.

6. Conclusion, Implications snd Recommendation for Future Research

Multimedia learning creates a better learning experience to engage students in learning Mathematics. Based on the ITC framework, a better learning experience inevitably enhance academic achievement of Mathematics. It is proven by the statistically significant mean scores in *t*-Test. The "Academic Achievement (DV1)" of the experimental group was scored higher (9.65 out of 10) than the control group (8.03 out of 10). Hence, this study concluded that multimedia learning is an effective IT capability (ITC) to improve students' learning experience and academic achievement of Mathematics.

From the theoretical aspects, the results of this study have implications for the potential use of MMPASS in education, particularly in Probability & Statistics learning material. To date, limited research has conducted to improve learning experience and academic achievement by integrating multimedia content learning in Probability and Statistics. It provides some key ideas to the existing literature in improving performance of learning Mathematics. Besides, the results of this study have contributed to the knowledge and literature in educational research. This study provides practical implications for teachers and students. MMPASS has improvised performance of teaching and learning Probability and Statistics. Thus, multimedia content learning framework could contribute a better teaching and learning experience. This study appears viable by incorporating MMPASS in Probability and Statistics classroom, specifically in discrete and continuous probability distribution topic. Therefore, there is possibility in adoption of MMPASS as tool in teaching Probability and Statistics by lecturers and learning institutes. Students are benefited through MMPASS except the control group which did not use MMPASS. In addition, performance of students in quiz significantly has improved in system class. Other than that, the findings of the study show positive perceptions towards Probability and Statistics by adoption of MMPASS as learning tool. Students' perception is measured by four aspects, namely learning experience, system quality, information content quality and system performance.

As results show positive feedback, MMPASS is considered as a good approach in improving performance of learning Mathematics, particularly in Probability & Statistic subject. However, due to time constraint, this study involved and conducted only on a small sample. In order to obtain more valuable insights on the integration of MMPASS to improve students' performance in Mathematics, a similar study can be conducted in a larger scale sample. By doing so, there are possibilities to learn more on aspects related to students' attitude, learning experiences and most importantly, performance towards using MMPASS in learning Mathematics.

Declarations

This study was funded by Multimedia University and FRGS (Ref: FRGS/2/2014/SSI09/MMU/03/2).

The article has obtained the university Public Disclosure approval.

The authors declare that they have no conflict of interest.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the university.

Informed consent was obtained from all individual participants included in the study.

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Proposing a Seamless Learning Experience Design (SLED) Framework Based on International Perspectives of Educators from Five Higher Education Institutions

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Abstract: Since seamless learning (SL) is still a rather unknown concept in higher education many educators classify it under the same categories as mobile, blended, online or hybrid learning. The purpose of this study is firstly to clarify the historical evolvement of the seamless learning concept over the past decades and, to position the seamless learning concept as it is understood today. Secondly, to find the most important concepts which can be proposed for a useful seamless learning experience design framework to assist educators with their course design. Considering this context, the research question for this study is formulated as follows: "Which concepts constitute a seamless learning experience design framework for students in higher education?" To answer this question, an inductive qualitative research analysis was conducted by collecting data from educators from countries on five continents on their views on this topic. Following a thematic coding approach of the combined dataset, five emerging themes crystallised, and are presented as part of a proposed Seamless Learning Experience Design (SLED) framework. They include core, positive, practical, human and design concepts – including sub-themes. The framework contributes to quality assurance processes in e-learning practices by providing a guide for developing seamless learning experiences for students.

Keywords: Seamless learning, Seamless learning experience, Innovation, Technology in education, Framework

1. Introduction

Since educational technology (EdTech) is evolving at an overwhelming pace, the pressure on educators to use technology and to improve learner engagement in order to achieve a high level of learning can be daunting. This study, therefore, proposes a framework for a seamless learning approach. The need for such a framework is supported by Bidarra and Rusman (2016, p.6) who argued that "to profit from the opportunities that the seamless learning spaces of today offer, we need an innovative perspective for the instructional design supported by an operational model of activities". Currently numerous learning models are available for e-learning, hybrid learning, blended learning and hyflex learning, but limited literature is available on the development of a seamless learning framework in higher education specifically (Marín, et al., 2016; Laru, et al., 2019; Yafie, et al., 2020).

Olszewski and Crompton (2020) and Milrad et, al. (2013) stated that knowledge delivery was no longer one of the foremost trials of education. The greatest challenge lies in designing learning experiences which will enable students to construct knowledge to engage and inspire them to learn. Considering this statement and the need for an operational model, this study focuses on establishing a useful framework for such a purpose.

Since educators may not be familiar with the definition of seamless learning, nor with the development of a seamless learning experience, the purpose of this study is to propose a seamless learning experience framework based on original data collected from educators at five international higher-education institutions, from Malaysia, New Zealand, The Netherlands, South Africa and the USA. The combined dataset was analysed inductively following a qualitative research coding process, where five overarching themes or concepts were identified. These include core, human, positive, practical and design concepts. The concepts constitute a Seamless Learning Experience Design (SLED) framework by answering the research question of the study: "Which concepts constitute a seamless learning experience design framework for students in higher education?" The article unfolds as follows: a short exploration of the historical review of relevant literature, a description of the qualitative methodology and findings (analysed themes and sub-themes, complemented by verbatim quotes), and finally, the discussion of the concepts of the SLED framework. It concludes with suggestions for implementing the SLED framework in the higher education environment.

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2. Theoretical Framework and Historical Literature Review

The theoretical stance of the study is informed by the theory of connectivism. Connectivism suggests that theories, thoughts, perspectives and general information are combined in a useful manner to make sense of the picture (Siemens, 2005). This approach is particularly relevant as seamless learning comprises connecting perspectives for generally separated environments. The next section includes a historical overview and theoretical conceptualisation of SL. Subsequently, evolving education technology frameworks are presented.

2.1 Historical Evolvement of the Term Seamless Learning

The term “seamless learning” dates back to the eighties when Papert (1987, pp.22-30) describes scenarios using books and computers for learning. Students would use their textbooks for homework and static computers during classwork. Knefelkamp (1991) indicates a need for a "seamless curriculum" to provide "holistic student education". He does not mention technology per se but speaks about experiential and in-service learning, which implies more than knowledge from books or learning in a classroom. Kuh (1996) published SL in connection with an "in-class and out-of-class" learning experience and a link between "formal and informal learning". The term "seamless learning" evolved when technology became more readily available to students as a personalised or collaborative learning tool.

Initially, Chan, et al. (2006, p.6) used the term Mobile Seamless Learning or MSL and defined it as:

> *[a] learning model where a student can learn whenever they are curious in a variety of scenarios and in which they can switch from one scenario or context (such as formal and informal learning, personal and social learning) to another easily and quickly using the personal device as a mediator.*

Sharples, et al. (2012, p.24) used the Seamless Learning term and defined it as:

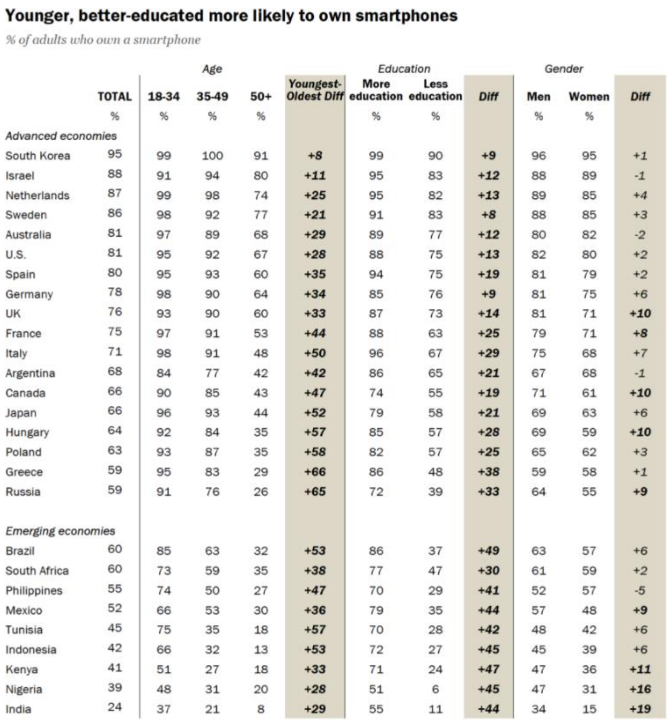
> *Seamless learning is when a person experiences a continuity of learning, and consciously bridges the multifaceted learning efforts, across a combination of locations, times, technologies or social settings.*

Wong (2015) undertook a systematic literature review exploring publications on MSL and SL from 2006 to 2014. He noticed a gradual shift in researchers' perceptions of MSL from a technology-enabling perspective to a curriculum design perspective to the foregrounding of the roles of learning spaces to the fostering of learning culture (Wong, 2015, p.6). After 2015 the word MSL was no longer used and replaced by the shorter SL version. In 2019, Rusman, et al. (2019) added "personal experiences both in and across contexts" to the SL definition.

In Figure 1, the use of smartphones among different age groups, education levels and gender differences is presented. The figure indicates the high use of smartphones among the student population. These statistics support the notion that seamless learning is becoming even more accessible and relevant in higher education.

With more clarity on the definition of seamless learning, the next part of the literature study focuses on existing frameworks as motivation for the proposed framework of this study.

In the context of this study, the ADDIE Instructional Design model is considered as the design approach aiming at developing a framework for seamless learning (Kurt, 2018). This model is historically known to be a functional and encompassing design approach and includes an iterative process from analysis to development, to design, to implementation and evaluation, and then to improve where necessary. This approach also allows for an existing framework to evolve to a more appropriate approach as continuous changes occur on various levels. The following frameworks are presented as evolving frameworks from existing models for learning with educational technology and have gone through similar design processes as per the ADDIE model. The ultimate goal of these frameworks is to “promote quality teaching on campus, enrich the student learning experience, and facilitate the career development of professors in the area of pedagogy and teaching innovation” (Vaughan, et al., 2017, p.105). These frameworks are presented in the following section.



Younger, better-educated more likely to own smartphones

% of adults who own a smartphone

	TOTAL	Age: 18-34	Age: 35-49	Age: 50+	Youngest-Oldest Diff	Education: More education	Education: Less education	Diff	Gender: Men	Gender: Women	Diff
	%	%	%	%		%	%		%	%	
Advanced economies											
South Korea	95	99	100	91	+8	99	90	+9	96	95	+1
Israel	88	91	94	80	+11	95	83	+12	88	89	-1
Netherlands	87	99	98	74	+25	95	82	+13	89	85	+4
Sweden	86	98	92	77	+21	91	83	+8	88	85	+3
Australia	81	97	89	68	+29	89	77	+12	80	82	-2
U.S.	81	95	92	67	+28	88	75	+13	82	80	+2
Spain	80	95	93	60	+35	94	75	+19	81	79	+2
Germany	78	98	90	64	+34	85	76	+9	81	75	+6
UK	76	93	90	60	+33	87	73	+14	81	71	+10
France	75	97	91	53	+44	88	63	+25	79	71	+8
Italy	71	98	91	48	+50	96	67	+29	75	68	+7
Argentina	68	84	77	42	+42	86	65	+21	67	68	-1
Canada	66	90	85	43	+47	74	55	+19	71	61	+10
Japan	66	96	93	44	+52	79	58	+21	69	63	+6
Hungary	64	92	84	35	+57	85	57	+28	69	59	+10
Poland	63	93	87	35	+58	82	57	+25	65	62	+3
Greece	59	95	83	29	+66	86	48	+38	59	58	+1
Russia	59	91	76	26	+65	72	39	+33	64	55	+9
Emerging economies											
Brazil	60	85	63	32	+53	86	37	+49	63	57	+6
South Africa	60	73	59	35	+38	77	47	+30	61	59	+2
Philippines	55	74	50	27	+47	70	29	+41	52	57	-5
Mexico	52	66	53	30	+36	79	35	+44	57	48	+9
Tunisia	45	75	35	18	+57	70	28	+42	48	42	+6
Indonesia	42	66	32	13	+53	72	27	+45	45	39	+6
Kenya	41	51	27	18	+33	71	24	+47	47	36	+11
Nigeria	39	48	31	20	+28	51	6	+45	47	31	+16
India	24	37	21	8	+29	55	11	+44	34	15	+19

Figure 1: Statistics on smartphone users (Taylor and Silver, 2019, p.13)

2.2 Overview of Evolving Learning Frameworks Within the Educational Technology Environment

Various learning frameworks, including Educational Technology, have been developed over the past decades. These frameworks include the TPACK framework (Mishra and Koehler, 2006), the FRAME model (Koole, 2009), the Seamless-learning Design model (Wong, 2012) and the Multi-Device Learning Framework (MDLF) (Krull and Duart, 2017) (see Figure 2).

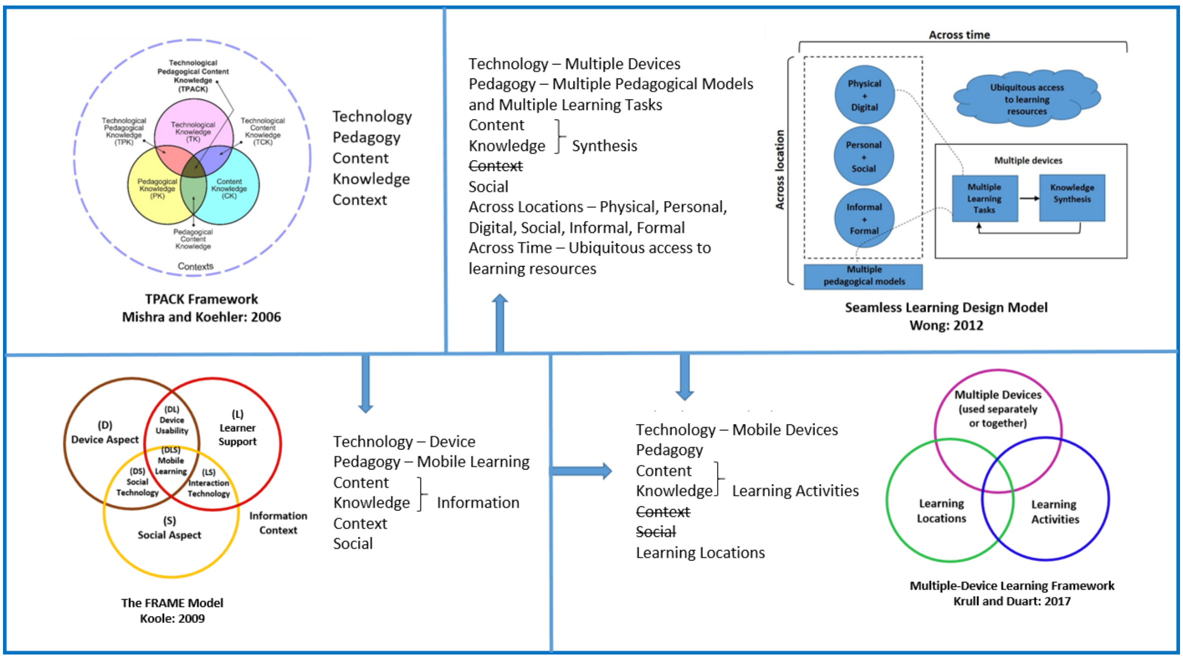


Figure 2: Educational Technology Frameworks (2022) (Note: The strike-through "context" and "social" indicate that these concepts were absent in these frameworks.)

Mishra and Koehler (2006) identify five components of successful EdTech learning experiences: Technology, Pedagogy, Content and Knowledge applied in a specific Context. The identified gap for a seamless learning experience is that they do not include learning environments. Koole (2009) builds on the TPACK framework by compiling a FRAME model for mobile learning, adding a social component that comes with the mobile device's connectivity affordance and recognising the importance of learner support as supported by comprehensive studies by Engstrom and Tinto (2008). Again, no specific reference to transitioning from one learning environment to another is included. The gap identified is supported by Gagne, et al. (2005), who contend that a specific objective needs to be identified for a successful learning experience, which includes a well-planned program with smooth transitions between various interactions with the content, as also mentioned by Owen (2014).

Three years later, Wong (2012) designed an SL framework that includes the five TPACK components and adds Time, Location and Ubiquity as new concepts. Again, switching between learning environments is not mentioned. In 2017, Krull and Duart (2017) also used the main concepts of the TPACK model but combined Pedagogy, Content and Knowledge as part of the learning activities. They added multiple devices as part of the Technology component and various Learning locations as a part of the Multiple Device framework, acknowledging the greater importance of mobility between multiple environments. This framework incorporates location transition options that are important for seamless learning but could be explained in more detail. The shortcomings identified in the Krull and Duart study for seamless learning are human and positive concepts which will be elaborated on in the discussion section of this study. Furthermore, equal access (Chan, et al., 2006; Gillwald and Mothobi, 2018; Kukulska-Hulme, et al., 2021), affordability of technology (De Villiers, 2020), adoption of infrastructure (Antwi-Boampong, 2020) and “enlarged learning environments” Wong (2012, p.22) are identified gaps for a successful seamless learning experience. All of these are guided by institutional policies (Graham, Woodfield and Harrison, 2013). According to Sharples, et al. (2012), SL includes a set of meta-cognitive abilities and needs a framework that helps to establish valuable guidelines. Wong (2015, p.9) advocates for SL as follows: "The key is to facilitate and nurture genuine transformations of beliefs about and habits of learning among the learners."

In conclusion, the existing frameworks may have been relevant for a specific time in a specific context. The introduction of the TPACK framework (Mishra and Koehler, 2006) was developed when technology was added to the learning approach as a whole. However, most technologies were static and not used outside the classroom. This framework is too limited for a seamless learning approach with the emphasis on flexibility. Although the FRAME model for mobile learning, (Koole, 2009) includes a social aspect, the smooth transitioning between learning environments needs to be more explicit for a seamless learning experience. The SL framework proposed by Wong (2012) focuses on the ubiquity and flexibility mobile technology affords. Still, since more aspects are involved, it needs to be adjusted for a seamless learning experience. Sharples, et al. (2012) points to the metacognitive abilities of the student that need to be integrated into the SL approach, while Wong (2015) mentions beliefs and habits. These gaps necessary for an even more comprehensive SL experience framework are incentives for this study.

3. Method

Participants from HEIs in five different countries (South Africa, the United States of America, the Netherlands, New Zealand and Malaysia) participated in the study. Disney's Creative Strategy Method, as suggested by Rusman, Tan, and Firssova (2018), was applied and included a workshop where a creative brainstorming session was conducted in each country respectively. The participants were assigned one of three roles: the dreamer, the realist or the critic (Elmansy, 2015; McGuinnes, 2009). The dreamer thinks creatively, passionately, enthusiastically, and without restrictions about the solutions, inspirations, and benefits of a specific aspect. In contrast, the person who assumes the realist's role adopts more logical thinking, including manageable ideas, necessary resources, and timelines. The critic is the voice of reason who illuminates barriers, risks, and weaknesses and gives constructive criticism. The method is described in more detail in the book “Seamless learning in Higher Education” (Hambrock, et al., 2020, pp.5-12).

Creswell (2014, pp.251) states ‘When qualitative researchers provide detailed descriptions of the setting, for example, or offer many perspectives about a theme, the results become more realistic and richer. This procedure can add to the validity of the findings.” Based on this statement a qualitative research approach is followed and the data is presented verbatim.

3.1 Sampling and Population

The target population consisted of educators from five universities from five countries on five respective continents. They were selected by purposive sampling (specifically selected participants) and snowball sampling (suggested by participants) (Jupp, 2006, pp.88, 196). The inclusion criterion for the purposive sampling was that the participants needed to be part of the academic staff. The population is indicated in Table 1.

Table 1: Participants of the study

	Malaysia	The Netherlands	New Zealand	South Africa	USA
N	12	21	8	20	17
Male	4	11	4	4	8
Female	8	10	4	16	9

3.2 Data Collection

The data were collected during a workshop that started with an introduction to the definition of SL and an explanation of the Disney method. The statement: "Seamless learning experiences should become a standard component within your institution's curriculum" was presented to the participants, and they were requested to give their assigned perspectives on Post-it notes. After a 20-minute brainstorming session, the thoughts of each group were presented to the rest of the participants, followed by a discussion.

3.3 Data Analysis

In order to find overall commonalities, the comments from the participants of the five countries were combined as one dataset. For the analysis of the data, an interpretive inductive approach was followed. The process is supported by Burnard et al. (2008, p.429), who describe inductive analysis as "analysing data with little or no predetermined theory, structure or framework", and by Braun and Clark (2006) who refer to inductive analysis as a form of thematic analysis where themes are identified within a data set. Additionally, Saldãna (2013) supports the unique researcher perspective, as applied in this study, by stating that a thematic analysis recognises that the analysis is informed by the researcher's unique and subjective perspective. An example of the coding process by Saldana (2013) is presented in Figure 3.

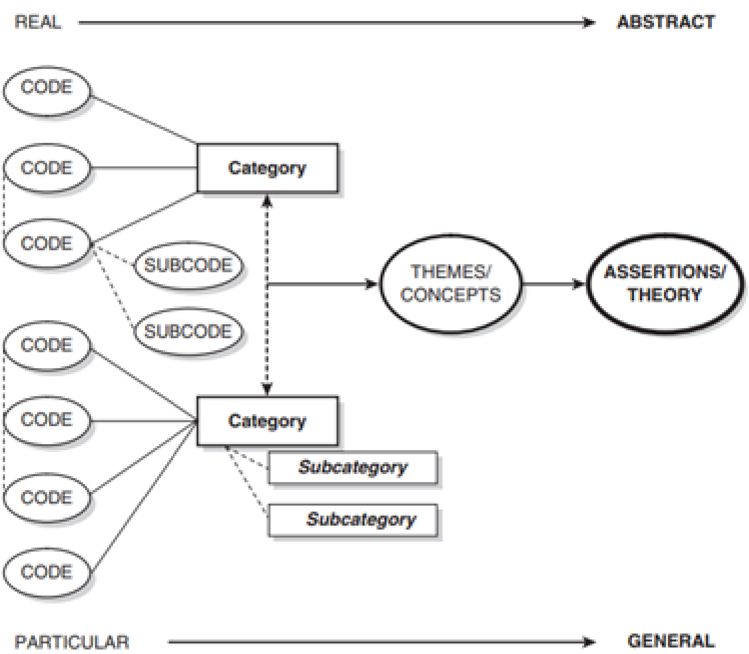


Figure 3: Inductive analysis with coding process: From code to theory (Saldãna, 2013, p.12)

Figure 4 (below) is the visual representation of the research collection and analysis process used for this study. First, the workshops were conducted by collecting statements from the three views (the dreamers, the critics and the realists). Then the data was combined, coded and organised into themes which crystalised as five concepts.

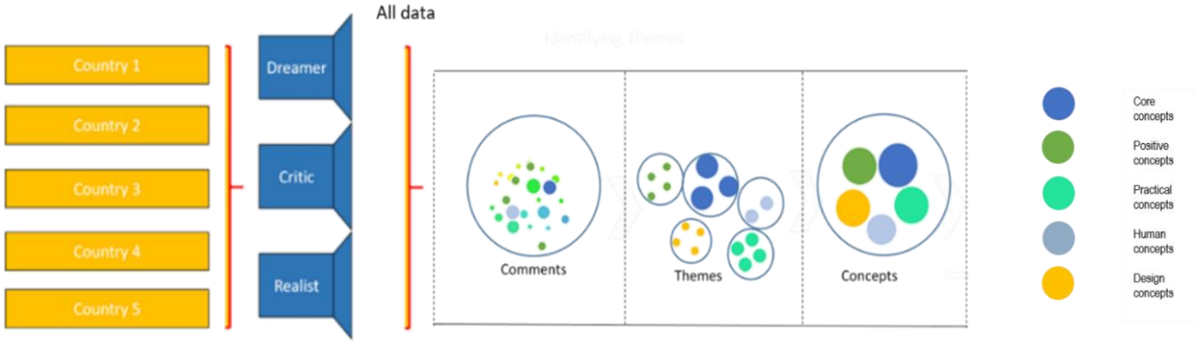


Figure 4: A diagram of the data analysis and coding process

To ensure that the analysis includes reliability, validity and trustworthiness, the researchers followed the approach of Merriam and Tisdell (2016, pp.237-238), who state that the data should be analysed ethically by giving attention to the conceptualisation, data collection, analysing, interpreting and presenting the data. To address the possible bias of the researcher, a peer review of the data analysis process was done by the co-author. This approach is supported by Merriam and Tisdell (2016) and Creswell and Creswell (2018), who mention that a colleague who is familiar with the research can do peer review (or peer examination) by looking at the raw data and assess whether the findings are plausible.

For the process of coding and identifying themes and concepts, *Atlas.ti 8,* a computer-assisted qualitative data analysis software program, was used. Friese (2019) reports that the benefits of this software program include visualising themes by using network functions and visually integrating the findings to better understand the phenomenon being studied. The identified themes, sub-themes and explanatory quotes from the participants are presented below. *Atlas.ti 8* uses a number system to identify the participants. The first number represents the country, and the second the number of the comment of the country's data set. The country identifiers are as follows: 1 (South Africa), 3 (New Zealand), 4 (USA), 5 (Malaysia), and 6 (The Netherlands) (there is not a country number 2). Only verbatim quotes were provided with quotation marks.

4. Findings

In this section, the overarching themes are presented to answer the research question: Which concepts constitute a seamless learning experience design framework for students in higher education?" The sub-themes are presented in Table 2 to Table 6 with the number of comments within each sub-theme in brackets. These comments and numbers are also illustrated by the graphs and thereafter the actual words in verbatim are discussed within the HEI context. This approach contributes to a deeper and richer understanding of the data (Creswell, 2014, pp.215).

4.1 Core concepts

The core concepts include sub-themes that either contribute to achieving an SL experience for students and educators or point to aspects needed to accomplish or improve an SL result.

Table 2: Sub-themes and the number of associated comments

Alternative teaching and learning (71)	Measurement of success (2)
Challenges (90)	Network with other students (13)
Experts' engagement (14)	Scholarship (11)
Innovation (26)	

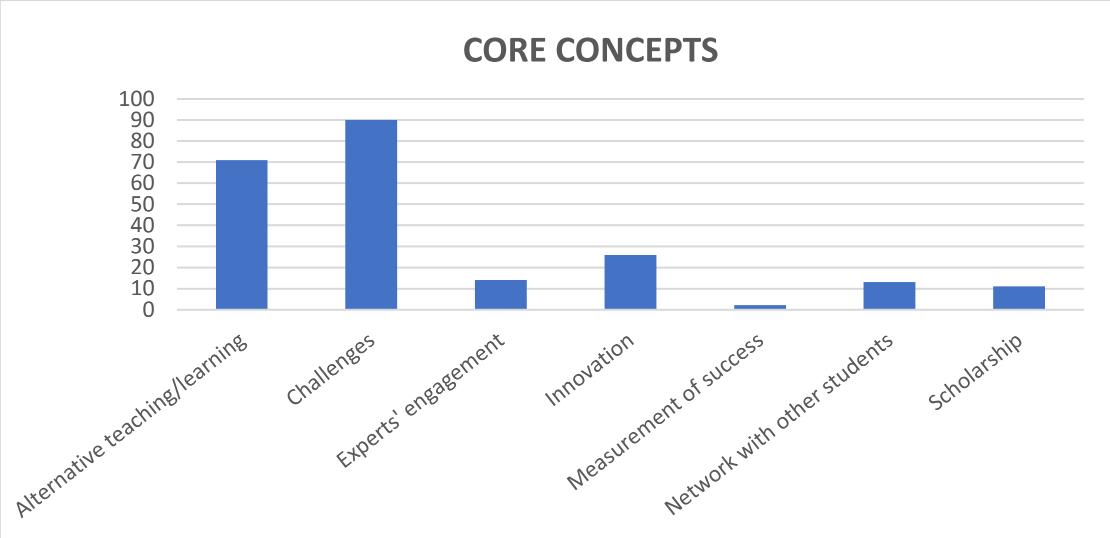


Figure 5: Sub-themes of theme 1: Core concepts

4.1.1 Alternative teaching and learning opportunities

One participant described SL as "a university without walls" (4:11); others said that SL has no barriers regarding location (3:14; 4:10; 1:50). They also mentioned that it would enhance the flow experience (1:78) and allow students to utilise all their senses while learning (1:70; 1:87). SL permits the students to "experience real-world scenarios" (1:94, 6:19) where learning can happen anywhere (3:5; 3:4; 3:16). They can connect to the community (1:121) and improve contextual knowledge (1:128). Learning is not one-dimensional (3:22; 3:13), and students go to places "where they would not normally go" (4:1). It is an "unbiased learning environment" (1:120), a "cross-cultural classroom" (4:32), and it allows for "exploration" (4:3), "interaction" (4:8) and "diverse learning methods" (4:52; 4:49) and learning styles (4:115; 1:107).

Furthermore, the participants mentioned that SL could integrate practice and theory (3:8), especially when aided by innovative applications (6:14; 3:14). Other suggestions include "virtual trainers" (1:125), virtual simulation of settings like businesses and hospitals (4:35; 4:61; 4:2); "artificial intelligence tools" (4:25) and lecturers being present while students are doing practical work (1:96; 6:25).

4.1.2 Challenges

Challenges include technology failures (6:51; 6:39; 4:117; 4:107; 4:50), “technical issues” (4:88), power loss and connectivity (4:88; 1:23; 4:100), capacity (6:52), lack of IT specialists (5:3; 4:104), Wi-Fi accessibility (1:34; 4:56), “stability” (1:97), data, support and cost (1:4; 1:12; 4:50; 4:71; 4:92). Digital literacy deficiency (4:108; 4:58; 5:10; 1:51; 4:105) may be a hindrance to successful implementation. The extra workload for the lecturers (4:91; 1:20; 1:38; 6:69), curriculum changes (1:41; 1:42), and time consumption (4:39) were raised as challenges for the lecturers. More concerned comments included that SL is not always practical for all kinds of content (1:54; 6:68) and that assessment may be difficult (5:8; 3:24; 6:66; 1:43). This raises the question of support and infrastructure (1:11; 1:21; 4:63) and how to implement SL in the higher education realm (4:65; 4:67; 4:112). Other limitations include “lack of training” (5:11), “lack of expertise” (5:14), and the difficulty of implementation (6:59; 6:61).

4.1.3 Expert engagement

The lecturers (1:145; 1:152) and the students (1:153; 6:27) must partner with experts in the industry (1:160; 6:47; 6:37; 5:27). One suggestion was that students should have "live interviews with experts in their environment" (4:4). It was repeatedly suggested not to re-invent the wheel but to get advice from people who have done it before (1:165; 1:179; 1:184).

4.1.4 Innovation

The application of SL may stimulate creativity, innovation, unique learning opportunities (3:15; 1:110; 1:85) and also challenge students (1:119). New ways of learning may include that learning can take the form of "exploration, guided by questions and answers" (4:3). Innovative ideas are, for example, "cross-cultural" (4:32), virtual (4:33), and "hologram" (5:15) classrooms and incorporating AR/VR to support learning (3:42).

4.1.5 Measurement of success

There is "hardly any empirical basis" (6:63) to support the effectiveness of SL. Research is necessary to "monitor and evaluate the effectiveness of seamless learning and the relationship with student success" (1:131). This also means that feedback from students needs to be included to learn from them what could be improved.

4.1.6 Network with other students

SL can improve "interpersonal social learning" (1:86) and "collaborative learning and social constructionism" (1:112) by using a "centralised social interactive LMS" (3:17). They can study a topic in a group (4:7) and "consult with each other for group assignments" (6:22). Classes are accessible to anyone, anywhere (3:111; 4:5; 4:111).

4.1.7 Scholarship

SL can create a culture of scholarship of teaching and learning (1:175; 1:10). This is done by relating to other disciplines (1:77), "including authentic contexts" (1:89), and developing innovative apps "that combine theory and practice" (6:14). Some participants comment that it is impractical to make it compulsory for all modules (1:49; 1:54). A panel in a department needs to decide on the best approach for including SL (1:186).

4.2 Positive Concepts

The positive concepts include aspects that contribute to achieving successful SL experiences for the student.

Table 3: Sub-themes and the number of associated comments

Student-centred approach (28)	Real-time interaction (20)
Globalisation (17)	Remote access (15)
Practical experience (16)	Research opportunities (7)
Preparation for future (8)	

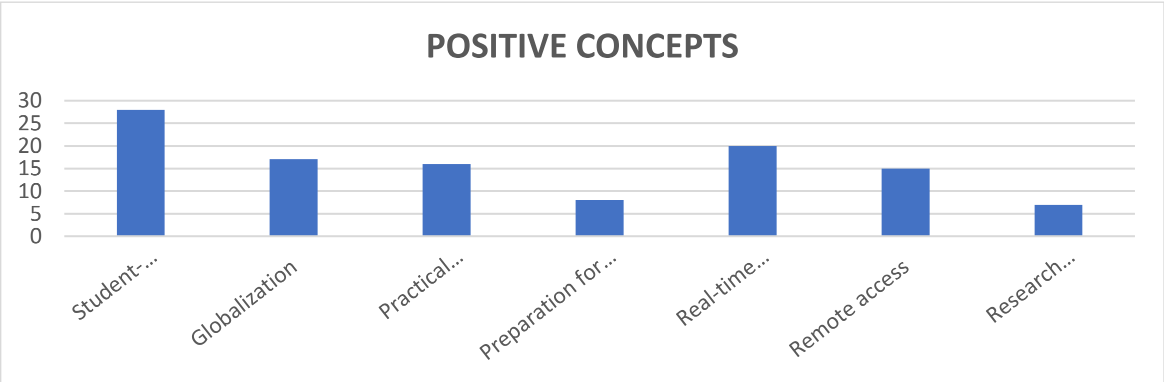


Figure 6: Sub-themes of theme 2: Positive concepts

4.2.1 Student-centred approach

The student needs to be central in the design. Students with disabilities (1:108) and different learning styles/methods (3:29; 4:115; 4:52; 4:64) should be accommodated. SL can encourage self-regulated learning (1:109; 4:78) and "enhance critical thinking and reasoning skills" (1:111) when students are allowed to give input (6:28; 4:70; 4:69). The application of SL may increase “learner engagement” (4:18; 4:74) and “motivation” (4:17; 3:15; 1:79).

4.2.2 Globalisation

A universal platform can be created (3:19) to incorporate "global methods and resources" (4:29). The "online environment allows for a more diverse global perspective" (4:60). The participants even mentioned a "virtual international classroom" (4:33) from diverse cultures (4:32; 4:60). One participant expressed it as follows: "technology allows a global community in your hands." Students can learn anywhere (3:16; 3:4; 3:5; 4:14; 4:98; 4:13; 4:10).

4.2.3 Practical experience

Quite a few participants reflected on the benefits of learning from experience (6:12; 1:74; 6:20; 6:30; 1:116; 1:69; 1:78) and linking skills and practices to real life (6:7; 6:31; 3:8; 6:19; 4:44). Exposure could "improve their contacts and employability" (1:127).

4.2.4 Preparation for the future

In line with and closely related to the previous sub-theme is the assumption that SL helps students to be better prepared for the future. One participant stated: "Through seamless learning, students will be better equipped for life after graduation" (1:63). Professional development is needed (4:77), and the scenario of talking to experts and experiencing real-life situations "will create better employers" (1:117).

4.2.5 Real-time interaction

The possibility of real-time (immediate) feedback (1:58) and connection with any role player or fellow students are advantageous. Connectedness is high on the list of positive aspects, and the fact that several students can interact simultaneously (6:3; 6:25; 6:11) and even "communicate with one another or the lecturer outside official class time" (1:72) is appealing. It will "support more connected learning" (3:10). Students doing clinical or practical work can contact the lecturers directly (1:56; 1:96). Assessment can be done through written reports on the cloud, where the lecturers can have immediate access (1:126; 6:16). Connectivity opens the doors to alternative work methods such as interactive classes (1:126).

4.2.6 Remote access

With the use of technology (6:9; 6:10) and the alternative strategies of SL, remote learning is possible (3:11; 3:10; 4:20; 4:5; 4:14; 4:13) at any time. The learners can learn "from their own situation with their own resources and aptitude" (6:4), where information is available at any time (5:26; 4:76; 4:16; 4:57). Students from different cities (4:5; 4:6) can be connected. There are "no barriers" (3:14; 6:1).

4.2.7 Research opportunities

The relatively new field of SL can result in "increased research output and publications" (1:95) and increases research possibilities (1:114; 4:68). Results can be shared at conferences (1:176), and a database can be created "for future research" (1:93). Publications can enhance the marketing opportunities of the institution's innovative capability (1:150).

4.3 Practical Concepts

The practical concepts include the technical, financial and legal access and support necessary for successful, SL implementation.

Table 4: Sub-themes and the number of associated comments

Data and Wi-Fi (32)	Poicies (6)
Devices and hardware (18)	Software (13)
Funding and cost (19)	Support (26)
Infrastructure (17)	Technology (53)

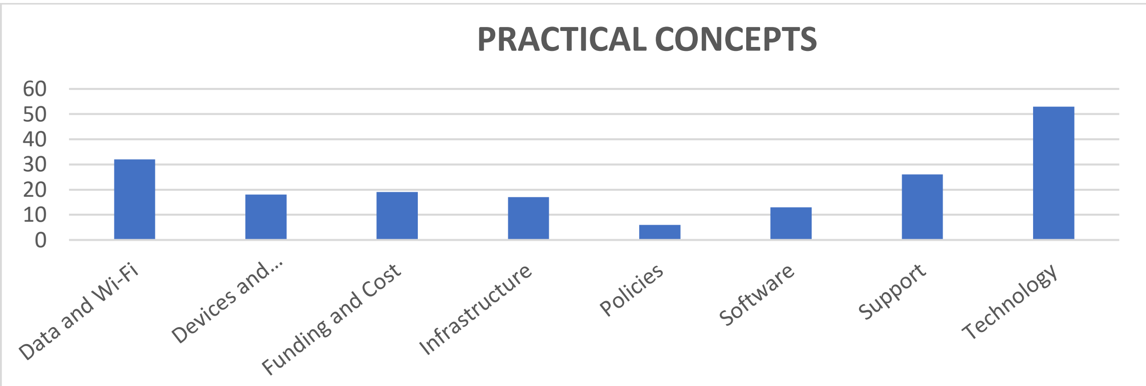


Figure 7: Sub-themes of theme 3: Practical concepts

4.3.1 Data and WiFi

Many respondents emphasised the issues of data and Wi-Fi (1:4; 1:12; 1:34; 1:134) connectivity (4:88; 1:134; 1:23; 4:56; 3:11), unstable Wi-Fi networks (1:97) and accessibility (1:34; 1:135). Access to resources (1:37; 3:25; 4:89; 4:70; 1:132; 3:40), technology (1:36; 1:122; 3:25; 4:86) and information (4:57; 4:16; 4:73; 4:76) is required.

4.3.2 Devices and hardware

Different aspects of devices and hardware seem to present possible hindrances. Ideally, each student must have a tablet or a smartphone (5:28; 1:100; 1:59; 4:71; 5:7; 3:6) but stolen devices (1:33) and insurance (1:151) are concerns. Possible solutions are that the institution must “partner with tech industry” (1:154) and issue devices (1:138; 4:31; 1:101; 1:155; 4:86) where the students sign contracts with the companies (1:155).

4.3.3 Funding and cost

Most of the respondents who commented on funding and cost agreed that it is a concern (1:23; 1:18; 1:47; 1:52; 4:36; 4:51; 4:59; 4:92; 6:50; 4:81; 5:30; 6:69); comments mentioned “financial issues” (5:5) and that “software and technology is [sic] expensive” (4:36). Students need “ongoing support and funding” (3:46), high-speed Wi-Fi (5:16; 1:135) and subsidised (5:25) or free data (1:123; 1:102; 1:159; 4:79; 1:67; 5:25).

4.3.4 Infrastructure

When implementing a different learning strategy such as SL, one needs support and infrastructure (1:11; 1:21; 4:28; 4:63; 5:1). There should be "commitment from top to bottom" (1:166), "cooperation across faculty" (6:46), and the WiFi speed must be adequate across campus (1:135).

4.3.5 Policies

Policies are essential (1:170; 6:42), and "assessment policies must be improved" (1:157). A guiding document/framework must be distributed (1:198), and all lecturers "need to understand what seamless learning is" (1:148) and what "good practice entails” (1:132).

4.3.6 Software

Exciting suggestions were made regarding software and apps for SL. A few are apps that "keep track of your practical hours spent" (1:192), "measure the progress" (6:13), and “disseminate assignments randomly” (6:15). The development of apps must be supported (3:2; 3:14). It would help to have one consistent learning platform (3:20; 3:38).

4.3.7 Support

Excellent support is necessary at institutional level, like a call centre (1:164; 1:167; 1:105’4:27), support services (4:45; 4:72; 1:161; 1:162; 1:195), a support structure for staff implementation and training (3:40; 1:156; 3:39 1:149; 6:71; 1:172) (for example, AI tutors (4:26) and IT specialists (5:3; 6:37; 6:38)). Students also need training and support (1:147; 3:26; 4:28).

4.3.8 Technology

Given that SL is dependent on technology, a myriad of comments were made regarding technology (1:188; 1:185; 1:4; 1:12; 4:51; 4:71; 4:75; 1:136). Free technology would be advantageous (1:123). The staff (1:98) and students (1:99) must be motivated to use technology. Positive aspects include that "technology provides a connection between students over a distance" (6:10) and "technology allows a global community in your hands" (4:53). Negative aspects were that there could be "chaos in platforms" (6:49), and not all students and staff have access to technology (3:25).

4.4 Human Concepts

The human concepts include aspects referring to educators’ and students' ability, availability, and interest in implementing an SL approach.

Table 5: Sub-themes and the number of associated comments

Skillset (21)	Equality (12)
Time-consuming (12)	Mindset (39)
Training (34)	Positive outlook (11)
Differences in norms and convictions (5)	

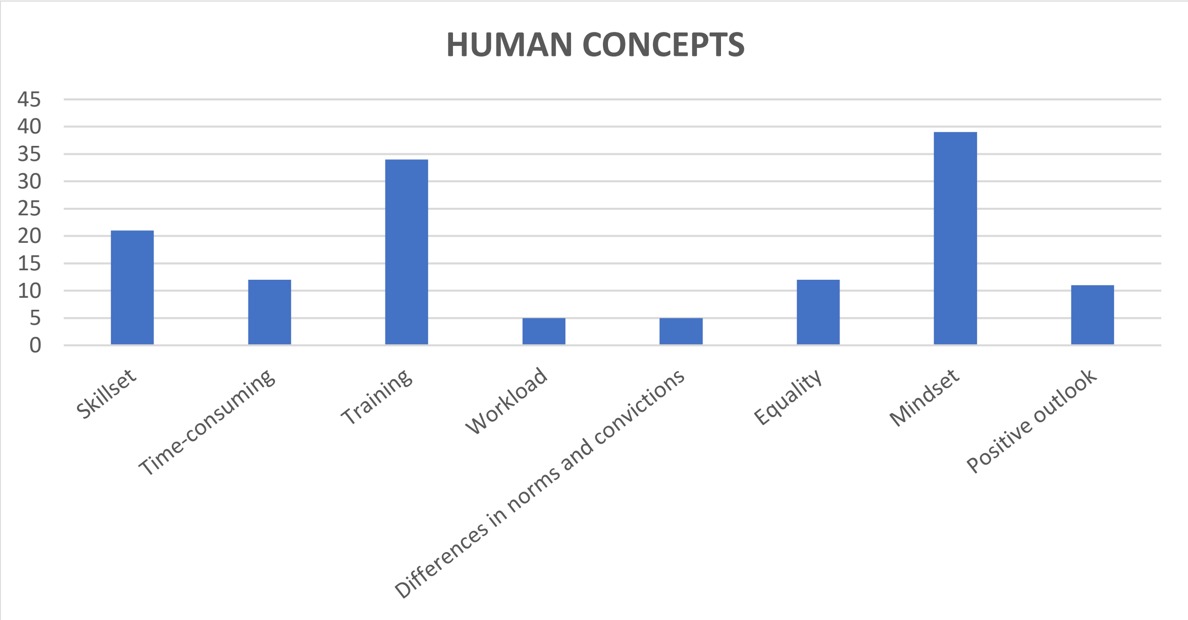


Figure 8: Sub-themes of theme 4: Human concepts

4.4.1 Skillset

The students' "base knowledge level" (1:6) and "computer literacy" (1:30) may be problematic, and "some students may be left behind" (1:13; 1:22). They need to be able to "apply knowledge" (1:65) and be digitally literate and skilled (5:10; 4:105). Implementing SL can help students get employment because of their skills (6:7; 6:8). The "computer literacy of lecturers" (1:15) and the fact that they are not all "tech savvy" (1:51) and perhaps "unable/unqualified/uncomfortable" (3:27) may be concerning.

4.4.2 Time-consuming

Implementing SL will be time-consuming (1:53; 5:12; 6:64; 6:73) and create extra work for students (1:27) and lecturers (1:38; 1:20; 4:91; 6:58). Some concerns were expressed as follows: "Time/experience available for developing digital activities" (6:73); "The time and resources to re-create assignments to match new modes of learning could become too great" (3:24).

4.4.3 Training

Workshops and training must be provided (1:171; 1:174; 3:35; 3:39; 4:42; 4:58; 4:109; 4:110; 4:121; 5:11; 5:23; 6:42; 1:147; 4:23). Students need instruction and training (6:35; 3:26; 1:130; 4:80). Lecturers must be trained (6:40; 4:80; 6:53; 6:71) in "effective use of the technology required" (1:146) and implementing SL (1:141; 1:103). They need to understand what “good practice entails” (1:132) and “what seamless learning” (1:148) is.

4.4.4 Differences in norms and convictions

Problems, according to some participants, can be "differences in cultural convictions, moral norms, and political affiliations" (1:8) and "less political, racial and gender equality" (1:84) when implementing SL. Others consider differences an advantage, stating that it is like sitting in on a global class (4:32) and that "geographically dispersed people can be engaged" (4:111).

4.4.5 Equality

There needs to be equality of "interactions and learning" (1:22), fairness to all (1:80), "equity of access" (3:23), "inclusion of all disabilities" (1:88) and increased diversity (4:34; 4:34; 4:52; 4:94). Students must all get "the same chance to succeed" (3:28) and be able to participate fully and equally (4:93). Most of the resources must be open-sourced (3:49).

4.4.6 Mindset

Regarding a positive mindset, there must be "no critical disposition" (1:90), and everyone must be "stimulated and inspired" (1:118). Students (1:81; 1:99) and staff (1:98) have to be motivated to use technology. Awareness (5:4; 4:75), responsibility (4:55), integrity (5:9) and a good attitude (5:13) are crucial. Lecturers must have the "right mindset and not be offended" (1:14). Students "won't buy in if not done perfectly" (1:29). Some may be "uninspired and lazy" (1:32), so they need to be challenged (1:119).

4.4.7 Positive outlook

Overall, the participants were optimistic about the implementation of SL. A few examples are: "Yes we can do it!" (1:189), "How can we make this work?" (1:190), "I am going to make it work" (1:193), "So let us start planning" (1:196), and "This is very exciting" (1:197).

4.5 Design Concepts

The design concepts include the aspects needed for designing a successful SL experience.

Table 6: Sub-themes and the number of associated comments

Application of knowledge (8)	Feasibility (14)
Assessment (18)	Implementation (37)
Curriculum and design (36)	Learning strategies (25)

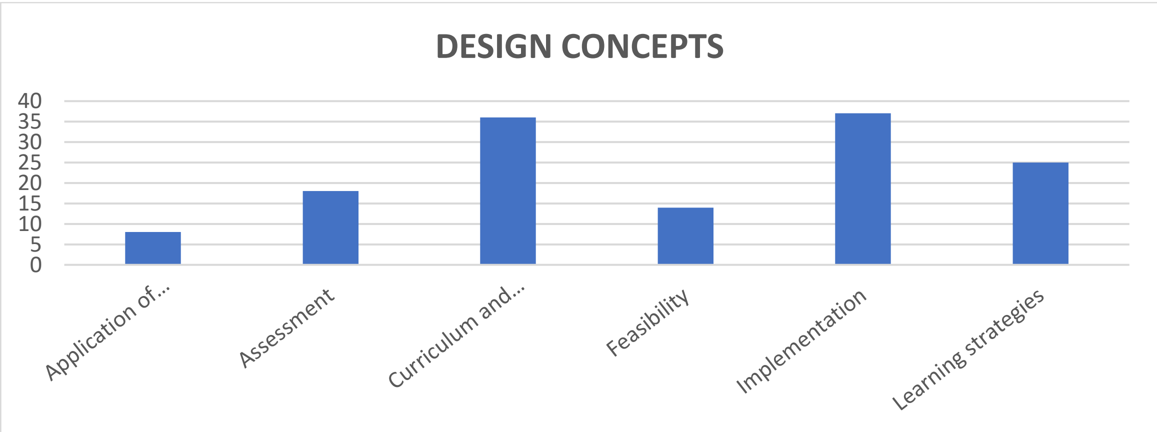


Figure 9: Sub-themes of theme 5: Design concepts

4.5.1 Application of knowledge

Students must be able to apply knowledge (1:65; 6:30), e.g., taking on "various roles" like a lawyer, prosecutor, judge (6:17; 6:19) or compiling a marketing plan (1:66). There is also the potential to "integrate practice and work placement learning into the classroom" (3:8).

4.5.2 Assessment

The participants were worried about assessment strategies (1:117; 1:43; 3:24; 5:8; 6:66), adding "different types of assessment methods must be explored to complement different methods of learning" (1:71), a "more proactive use of technology" is needed (4:19), as is "using apps for measuring progress" (6:13). Some participants favour continuous assessment and feedback (1:140; 1:68), whereas others want to "measure students' performance after relevant time" (1:139) and compare it with a baseline (1:142; 1:139).

4.5.3 Curriculum and design

Concerns were raised about further curriculum changes (1:41; 1:42; 1:158; 4:116; 5:24), that "different architectures [are] needed" (3:48), and not all modules can implement SL (1:35; 1:104; 1:2; 6:68). Regarding design, it was suggested that "instructional design" (1:163), "effective and conscious design" (3:37), a "question-answer model" (6:23), and an initial steps-design phase" (6:48) be pursued. For this, you need educational experts (6:47, 6:73). Other recommendations were the use of "AI tools" (4:25) and that the module must be redesigned and not merely uploaded to an online platform (3:34).

4.5.4 Feasibility

Questions asked were: "Is this feasible?" (4:82), "Do the benefits outweigh the barriers?" (4:83), "Can the university's servers handle the strain?" (1:28), and "Doesn't all this deduct from the education itself?" (6:55). A pilot program should iron out any errors and assure the project's feasibility (6:36).

4.5.5 Implementation

Participant comments included aspects like class sizes (1:1; 1:7; 1:16), implementation problems (5:2; 4:65; 3:33; 4:48; 4:40), one needs a plan of action and coordination (4:66; 6:43; 6:58; 4:112) and good technical support (4:46). Decisions must be communicated to all staff (1:136; 1:168) and students (1:143; 6:34; 6:41) and the time of implementation must be considered carefully (4:40).

4.5.6 Learning strategies

Positive remarks included that it will "make learning more connected" (3:10; 3:12), "encourage creative and unique learning opportunities" (3:15) and change learning from one-dimensional to multi-dimensional (3:13; 3:22). Online learning allows for a "philosophy of open education" (3:21), "advanced engagement" (4:95) and an "accelerated curriculum". Proposals were that "people need straightforward instructions, processes and expectations" (4:118), "new modalities need to have value academically" (4:102), and "perceptions need to be managed during conceptualisation" (4:101).

5. Discussion

The following section includes a reflection on the over-arching themes that emerged during the data analysis. The themes are discussed in the context of best practices for SL, which are presented as the Core, Positive, Practical, Human and Design concepts. They are discussed with reference to the literature.

5.1 Core Concepts

A concern that emerged during the data analysis was the importance of understanding SL: educators need clarity about what SL pedagogy entails. Gagne, et al. (2005) explain that students need to understand and know the SL pedagogy and its objective to be effective. Access to mobile devices, power, and the internet is particularly important. Challenges with access to WiFi and data are echoed by Gillwald and Mothobi (2018), who writes about digital inequality. According to Engstrom and Tinto (2008), a direct correlation can be found between student success and support (a sub-theme that was identified: measurement of success). Sub-themes that set SL apart from other approaches – all readily available, interchangeable and independent of time and place – are alternative teaching and learning approaches, experts' engagement, networking with other students, applying innovative ideas, adjusting measurements of success, improving scholarship opportunities, and challenges.

5.2 Positive Concepts

Another theme that emerged from the data analysis but which is difficult to trace back to the literature is the positive concept of SL. Sub-themes identified as best practices for a positive SL experience included a student-centred approach, real-time interactions with educators and fellow students by receiving immediate feedback, remote access to learning, including a wider globalised experience, practical application of knowledge, extended research opportunities and good preparation for the future. These findings not only contribute to an innovative approach to the SL experience but also contribute to a list of best practices for future implementation. These aspects as a whole are best explained by Vaughan, et al. (2017, p.105), who state that technology-supported learning can improve student access and success: it can "extend access to new populations of students, alleviate the demand on physical infrastructure, and enhance the process of teaching and learning for the diverse body of students". Regarding the real-time interaction mentioned by the participants, the outcome of a study by Owen (2014) indicated that the participants demonstrated high levels of engagement, assessed by increased interaction throughout the programme.

5.3 Practical Concepts

Abundant literature can be linked to devices, hardware/software, infrastructure, cost and funding, and other sub-themes of practical concepts. These sub-themes highlight that the SL experience would be quite difficult to achieve without these elements. The comments also indicate that not all the students have the same devices, some more sophisticated. Chan, et al. (2006) emphasise that students must have access to one or more personal devices to connect formally or informally, individually or socially, in a context of their choice to support their learning. Wong (2012, p.22) emphasises that a "seamless learner should be able to explore, identify and seize boundless latent opportunities that his daily living spaces may offer to him mediated by technology". This statement is supported by the findings from the data, where the importance of a functional infrastructure was stressed. Access to mobile devices, power, and the internet is essential. De Villiers (2020) mentions costs and funding when mentioning that online education is not a cheap alternative to classroom teaching. Funding devices and data would help to implement SL.

According to Antwi-Boampong (2020) the importance of infrastructure, also pointed out by the participants of this study, is one of the core elements when technology is included in learning. The other three elements are the readiness of the HEIs for change, technical familiarity, and acceptance by and support systems for staff. Regarding policies, Graham, Woodfield and Harrison (2013) emphasise the importance of institutional policies, as they determine the framework within which teaching staff should operationalise blended-learning approaches.

5.4 Human Concepts

An essential theme is the human concept, with the students at its centre – every part of the planning should include the students, if they succeed. Engstrom and Tinto (2008) contend that a direct correlation between student success and support can be found. The student's psychological, physical, and mental capacity needs to be supported by the educator, peers, and the student support office. Kukulska-Hulme, et al. (2021) highlight a trend related to equity-oriented pedagogy. All students should have equal opportunities to benefit from SL and to achieve fair and comparable outcomes, regardless of their backgrounds. As with the theme positive concepts, in previous SL frameworks, human concepts are also not mentioned explicitly as part of best practices.

5.5 Design Concepts

The last theme is design concepts: it embraces sub-themes such as assessment, feasibility, learning strategies, and implementation. Different assessment methods must be explored to complement different methods of learning. Students must be challenged in ways other than formal assessment. Augmented and virtual reality and artificial intelligence tutors and tools that allow virtual interaction can be incorporated. As mentioned in the literature review, the design approach for SL can be based on the ADDIE model (Kurt, 2018), which includes analysing the content, environment and technology, designing and developing the intervention, implementing it and then re-evaluating it. The importance of knowing what the educators have to work with is part of an initial needs analysis before the planning of any design can begin. Once they see the environment's capacity, this knowledge can be used to select the activities and settings. Educators need to keep the goal in mind and focus on improving SL and selecting appropriate activities.

6. Conclusion

In conclusion, this study aimed to answer the research question: "Which concepts constitute a seamless learning experience design framework for students in higher education?" by asking educators from five universities from five countries on five continents to contribute to the investigation. Their views were combined into one dataset. A qualitative approach was followed, and the rich dataset was analysed by an inductive process that included coding and identifying themes from the data. The overall identified concepts for a seamless learning experience design framework include core, positive, practical, human and design concepts. Increasing the sample size by including more educators and more countries and more continents could lead to more comparative analysis opportunities and further validation of the framework.

Compared to existing EdTech learning frameworks as discussed in the literature review these five concepts add additional perspectives to understanding, developing and implementing a seamless learning experience across several environments (physical and virtual) and across various technologies using a combination of relevant pedagogical approaches.

A few suggestions for educators that aim at implementing seamless learning, include the following practical steps:

- decide which core goals to achieve in the course, such as interactive pedagogical approaches and including interview with experts to understand the world of work better.
- select the relevant positive concepts, such as activities that contribute to a positive and engaging experience;
- consider practical concepts such as the availability of technology for the students;
- accommodate human concepts such as the ability and availability of the students;
- ensure that all design concepts, such as "where in the course" and "which assessment will be added", are included.

These five concepts are combined as a Seamless Learning Experience Design (SLED) framework (see Figure 10).

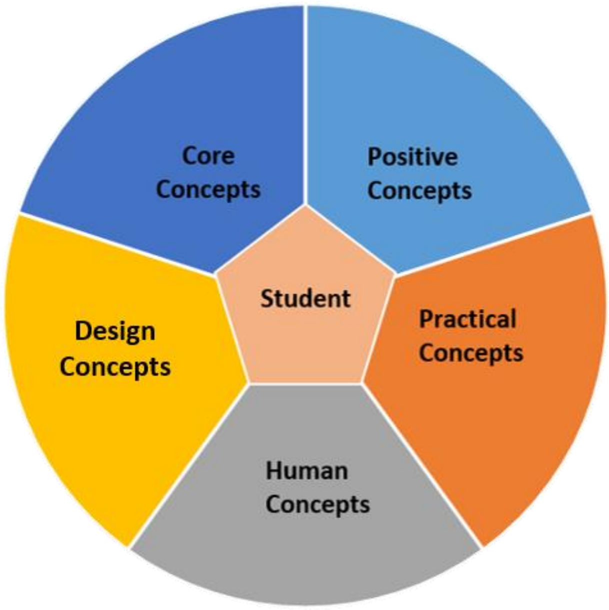


Figure 10: The Seamless learning experience design (SLED) framework

7. Future Recommendations

The SLED framework can be used as a guideline for further research in the field of seamless learning in higher education to find gaps in courses or to design courses from scratch. The SLED framework is also useful for establishing whether a course or program is seamless learning ready or not. It can further be applied for research studies within a department, a university, a country or as a comparative study between countries. Using this framework can contribute to innovatively changing the world of teaching and learning and can be used as an "operational model of activities", as suggested by Bidarra and Rusman (2016). It can also enable students to construct knowledge to engage and inspire them to learn (Olszewski and Crompton, 2020; Milrad, et al., 2013).

To cope with global changes, technological developments and educational advances, educators have to embrace the changes, re-think, re-plan and adjust their practices. Since all these challenges can seem rather daunting and challenging to educators, this study proposes using a seamless learning experience design framework as a valuable tool to focus on the relevant aspects to create a successful, seamless learning experience for our students.

Abbreviations

AI: Artificial intelligence

HEIs: Higher-Education Institutions

IT: Information technology

LMS: Learning management system

MSL: Mobile seamless learning

SL: Seamless learning

SLED: Seamless learning experience design

VR: Virtual reality

Declarations

Ethics approval and consent to participate

Ethics approval was received from the University of the Free State Ethics Committee, number UFS-HSD2019/0410. Consent for publication was obtained from all the participants.

Consent for publication

The following researchers collected data:

Dr Shamsul Arrieya Ariffin, Tanjong Malim, Perak, Malaysia.

Dr Frelét de Villiers University of the Free State, South Africa.

Dr Helga Hambrock, Concordia University Chicago.

Dr Kathryn MacCallum, University of Canterbury, New Zealand.

Dr Ellen Rusman, Open University of the Netherlands.

They gave their written permission for data use without being co-authors.

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