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An Experimental Study Comparing the Effectiveness of Mobile Learning and Text Learning on Knowledge Retention Among MMMC Students

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Abstract

Mobile learning, also known as m-learning, is a new way to access learning content using mobiles that embraces the utilization of mobile technology to accomplish universal learning at all times and all places. The purpose of this parallel randomized control trial is to find out whether mobile learning or traditional learning method is more effective in the retention of knowledge and to assess the student's satisfactory level with mobile learning in medical students of Melaka Manipal Medical College, Malaysia. 50 undergraduate medical students voluntarily participated in our study. Block randomization was done which separated the students into 2 groups consisting of 25 students using mobile learning and another 25 students using text learning. The group of students assigned to M- Learning carried out their session on using Population Collapse app while the text learning group were given the text material. The short term knowledge retention and satisfaction were assessed according to the total test score which was conducted after the learning session. Chi square test and unpaired t test were used for statistical analysis. The participants who were assigned to mobile learning scored higher results compared to text learning group. This indicates that mobile learning helps in knowledge retention which enabled the participants to score better than those in text learning. 84% participants were satisfied with mobile learning whereas 80% were satisfied with text learning. However, there is no significance as the p value was more than 0.05 (P value= 0.54). Majority of the medical students' knowledge retention were enhanced due to mobile learning. Interventions should be implemented to improve knowledge retention and encourage the usage of mobile learning among medical students so that the learning will be more efficient.

Keywords

Mobile Learning, Knowledge Retention, Satisfaction, Randomized Controlled Trial

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1. Introduction

The transition from the nineteenth to twentieth century was accompanied with technological advancements in education system all through the world which are constantly attributed by the educational institutions as the catalyst which can revise the methods of teaching and learning. Based on the report by the Malaysian Communication and Multimedia Commission, mobile phone penetration in the recent years have been growing enormously in many of the states in Malaysia with 75.9% residents being smart phone users whose age mainly ranges from 20 to 49 years indicating that most people in Malaysia are dependent on their phones for their daily functioning [1]. With the guide of technology, educators will have the option to direct educating to the

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degree that is past the traditional classroom environment [2]. 20–25% of students in 28 OECD (Organisation for Economic Co-operation and Development) countries have been classified as having poor participation and/or a poor sense of belonging indicating that students are exhibiting pervasive disengagement which is both a local and global issue [3][4]. Through technology, students will have the option to encounter learning in manners that have not been conceivable previously: active learning [5], and positively motivated on the learning processes [6] and as a consequence from these learning advantages, numerous activities have been led for educational benefits, including the incorporation of computer assisted, computer mediated methodologies [7] and in recent years, the mobile technology.

According to the recent definitions of M- learning, it is described as a method that intersects mobile computing and e-learning [8], that embraces the utilization of mobile technology to accomplish anytime, anyplace, universal learning [9] and that emphasizes students' mobility and customized learning [10]. Educational courses structured dependent on smart phones encourage a self-directed learning environment that offers the user the chance to have easy access to data and practice past physical and time restrictions. Besides that, M- Learning provides a chance to students to enjoy a pressure free learning environment without any judgement where they can train and practice multiple times without the fear of making a blunder as the conventional learning in clinical labs often result in students being afraid of practicing due fear of making a mistake [11]. A study that was conducted in Iran evaluating the effect of Mobile based education on dental students' learning in practical course of oral pathology which compared the mobile teaching with traditional classroom teaching, resulted in the students who were taught using mobile having a significantly higher final score than the students who were educated with the traditional teaching method [12]. Another research done by Pimmer C and Mateescu M to determine the effects of smart phone-based communications such as speech only, speech and images and speech, images and annotations using a case of sub capital fracture of the fifth metacarpal bone, proved that mobile learning influences the recall and transfer of visually transferred medical knowledge significantly positive when it involves speech, images and image annotation [13]. M-Learning uses the combination of both text, images and annotations which improves the comprehension of a complex topic and thus results in a better understanding by a person with poor prior knowledge [13].

This can be related to the cognitive science which shows that visual representations promote human processing and understanding as the processing pathways for both images and text are in 2 varying channels and both are used to construct coherent mental knowledge representations, and images carry distinct information than words (concrete vs abstract) [14-17]. Concrete evidence suggests that information recall is enhanced when using both text and pictures [15]. Studies have demonstrated that educational tools that give learning alternatives for reasoning involving a critical thinking situation are better for learning [18-22]. As indicated by these studies, this happens in light of the fact that learning strategies that utilizes these sorts of tools may decrease the working memory cognitive load and subsequently encourage the learning process. Rondon, S., Sassi, F.C. & Furquim de Andrade performed a comparison of computer game-based learning and traditional learning method on knowledge retention on the topic of head and neck Anatomy and Physiology among Speech-Language and Hearing pathology undergraduate students by the means of assessing their prior knowledge, short term and long-term knowledge retention using multiple choice questionnaires. In accordance to this paper, students performed better immediately post-test in game-based learning for Anatomy which would indicate a better short term knowledge retention while students with traditional learning method seemed to be more effective in improving both short term and long-term knowledge retention [23].

Furthermore, many papers have proven that M- Learning aids to strengthen communication and improve the students' learning experiences [24], and affects the students' motivation, teamwork, knowledge exchange, mobility and interactivity [25]. M- Learning without a doubt can possibly change from the traditional 'chalk and talk' mode towards all the more technologically advanced, 21st century learning environment that matches the attribute of millennial students, who acclimated having all information readily available. These students for surely would profit significantly from mobile learning abound, due to their information technology mentality and multitasking abilities [26] where they adapt best when the learning occurs in a socially constructed and contextual, self-controlled method [26] [27].

Only a few studies had been conducted on mobile learning in Malaysia. Their studies were mainly focused on the readiness for the integration of mobile technologies in the education system within the learning institutions and the influence of culture on mobile learning. Unlike other studies done in Malaysia, our study mainly focuses on how mobile learning and traditional learning affect the short-term knowledge retention. Furthermore, our study also analyses the association between knowledge retention and other factors such as gender, sleep duration of the previous night, breakfast intake, meditation, physical activity (exercise) and motivation. Lastly, our study aims to assess student's satisfaction with mobile learning.

1.1. Research Question

Is mobile learning more effective in short term knowledge retention and brings more satisfaction among MMMC students compared to textbook learning method?

1.2. Research Objectives

The purpose of this study is to assess the short-term knowledge retention using mobile learning methods and textbook learning methods among the students of MMMC. The second objective is to assess the level of satisfactory of MMMC students using mobile learning methods and Textbook learning methods.

1.3. Research Hypothesis

It was hypothesized that mobile learning provides a better short term knowledge retention and level of satisfaction among the students of MMMC.

2. Methodology

2.1. Study Design

The study design adopted for this research was a parallel randomized controlled trial that aims to find out whether mobile learning or traditional learning method is more effective in the retention of knowledge and to assess the student's satisfactory level with mobile learning among the medical students of Melaka Manipal Medical College (MMMC). Melaka Manipal Medical College (MMMC) constitutes of 3 programmes which are the MBBS, BDS and FIS. MBBS programme consists of 5 semesters in Manipal, India and 5 semesters in Malaysia with 2 semesters in Muar Campus and remaining 3 semesters in Melaka Campus. There were 5 batches with an estimation of 750 students.

2.2. Study Setting and Study Population

This study was conducted in Melaka Manipal Medical College (MMMC), Muar, Johor, Malaysia in which an estimated student population of 300 comprising of 2 batches (Batch 39, Batch 40) of 4th year students from Bachelor of Medicine & Bachelor of Surgery (MBBS).

2.3. Study Time

The duration of our research was from December 2019 to January 2020.

2.4. Sample Size

Sample Calc was used in this research to calculate the sample size. Figure 1 shows the sample size calculation by Sample Calc:

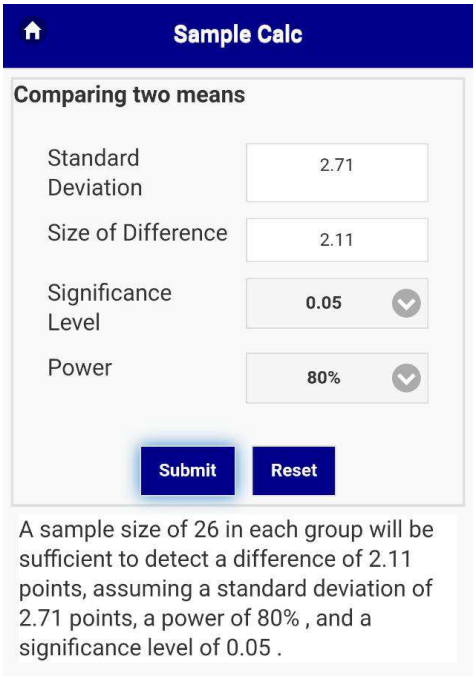


Figure 1. Sample size calculation by Sample calc.

Where;

Standard deviation of the score of participants who have undergone mobile learning was 2.71. [28]

Size of difference: 2.11, mean score difference between participants who have undergone mobile learning and participants who have undergone traditional learning [28]

Therefore, based on the application Sample Calc, the minimum sample size per group is 26.

Non response

Minimum sample size per group needed: 26

Maximum percentage of non-response allowed was 10%

To allow for non-response, the final sample size was calculated using the formula below:

n final = n calculated / (1-percentage of non-response)

n final = 26/1-0.1

=29

Therefore, the final sample size per group is 29 with a total of 58 after rounding off. However, due to time limitation, we recruited 50 undergraduate medical students in this study.

Among the 50 participants, 25 participants were randomised into intervention group where they had mobile learning. Another 25 participants were randomised into control group where they had traditional learning. Data collection, data recording and data analysis were done by using Microsoft Excel.

2.5. Sampling

Our study population consisted of 300 students in this study. 60 students had voluntarily participated in our study. Purposive sampling was used to recruit MBBS students in this research, which is a non-probability sampling method. Sample is selected specifically for this research as they fit into the eligibility criteria which were the inclusion and exclusion criteria as shown in *Table 1*. After excluding the participants who did not meet the eligible criteria, 50 participants were left which fitted in our final sample size (n=50). The sampling and randomization method were summarized in Console Flow Chart as shown in *Figure 2* [29].

2.6. Randomization

For randomization of the distribution of the students, Block Randomisation were used by using software called Research Randomizer (https://www.randomizer.org/) [30]. The following *Table 2* shows the block randomisation generated. A total of 50 students were divided into 2 groups with 25 sets based on the number given. 1 indicates Mobile Learning and 2 indicates Textbook Learning.

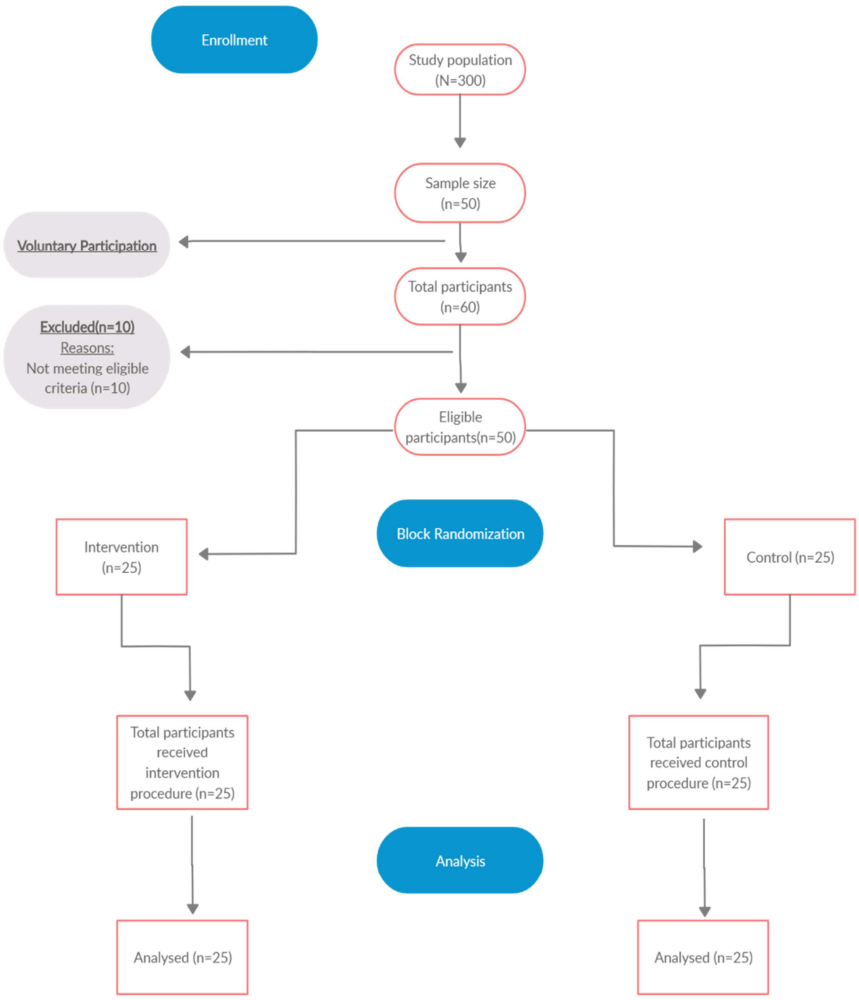


Figure 2. Console Flow Chart.

Table 1. Inclusion and Exclusion criteria.

Inclusion Criteria	Exclusion criteria
Students who were not previously exposed to 'Population Dynamics'	Students who were previously exposed to 'Population Dynamics'
Voluntary participation	Decline participation
Students who provided informed consent	Students who did not provide informed consent
Both gender	Drank alcohol the night before the learning session
Any ethnicity including international students	Smoked the night before night and the morning of learning session
	Suffered from any acute medical conditions such as Fever, Migraine
	Suffered from any chronic medical conditions such as Schizophrenia, Depression, Anxiety
	Suffered from any neurological diseases
	Currently taking any medications such as antidepressants, antipsychotics, antibiotics

Table 2. Randomization to separate undergraduate participants into intervention groups and control group of both mobile and text learning respectively.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	1	2	2	2	1	1	2	1	2	2	2	2	1	2	1	1	1	2	2	2	2	2	2	1
2	2	1	1	1	2	2	1	2	1	1	1	1	2	1	2	2	2	1	1	1	1	1	1	2

2.7. Intervention Procedure

The study was conducted to evaluate the effects of mobile learning on short term knowledge retention when compared with text learning among year 4 MBBS students of Melaka Manipal Medical College. In order to encourage participation in our study, we promoted our research by announcing about the conduction of study to the students during class and also informing the students about the purpose and procedures of the research project on social medias. Incentives, such as a can drink, were also given to further boost participation.

The participants who volunteered were asked to gather in the lecture hall and they were given the informed consent form prior to the beginning of the intervention. The participants were then asked to fill in a form on the demographic data and personal habits history (smoking, alcohol drinking the previous night, sickness) and those who did not fulfil the eligibility criteria were excluded from the study. Following that, the eligible participants were randomized using block randomisation and separated into a control group (text learning) and intervention group (mobile learning).

Next, the students in the intervention group were asked to download the "Population Collapse" application on their mobile phones. The Population Collapse application allows its users to understand more about the concepts of population growth and how it will lead to its collapse using a model and simulating its collapse. By doing this the users are able to manipulate the factors affecting population (population, resource capacity, demand per person, fractional degradation rate, fractional birth rate, fractional death rate) by themselves and observe the effects on the population model which uses images and diagrams to enhance understanding. Preceding the study, we have developed a text version with relevant diagrams of the content on the mobile app on the topic of 'Population collapse over a period of 2 days. The control group subjects were given the text material. The learning session was then conducted for 30 minutes in an empty, quiet lecture hall to minimise distractions and maximise learning. The students were instructed to perform their study individually the same way they would at home.

Immediately post learning session, participants from both groups were subjected to a handwritten test session, consisting multiple choice questions and short answer questions which is based upon the quiz section of the population collapse mobile app related to the topic and lasted for 10 minutes. Finally, participants from both groups were asked to answer questions pertaining to their satisfaction with the learning method they have been assigned to.

We collected and assessed the test papers comparing the students' performance between the intervention and control group to evaluate their short-term knowledge retention. The students who answered correctly for each question was given 1 mark which would result in a total of 11 marks overall. The marks from both the group were compared and analysed.

3. Data Collection

The questionnaire was distributed to MBBS students of Melaka Manipal Medical College and returned back in the presence of the researchers. The questionnaire consisted of 3 main parts. First part was sociodemographic data which included age, gender, physical activities, meditation, and sleep duration for the previous night, multivitamin supplementation, medication consumption, smoking, and alcohol consumption. The second part was evaluating the score and performance after undergoing different types of learning methods respectively by answering 10 questions which consist of 7 multiple choice questions, 2 'True or False' questions and 1 subjective question. Third part of the questionnaire was evaluating the students' satisfaction towards different types of learning which were mobile learning and textbook learning.

It was a voluntary participation from the students and they were given the option to decline without providing any reasons. Prior to the distribution, the students were explained about the objectives of the study. Students who fulfilled one of the exclusion criteria were excluded from the study. Then, block randomization was done which separated the students into 2 groups consisting of 25 students using mobile learning and another 25 students using text learning. Both groups of students carried out their learning sessions in the same lecture hall at the same time. At the beginning, the first part of the questionnaire was handed out and students were given approximately 10 minutes to answer them. The group of students assigned to M- Learning were then asked to download the "Population Collapse" app prior to the beginning of the learning session. Students then took approximately 30 minutes to read about the topic given and approximately another 10 minutes to complete the second and third part of the questionnaire without any difficulties and the questionnaires were collected back after the time was over.

3.1. Data Collection Tool

The second part of the questionnaire was derived from an app called 'Population Collapse' which was authorised by Ninad Jagdish with systemic dynamics as the modelling method in combination with some other related references (citation) and later developed by BTN PTE. LTD. as an online application. This app consists of questions related to the model created by the author with only one correct answer.

3.2. Data Processing and Data Analysis

Data were entered into Microsoft Excel compiled. Sample Calc V1.0.0 was used to statistically analyse the data. For the analysis of the data, data obtained from the questionnaires were taken and tabulated manually using Microsoft Excel Version 2007. The values were cross checked and double checked to prevent any error that might affect the results. From Microsoft Excel, the information was then being processed by analytical software Epi Info version 7.2 from Centre from Disease Control and Prevention website and Graph Pad, Prism.

For descriptive statistical analysis, we included mean, standard deviation (SD), frequency and percentage for quantitative data. Mean and standard deviation were used to analyse and represent the data. The mean of 2 different learning styles can be used to compare to see which learning style is more effective. Frequency and percentage were also used to represent the data in a more simplified way. Next, the magnitude of the association was measured by using Relative Ratio (RR). The level of confidence was set at 0.05 or 5%, which also mean any P-values greater than 0.05 were considered not statistically significant. The smaller the P-values, the greater the findings, which also indicates it is statistically significant. Mean plot were used to represent the effectiveness of mobile learning and traditional learning on memory retention. This is done by using the mean score collected from the subjects. Bar charts were also used to represent the data in comparing the 2 groups. Unpaired t-test was also used to compare the effectiveness of Mobile learning and Traditional learning on memory retention. Chi-square test was used to compare category variables. Chi-Square test was used to compare the 2 different learning methods and the satisfaction feedback from the subjects. *Table 3* has shown statistical test used for data analysis.

Table 3. Statistical test used for data analysis.

Independent Variable	Dependent Variable	Statistical Test
Mobile learning Vs Text learning	Knowledge retention	Unpaired t Test
	Students' satisfaction	Chi-square test

3.3. Ethical Consideration

An informed consent form with all important relevant details of the study was given to the participants. Written informed consents were obtained from the participants prior to the study. The informed consent form had a clear explanation about the study. The participants of this study were informed that their participation is completely voluntary and they have the right to withdraw from the study at any point of time if they wish to do so. In addition, an additional inclusion & exclusion criteria form was given to the participants as well to rule out participants who were not qualified. The exclusion criteria include some of the private information from the participants. So, the participants of this study have been guaranteed that the research data will be strictly confidential and will not be shared with anyone. This study has included the questionnaires generated by us, which was approved by the Research Ethics Committee, Faculty of Medicine, Melaka Manipal Medical College, Muar campus. This research topic has been approved by the Research ethics committee, Faculty of Medicine, Melaka Manipal medical college, Malaysia.

4. Results

Table 4. Comparison of Total Test Score between the intervention (mobile learning) and control group (text learning).

Outcome variables	Mean (SD)		Mean differences (95%CI)	t- statistics (df)	P- value
	Intervention group (n=25)	Control group (n=25)			
Total test score	6.6 (1.44)	5.4 (2.14)	0.8 (0.16, 2.24)	2.32 (48)	0.024

Table 4 shows the comparison of the total test score between the intervention (mobile learning) and control group (text learning).

Total mean score for participants took part in mobile learning was 6.6 (SD= 1.4434) while the total mean score of participants took part in text learning was 5.4 (SD= 2.1409) as shown in Graph 1. The mean difference was 0.8. This indicates that participants took part in mobile learning have more knowledge retention which enable them to score better than participants in text learning. The 95% Confidence Interval for this variable ranges from 0.161698 to 2.238302 where 0 is not found in between the range thus there is a significant difference between mobile and text learning on knowledge retention. The t- statistics of total test score between the mobile learning and text learning group is 2.32. P-value is found to be 0.0244 which is less than 0.05 so it shows significance. There is a significant association in mobile learning on knowledge retention.

Table 5. Comparison of learning method preference between the intervention (mobile learning) and control group (text learning).

Statement	Mobile learning n=25	Text learning n=25	P value
I prefer the type of learning method which I have been assigned to.	18(72%)	15(60%)	0.37
I do not prefer the type of learning method which I have been assigned to.	7(28%)	10(40%)	

Table 5 shows a comparison of learning method preference between the intervention (mobile learning) and control group (text learning).

Most of the students preferred mobile learning over text learning. As shown in *Graph 2*, 18 (72%) participants in the mobile group preferred the learning method which they have been assigned to, whereas 15(60%) participants in the text learning group preferred the learning method which they have been assigned to. However, the P value is 0.370, which is greater than 0.05. This indicates that the comparison of learning method preference between mobile learning and text learning was not significant.

Table 6. Comparison of satisfaction level towards mobile learning and text learning.

	Group		
Learning Method satisfaction	Mobile learning, N (%)	Text learning, N (%)	P value
0 (very dissatisfied)	0(0.00%)	2(8.00%)	0.54
1 (Dissatisfied)	4(16.00%)	3(12.00%)	
2 (Satisfied)	17(68.00%)	16(64.00%)	
3(Very Satisfied)	4(16.00%)	4(16.00%)	

Table 6 shows a comparison of satisfaction level towards mobile learning and text learning. As shown in *Graph 3*, none of the participants from mobile learning were very dissatisfied with the learning method assigned to them while 2 participants from the text learning group were very dissatisfied with the learning method assigned to them. Next, 4 of the subjects from the intervention group were dissatisfied with mobile learning whereas 3 participants from the control group were dissatisfied with the text learning. Majority of the participants from the mobile learning group were satisfied with their learning method (68%). However, the P value is 0.54, which is greater than 0.05. This indicates that the comparison of satisfaction level towards mobile learning and text learning was not significant.

Table 7. Comparison of opinion on learning method (mobile learning and text learning) in improving knowledge retention.

Statement	mobile learning n=25	text learning n=25	p value
I think that the learning method which I have been assigned helps improving knowledge retention	19(76%)	17(68%)	0.53
I think that the learning method which I have been assigned does not help in improving knowledge retention	6(24%)	8(32%)	

Table 7 shows a comparison of opinion on learning method (mobile learning and text learning) in improving knowledge retention. As shown in *Graph 4*, 19(76%) participants from the mobile learning group thinks that the learning method which they have been assigned to help in improving knowledge retention, while 17(68%) participants from the text learning group have the same opinion. However, the P value is 0.71, which is greater than 0.05. This indicates that the comparison of opinion on learning method (mobile learning and text learning) in improving knowledge retention was not significant.

Table 8. Comparison of opinion on learning method (mobile learning and text learning) in helping and motivating learning.

Statement	mobile learning n=25	text learning n=25	p value
I think that the learning method which I have been assigned helps and motivates me to learn.	19(76%)	15(60%)	0.225
I think that the learning method which I have been assigned does not helps and motivates me to learn.	6(24%)	10(40%)	

Table 8 shows a comparison of opinion on learning method (mobile learning and text learning) in helping and motivating learning. As shown in *Graph 5*, 19(76%) participants from the mobile learning group thinks that the learning method which they have been assigned to helps and motivates them to learn, whereas 15(60%) participants from the text learning group have similar opinions too. However, the P value is 0.23 which is greater than 0.005. This indicates that the comparison of opinion on learning method (mobile learning and text learning) in helping and motivating learning was not significant.

5. Discussion

A parallel randomized controlled trial was conducted among the medical students in Melaka Manipal Medical College, Malaysia that aims to find out whether mobile learning or traditional learning method is more effective in the retention of knowledge and to assess the student's satisfactory level with mobile learning. Mobile learning uses the combination of both text, images and annotations which improves the

comprehension of a complex topic and thus results in a better understanding by a person with poor prior knowledge [13]. Besides that, mobile learning also influences the recall and transfer of visually transferred medical knowledge significantly positive when it involves speech, images and image annotation [13].

Our present study found a significant difference in total test score among mobile learning and text learning, where the total mean score for participants took part in mobile learning was 6.6 while the total mean score of participants took part in text learning was 5.4. This indicated that there was significant association in mobile learning on knowledge retention. Previous study was conducted among seventh grade students enrolled in a World History course in five social studies classes in United States of America (USA) in which the participants that completed the computer-based project had the highest overall retention test score, 29.67, while the participants that completed the paper-based project in had a mean retention test score of 28.33 [28].

The results from our research paper corresponds to the findings from a study done among dental students in practical course of oral pathology in Iran where results indicated that M-Learning significantly influenced students' final scores and there was a significantly higher mean score in the two groups assigned to mobile learning when compared to the classroom learning method [12]. Our study is also supported by another research conducted by D. Furió, M.-C. Juan, I. Seguí, R. Vivó among Spanish children aged eight to ten comparing the effectiveness of mobile learning against traditional classroom lessons in learning about the water cycle, where the results proved that the iPhone method achieved higher knowledge results than the traditional classroom lesson, however in this paper no statistically significant differences were found between both the learning methods [31].

According to our study, most students preferred mobile learning over text learning. 72% of the participants from the mobile group preferred the learning method which they have been assigned too, whereas 60% participants from the text learning group preferred the learning method which they have been assigned to. However, this is not significant. Next, moving on to the satisfactory level, two participants from the control group were very dissatisfied with the learning method assigned to them, whereas no participants from the intervention group were very dissatisfied with their learning method. Four participants from the intervention group were dissatisfied with their learning method, while three participants from the control group were dissatisfied with the learning method assigned to them. 17 participants from the intervention group and 16 participants from the control group were satisfied with their learning method. Lastly, four participants from both the control and intervention group were very satisfied with the learning method assigned to them. Howbeit, all these are not of significance.

Next, 19 participants from the mobile learning group thinks that the learning method which they have been assigned to help in improving knowledge retention, while 17 participants from the text learning group shared similar opinions, though it is not significant. 19 participants from the intervention group thinks that mobile learning helps and motivates them to learn, while 15 participants from the control group thinks that text learning helps and motivates them to learn, nonetheless it has no significant value. Based on a study conducted in Spanish National University of Distance Education (UNED) Spain, their study concluded that the usage of app developed specifically for following University subject were highly regarded by students, as mobile or app learning not only enhanced and increased learning but it also provides chances to form connection with the subjects they are learning. Not just that, mobile learning also helps in fostering a closer relationship between professors and students [10]. Besides that, when analysing the motivational outcomes, the results showed that the satisfaction levels in the students were higher in iPhone games when compared to traditional classroom lessons and the children's preference did not differ in iPhone or traditional classroom lesson which also supports our study [31].

For all types of study design, there will be some limitations to some certain extent. In our Randomized Control Trial study, there were a few limitations we have noticed after conducting the experimental study. Time plays an important role in our study. Due to the limitation of time, we were able to recruit a small population size from Muar campus, Melaka Manipal Medical College. This might not be able to give a significant p-value. This also means the results might not reflect the bigger population. For future reference, it will be better to recruit a larger sample size so that there will be a significant finding in the research. Beyond the scope of our study were also the long-term knowledge retention capability after getting exposed to different learning methods. We can only assess the short-term knowledge retention capability of the students in this study. Long term memory of the students was unable to get evaluated as this trial process only took around 45 minutes in total. Due to the anonymized data collection in our study, we were unable to follow up on the students and gather further data on this interesting topic. In case if there is any study in the future regarding to topic like this, we hope that a few more tests were given to the students over a longer period of time to assess long term and short-term memory. Furthermore, the topic we have given to the students was Population collapse. This topic was briefly mentioned in one of the lecture classes and thus, some students might have prior knowledge about this topic before taking this study. Having prior knowledge about

this topic will certainly affect the score for the test. In other words, the results we obtained from the students might not be 100% accurate as some of them already have been exposed to this topic beforehand. This limits us from knowing the actual score of all students.

This study has shown that Mobile learning is more effective in short term knowledge retention compared to traditional learning methods among medical students. Therefore, we recommend that more mobile apps should be developed not only on community medicine but also on the other fields of medicine such as Surgery, Radiology, Anatomy, etc. to enhance the knowledge and clinical skills of the medical students. Further studies should be conducted to determine the impact of mobile learning on long term knowledge retention. This study was done using a small sample size of 50 therefore the future researchers are recommended to conduct the study using a large sample size. Lastly, there is a need to evaluate the prior knowledge of the participants on the given topic before conducting the study in future studies.

6. Conclusion

Our present study found that mobile learning did enhance knowledge retention as there was a significant relationship between mobile learning on knowledge retention. Our study also observed that medical students' satisfaction level towards both mobile learning and text learning were similar to each other. However, this data finding was found not significant. Therefore, more mobile apps should be developed and implemented not only on community medicine but also on the other fields of medicine to enhance the knowledge and clinical skills of the medical students.

Acknowledgements

We would like to acknowledge and show our gratitude towards all the volunteers that participated in our study. Furthermore, we acknowledge the work and effort put in by our faculty, Dean Prof. Dr Adinegara Lutfi Abas, Prof. Dr Htoo Htoo Kyaw Soe, Associate Prof. Dr Sujata Khobragade, and Assistant Prof. Dr Mila Nu Nu Htay and would like to express our sincere gratitude for their guidance and support throughout this research. Lastly, we extend our appreciation to the Research Ethics Committee, Faculty of Medicine, Melaka Manipal Medical College, Malaysia.

Appendix

PARTICIPANT INFORMATION SHEET

Research title: Is mobile learning more effective in knowledge retention and brings more satisfaction among MMMC students compared to conventional learning method?

Investigators:

Ms. Hirrainny Ramu Naidu

Ms. Tharuki Uththara Rajapakshe

Mr. Nicholas Yee Nuen Zhe

Mr. Lye Jia Cai

Ms. Annabelle Ang Hwee Yee

Please read this form carefully. If you decide to volunteer to take part in this study you must sign the informed consent document below.

This study assesses the effectiveness of mobile learning in knowledge retention and the satisfactory level with mobile learning compared to conventional learning method among MMMC students. A total 60 participants will be assessed using these questionnaires. The participants will be assessed based on their performance in this questionnaire. The questionnaires will be collected within the same day and the answer to the given questions will be given upon collection of the questionnaire sheets.

The volunteers should be aged between 16-30 years old. Both male and female volunteers are eligible to participate in this study.

Entering a research study is voluntary. You may decline participation without giving any reason. The names of the participants will not be revealed during the conduct of this study. The answers of the participant for the questionnaire given will not be revealed either.

……

……

INFORMED CONSENT

Research title: Is mobile learning more effective in knowledge retention and brings more satisfaction among MMMC students compared to conventional learning method?

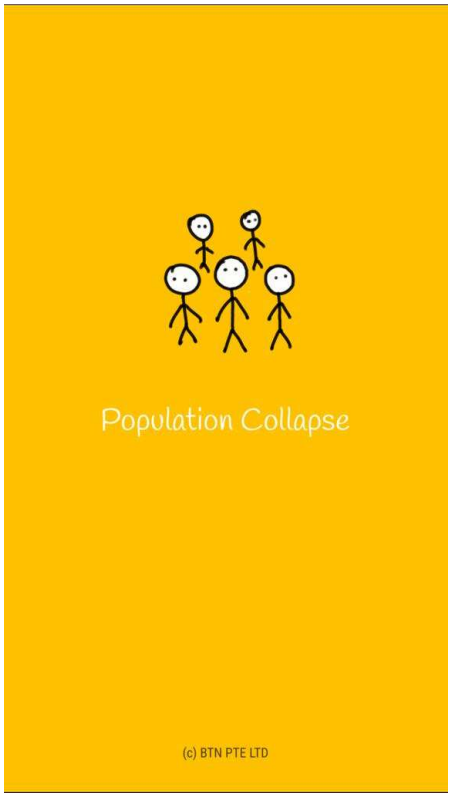
I understand that my participation in this study is voluntary and I can decline participation without giving any reason. I have been given sufficient opportunity to ask questions and received satisfactory answers. I understand that I am allowed to take a photograph of this signed and dated informed consent form as my reference copy.

Roll number of research participant:_____

Signature of the research participant: _____

Date:_____

Mobile application used in this study (Population Collapse)



Content for control group (Text learning)

Population collapse

The words "population" and "collapse" just do not go together and they shouldn't. But the world's population has been increasing up to 7 billion since the 2000 BC and it's not crazy to wonder what the future holds. Questions about the future like "will the population grow and stabilize?", "will resource shortage drive us to collapse?", or "will technology and innovation save the day" are commonly raised.

In order to explore how a population system behaves, we will give an example using a model with a bunch of people living on a remote island, using the resources that the land provides, to see how a population's growth can lead to its own collapse and what might help avoid it.

Building the model

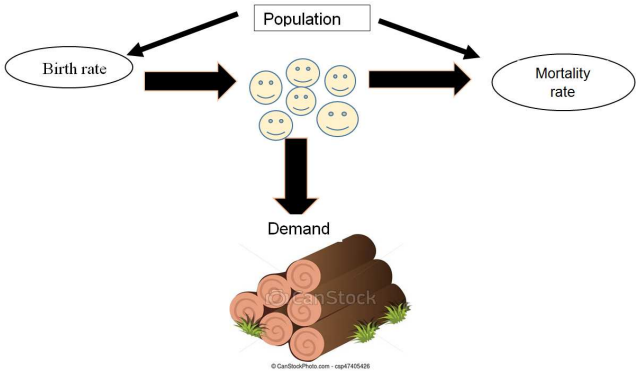
We start the model with 2000 people, living on an isolated island. The people are born, they live and they die. The Birth Rate depends on how many people there are (population) and what percentage of them have babies each year.

Let's just say that for every 1000 people alive there are 20 people born each year which is the fractional birth rate.

Similarly, the population's mortality rate depends on the number of people (population) and the fractional mortality rate which in this case let's assume 10 people die per 1000 each year.

$$\frac{\#\text{ births in 1 year}}{\#\text{ thousand total population}} = \text{Crude Birth Rate}$$

$$\frac{\#\text{ deaths in 1 year}}{\#\text{ thousand total population}} = \text{Crude Death Rate}$$



In order to live their lives, the people consume the trees that grow on the island. Now, imagine that the island's trees are an ideal renewable resource. If the people cut down 100 trees today, there'd be 100 new ones to take their place tomorrow. But the island does have a limit to the number of trees it can support (tree capacity). This tree capacity of the island is set at 100,000 trees/ year to begin with. The people's consumption results in a demand for island's trees. The size of this demand depends on the number of people and the demand per person. The demand per person is set at 10 trees per person per year.

Population x Demand per person (10) = Total Demand for trees

As people demand and consume trees, it places a "stress" on the island's environment. This stress can be measured as the Demand for trees in a given year given divided by the island's Tree Capacity.

Demand for trees per year / Tree Capacity = Stress

If only a fraction of the island's Tree Capacity is required by the people each year, the stress is low (a ratio much less than 1). If more than the island's Tree Capacity is required, then the stress is high (a ratio higher than 1).

For example, if the number of trees demanded is twice the island's capacity, the value of the stress ratio is 2. A stress ratio greater than 1 means there's a shortage of trees and some of the demand is not being met.

This shortage ought to affect the birth and mortality rates. When stress is low, resources are abundant, so birth rates would be close to normal. But when the stress crosses one, the birth rates should drop.

To capture this, let's multiply the birth rate by factor between 0 and 1. The value of this 'Birth Multiplier' will depend on

the amount of Stress. The multiplier is 1 when Stress is less than 1. As the Stress increases, it drops down until it eventually reaches 0. In a similar way, the Mortality Rate is also affected by the Stress. The Mortality Multiplier is equal to 1 when the Stress is less than 1 and rises up to a maximum of 5 as the Stress increases. And finally, the Stress placed on the island also ends up degrading the island's capacity to produce trees.

The Degradation Multiplier links the Stress to the Degradation Rate. It has a value of 0 when the Stress is less than 1 and rises to a maximum value of 1 as the stress increases. Together with the Fractional Degradation Rate, this multiplier determines the rate at which the island's capacity degrades. This completes the basic population model. To sum up- there are a bunch of people living on a remote island whose demand for resources places a stress on the island's capacity. That stress in turn affects births, deaths, and resource degradation.

Simulating Collapse.

The population grows exponentially, slows down, and collapses all at once. The island's tree capacity stays stable as the population grows, but then ends up collapsing as well. What is the sequence of events that makes this happen?

The model starts with only 2000 people on the island. Because there aren't too many people, the Demand for trees is much lower than the island's capacity and the Stress is less than 1. A low Stress means the Birth and Mortality Rates are at their normal values. With the Birth Rate higher than the Mortality Rate, the number of people increases. This reinforcing population growth loop causes the population to increase exponentially at first. But as the population grows, the demand for trees increases as well. The larger Demand raises the Stress. When the Stress goes beyond 1, the Birth and Mortality Multiplier kick in. The Birth Rate drops and the Mortality Rate rises. This balancing effect of Stress on the birth and mortality rates causes the population's growth to slow down.

As this is happening, the high Stress also spurs the degradation of island's Tree Capacity. With the Stress higher than 1, the Degradation Multiplier's value rises above 0 and the island's Tree Capacity begins to shrink. The shrinking Tree Capacity further increases the Stress on the system which increases the Degradation Multiplier even more speeding up the rate of degradation. This reinforcing loop of degradation causes the Stress to explode. The Birth Rate plummets and the Mortality Rate goes through the roof. The Birth Rate eventually ends up lower than the Mortality rate and that's when the population begins its fall. So you've seen now how population's growth can lead to its own collapse.

In Tech we trust

A lot of folks believe that technology and innovation are going to save the day and we do too! Whether it's high tech or low, machines or methods, it's exciting to believe that technology will make tomorrow better than today! But exactly what kind of technology is going to help prevent population collapse and how?

In the context of this model, there are essentially 2 broad types of technology to consider:

1. Technology that reduces the amount of resources consumed per person. Real life example includes water saving fixture and energy saving lighting. In the model, the effect of this type of resource-efficiency technology can be captured by changing the 'Demand per Person'.
2. Technology that reduces environmental degradation. Real life example include crop rotation, recycling and reducing pollution. In this model, the role of this second type of technology can be captured by the 'Fractional Degradation Rate'

Fractional Degradation Rate = Degradation/ Tree capacity

So, we will start with the first technology - Demand per person. Example: If we change the Demand per person from 10 to 2 trees/person/year, this will reduce the resource consumption per person by 80%. By reducing the consumption per person by 80%, the population grows to a much higher level and collapses much later than in the baseline run, this is progress!

However, the population still collapsed. So, just by cutting down the resource 'Demand per person' it does not really changes the underlying behaviour of the system but it does help to buy the people more time and allows the island capacity to support more people. This means that while resource efficiency is helpful, it is unlikely to be the only thing we need to do to prevent population collapse.

Moving on to the second type of technology- tech that reduces degradation. Example if we change the 'Fractional degradation rate' from 10% to 2% per year, the population has gone from a collapse to a slow decline. A slow decline buys us a lot more time to come up with a lasting solution. But, it is interesting to note that while such technology does turn collapse into a decline, the size of the population at the peak and the timing of decline are quite similar to the baseline values. This is in stark contrast to boosting resource efficiency which results in a lot people and also postpone the collapse.

Given that 2 types of tech bring different benefits it makes sense to use both together. Imagine by changing the Demand per person from 10 to 2 trees/person/year and changing the

'Fractional degradation rate' from 10% to 2% per year, the population grows to a much larger size than in the baseline, the collapse turns into a slow decline and decline starts much later. This is all good. We've managed to buy ourselves a lot more time but the population on the island still ends up eventually declining. So we haven't completely solve the problem. What else can we change?

Population planning

Countries across the world use varying forms of 'Population Planning' to try and influence population growth. Some have strict one or two child policies, while others might use reward and punishment to influence how many children people have. The common thing that these policies are trying to change is the Birth Rate. As we try to stimulate what population planning might do to the system, we will try doing this by changing the Fractional Birth Rate. Example: if we change the Fractional Birth Rate from 0.02 to 0.01, with the birth rate equal to the mortality rate, the population stays in a dynamic equilibrium and does not collapse.

But a major problem with this is that we might end up artificially supressing the population to a size that is much smaller than necessary. In previous runs, we reached a max population size of over 50,000 people. In the current run we got a stable population of only 2000. That is not good. If more people can be supported, without negatively affecting sustainability, more people should be supported. But if they can be done, it seems like population planning can be a way of avoiding collapse. Better yet, it is used along with a push to invent technologies that boost resource efficiency and reduce degradation. The technology improvements will buy us more time and allow many more people to live, while population planning creates a safe guard against collapse.

Socio-demographic data

Age: _____ years

Gender:

a) Male

b) Female

A). Diet

1. Have you had your meals (breakfast/lunch)?

a) Yes

b) No

2. Do you take any supplements?

a) Yes

b) No

B). Sleep

1. How many hours did you sleep last night?

a) Less than 5 hours

b) 5 to 6 hours

c) 6 to 7 hours

d) More than 7 hours

C). Physical activities

1. Do you exercise?

a) Yes

b) No

2. If yes, how many times a week?

a) Everyday

b) Once a week

c) Twice a week

d) Three times a week

3. Do you practice meditation/ yoga

a) Yes

b) No

D). Alcohol

1. Do you drink alcohol?

a) Yes

b) No

2. If yes, did you consume alcohol last night?

a) Yes

b) No

E). Smoking

1. Do you smoke?

a) Yes

b) No

2. When was the last time you smoked?

a) Today

b) Yesterday

c) More than 1 week ago

d) More than 1 month ago

F). Illness

1. Are you suffering from any medical illness?

a) Yes

b) No

2. If yes, please specify:

_____

3. Are you currently on any medication?

a) Yes

b) No

4. If yes, please specify:

_____

Population collapse Q&A:

1) The people have discovered a new island which can supply them with 50,000 more trees a year. Given this increase in Tree Capacity, will the population system still collapse?

a) Yes

b) No

c) Can't say

2) Calculate the birth rate

Total population: 5000

No. of new birth: 40

No. of Death: 50

a) 8

b) 10

c) 12.5

d) 15

3) The people on the island have realized that they need to do something to avoid collapse. A lot of them are focussing on bringing down the Demand per Person. What effect will this have?

a) The collapse will occur later

b) More people can be supported on the island

c) Both of the above

d) Population collapse will be avoided

4) If the value of Stress has increased from 0 to 2, which of the following also happens?

a) The birth rate decreases

b) The mortality rate rises

c) The degradation rate rises

d) All of the above

5) What kind of a feedback loop is the one that connects Stress, the Degradation Multiplier, the Degradation Rate and the Tree Capacity?

a) A reinforcing loop

b) A balancing loop

c) Both reinforcing and balancing loop

d) Can't say

6) The Fractional Mortality Rate has dropped by 50% and the Fractional Birth Rate has come down by 25% compared to the baseline run. When will the collapse of the population now occur?

a) Much earlier than in the baseline run

b) Much later than in the baseline run

c) Roughly around the same time as the baseline run

d) Can't say

7) If a new technology is invented that reduces the Fractional Degradation Rate to ZERO% per year, will the population still collapse?

a) No

b) Yes

c) Can't say

8) Name two factors affecting population growth.

a) ……..

b) ……..

9) What is the impact of technology on preventing population collapse?

a) Reducing the demand per person

b) Reducing the fractional degradation rate

c) Both of the above

d) None of the above

10) The total tree capacity of the island is set at 200,000 trees/ year. The demand per person is set at 10 trees per person per year. If the total population of the island is 20000, calculate the stress factor.

a) 2

b) 0.2

c) 0.1

d) 1

Survey form

1. Do you prefer the type of learning method that you have been assigned to?

a) Yes

b) No

2. How would you rate your satisfaction on the learning method which you have been assigned to?

a) Very satisfied

b) Satisfied

c) Dissatisfied

d) Very dissatisfied

3. In your opinion, do you think that the learning method that you have been assigned to helps in improving knowledge retention?

a) Yes

b) No

4. Was the learning method assigned to you motivating and helped you to learn?

a) Yes

b) No

Text learning (control group)

Mobile learning (intervention group)

A student in the intervention group using the "Population Collapse" application

References

[1] Malaysian Communications and Multimedia Commission (MCMC). Laporan Tahunan 2017 [Internet]. 2017 [cited 2019 Dec 18]. Available from: https://www.skmm.gov.my/skmmgovmy/media/General/pdf/AR-2017-BM.pd

[2] Ismail I, Azizan SN, Gunasegaran T. Mobile Learning in Malaysian Universities: Are Students Ready? International Journal of Interactive Mobile Technologies (iJIM). 2016 Jul 26; 10 (3): 17.

[3] Drigas AS, Ioannidou R-E, Kokkalia G, Lytras MD. ICTs, Mobile Learning and Social Media to Enhance Learning for Attention Difficulties [Internet]. Journal of Universal Computer Science; 2014 [cited 2019 Dec 18] p. 1499–510. Available from: http://www.jucs.org/jucs_20_10/icts_mobile_learning_and/jucs_20_10_1499_1510_drigas.pdf

[4] Willms J. STUDENT ENGAGEMENT AT SCHOOL A SENSE OF BELONGING AND PARTICIPATION RESULTS FROM PISA 2000 [Internet]. Organisation for Economic Co-operation and Development, Paris; 2003 [cited 2019 Oct 11]. Available from: http://www.oecd.org/education/school/programmeforinternationalstudentassessmentpisa/33689437.pdf

[5] Dzakiria H. New Technology Takes the Distance Out of Distance Learning [Internet]. CSU Online ValuED Blog. Malaysian Online Journal ofInstructional Technology, vol.1, no.1, 2004.; 2015 [cited 2019 Dec 18]. Available from: http://blog.online.colostate.edu/blog/online-teaching/new-technology-takes-the-distance-out-of-distance-learning/

[6] Passey D, Rogers C, Machell J, Mchugh G. The Motivational Effect of ICT on Pupils RESEARCH [Internet]. http://webarchive.nationalarchives.gov.uk/20130401151715/ http://www.education.gov.uk/publications/eOrderingDownload/Df ES-0794-2003.pdf. Nottingham, DfES; 2004 [cited 2019 Dec 18]. Available from: http://downloads01.smarttech.com/media/research/international_research/uk/lancaster_report.pdf

[7] Subramaniam G. Confronting Asian Concerns in Engaging Learners to Online Education. International Education Studies [Internet]. 2008 [cited 2019 Dec 18]; 1 (4): 10–8. Available from: https://eric.ed.gov/?id=EJ1065422

[8] Nee|Yahaya K. Review of Mobile Learning Trends 2010-2015: A Meta-Analysis. Educational Technology & Society [Internet]. 2017; 20 (2): 113–26. Available from: https://eric.ed.gov/?id=EJ1137658

[9] Hung J-L, Ke Zhang. Examining Mobile Learning Trends 2003-2008: A Categorical Meta-Trend Analysis Using Text Mining Techniques. Journal of Computing in Higher Education [Internet]. 2012 Apr [cited 2019 Dec 18]; 24 (1): 1–17. Available from: https://www.learntechlib.org/p/68010/

[10] Vázquez-Cano E. Mobile Distance Learning with Smartphones and Apps in Higher Education. Educational Sciences: Theory and Practice [Internet]. 2014; 14 (4): 1505–20. Available from: https://eric.ed.gov/?id=EJ1045122

[11] Kim S-J, Shin H, Lee J, Kang S, Bartlett R. A smartphone application to educate undergraduate nursing students about providing care for infant airway obstruction. Nurse Education Today [Internet]. 2017 Jan [cited 2019 Dec 18]; 48: 145–52. Available from: https://www.sciencedirect.com/science/article/pii/S0260691716302350

[12] BABAZADE KAMANGAR M, JAHANIAN I, GHOLINAI H, ABBAS ZADEH H. A PRELIMINARY STUDY OF THE EFFECT OF MOBILE-BASED EDUCATION ON DENTAL STUDENTS' LEARNING IN PRACTICAL COURSE OF ORAL PATHOLOGY. Www.sid.ir [Internet]. 2016 [cited 2019 Dec 18]; 9 (22): 21–6. Available from: https://www.sid.ir/en/journal/ViewPaper.aspx?ID=507048

[13] Pimmer C, Mateescu M, Zahn C, Genewein U. Smartphones as Multimodal Communication Devices to Facilitate Clinical Knowledge Processes: Randomized Controlled Trial. Journal of Medical Internet Research [Internet]. 2013 Nov 28 [cited 2019 Dec 19]; 15 (11): e263. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3868983/

[14] Clark JM, Paivio A. Dual coding theory and education. Educational Psychology Review [Internet]. 1991 Sep [cited 2019 Nov 9]; 3 (3): 149–210. Available from: http://www.umich.edu/~rdytolrn/pathwaysconference/presentations/paivio.pdf

[15] Mayer RE. Applying the science of learning to medical education. Medical Education [Internet]. 2010 Jun [cited 2019 Mar 20]; 44 (6): 543–9. Available from: http://content.ebscohost.com/ContentServer.asp?EbscoContent=dGJyMNXb4kSeqK44y9fwOLCmr1GeprRSsay4TLWWxWXS&ContentCustomer=dGJyMPGosFCwrLBJuePfgeyx9Yvf5ucA&T=P&P=AN&S=R&D=ccm&K=105207855

[16] Paivio A. Mental imagery in associative learning and memory. Psychological Review [Internet]. 1969 [cited 2019 Nov 22]; 76 (3): 241–63. Available from: https://pdfs.semanticscholar.org/a515/c6ef747b69d103305e8e326390f05d5f8caa.pdf

[17] Baddeley AD, Hitch G. Working Memory. Psychology of Learning and Motivation. 1974; 8–89.

[18] Sweller J. Cognitive Load During Problem Solving: Effects on Learning. Cognitive Science. 1988 Apr; 12 (2): 257–85.

[19] Sweller J, van Merrienboer JJG, Paas FGWC. Cognitive architecture and instructional design. Educational Psychology Review. 1998; 10 (3): 251–96.

[20] Rummel N, Spada H. Instructional Support for Collaboration in Desktop Videoconference Settings. Barriers and Biases in Computer-Mediated Knowledge Communication [Internet]. 2019 [cited 2019 Dec 19]; 14 (2): 59–88. Available from: https://link.springer.com/chapter/10.1007/0-387-24319-4_4

[21] Pearson J. Investigating ICT Using Problem-Based Learning in Face-to-Face and Online Learning Environments. Computers and Education [Internet]. 2019 [cited 2019 Dec 19]; 47 (1): 56–73. Available from: https://eric.ed.gov/?q=%22ICT+in+business%22&id=EJ732130

[22] Kester L, Lehnen C, Van Gerven PWM, Kirschner PA. Just-in-time, schematic supportive information presentation during cognitive skill acquisition. Computers in Human Behavior [Internet]. 2006 Jan [cited 2019 Dec 19]; 22 (1): 93–112. Available from: https://core.ac.uk/display/55534655

[23] Rondon S, Sassi FC, Furquim de Andrade CR. Computer game-based and traditional learning method: a comparison regarding students' knowledge retention. BMC Medical Education. 2013 Feb 25; 13 (1).

[24] Fahad N, Al-Fahad F. STUDENTS' ATTITUDES AND PERCEPTIONS TOWARDS THE EFFECTIVENESS OF MOBILE LEARNING IN KING SAUD UNIVERSITY, SAUDI ARABIA. The Turkish Online Journal of Educational Technology [Internet]. 2009 [cited 2019 Dec 12]; 8 (2): 1303–6521. Available from: https://files.eric.ed.gov/fulltext/ED505940.pdf

[25] Khaddage, F.; Lanham, E.; Zhou, W. A mobile learning model for universities : reblending the current learning environment. International journal of interactive mobile technologies [Internet]. 2009 [cited 2019 Dec 24]; 3 (Supp 1): 18–23. Available from: http://dro.deakin.edu.au/view/DU:30051955

[26] McMahon M, Pospisil R. Laptops for a Digital Lifestyle: The Role of Ubiquitous Mobile Technology in Supporting the Needs of Millennial Students [Internet]. Research Online. 2011 [cited 2019 Dec 24]. Available from: https://ro.ecu.edu.au/ecuworks/2636/

[27] Oblinger D. "Boomers, Gen-Xers, and Millennials: Understanding the New Students. EDUCAUSE Review [Internet]. 2003 [cited 2019 Oct 28]; 38 (4): 36-40, 42, 44-45. Available from: https://www.naspa.org/images/uploads/main/OblingerD_2003)_Boomers_gen-Xers_and_millennials_Understanding_the_new_students.pdf

[28] Granito, Mark and Chernobilsky, Ellina, "The Effect of Technology on a Student's Motivation and Knowledge Retention" (2012). NERA Conference Proceedings 2012. 17. https://opencommons.uconn.edu/nera_2012/17

[29] Creately [Internet]. App.creately.com. 2020 [cited 7 January 2020]. Available from: https://app.creately.com/diagram/oqVSMTyk7qB/edit

[30] Research Randomizer [Internet]. Randomizer.org. 2020 [cited 7 January 2020]. Available from: https://www.randomizer.org/

[31] Furió D, Juan M-C, Seguí I, Vivó R. Mobile learning vs. traditional classroom lessons: a comparative study. Journal of Computer Assisted Learning. 2014 May 22; 31 (3): 189–201.