Using a collaborative Mobile Augmented Reality learning application (CoMARLA) to improve Student Learning

Hafizul Fahri bin Hanafi, Che Soh Said, Asma Hanee Ariffin, Nur Azlan Zainuddin & Khairulanuar Samsuddin

Computing Department of Universiti Pendidikan Sultan Idris, Creative Department of Universiti Pendidikan Sultan Idris

Email: hafizul@fskik.upsi.edu.my

This study was carried out to improve student learning in ICT course using a collaborative mobile augmented reality learning application (CoMARLA). This learning application was developed based on the constructivist framework that would engender collaborative learning environment, in which students could learn collaboratively using their mobile phones. The research design was based on the pretest posttest control group design. The dependent variable was students’ learning performance after learning, and the independent variables were learning method and gender. Students’ learning performance before learning was treated as the covariate. The sample of the study comprised 120 non-IT (non-technical) undergraduates, with the mean age of 19.5. They were randomized into two groups, namely the experimental and control group. The experimental group used CoMARLA to learn one of the topics of the ICT Literacy course, namely Computer System; whereas the control group learned using the conventional approach. The research instrument used was a set of multiple-choice questions pertaining to the above topic. Pretesting was carried out before the learning sessions, and posttesting was performed after 6 hours of learning. Using the SPSS, Analysis of Covariance (ANCOVA) was performed on the data. The analysis showed that there were main effects attributed to the learning method and gender. The experimental group outperformed the control group by almost 9%, and male students outstripped their opposite counterparts by as much as 3%. Furthermore, an interaction effect was also observed showing differential performances of male students based on the learning methods, which did not occur among female students. Hence, the tool can be used to help undergraduates learn with greater efficacy when contextualized in an appropriate setting.

1.0 INTRODUCTION

At the dawn of the new millennium, the world has been witnessing a myriad of transformations affecting almost every facet of our lives. Naturally, these changes have reshaped the educational, political, and social landscapes, exposing humans to new challenges. One thing is certain, the dependency on Information and Communications Technology (ICT), especially computer technology, is becoming more intense [1], to which our daily activities will come to a stop without it, literally. For example, design engineers will rely on specialized equipment, notably ICT-based hardware and software, to analyse the mechanical properties and dynamics of components in their designs. Likewise, environmental scientists will use an array of ICT systems to gather and analyse a huge amount of environmental data before making precise predictions or forecasts. More importantly, those involved...
in teaching, such as lecturers, instructors, and teachers, have become more and more dependent on novel, innovative learning tools and materials (which are invariably based on digital technology) to improve their tasks [2]. Given the imperative to stay abreast with these technologies, it is not surprising that many nations have begun putting in every resource available to improve the ICT competency of their populace, as only through such competency can the nations move forward in this challenging time. In some nations, the efforts to educate the masses with an ICT start at the preschool level, such as Greece and China [3]. In Malaysia, its government has taken several initiatives to improve the ICT competency, notably by introducing relevant ICT-related subjects and courses at all levels of education. This includes mandating non-technical undergraduates (those majoring in social sciences) to learn ICT competency in their first year of studies. Nonetheless, their learning performances were not highly satisfactory, which were attributed to a host of problems such as students’ poor motivation, poor delivery of the subject matter, lack of learning aids, absence of collaboration, and insufficient practise [4], [5], [6].

In response to the above problems, several researchers in Malaysia have carried out studies to examine contributing factors and to provide appropriate solutions, which invariably involved the use of ICT technology [7], [8], [9], [10]. Such focus on ICT-based solutions is not surprising given the availability of powerful, affordable hardware and software to help in such developments. In recent years, new developments and improvements in ICT have spurred the use of digital multimedia [11], animation [12], virtual reality [13], [14], and augmented reality [9],[15], among others, in a diverse range of academic contexts, producing many interesting, promising results.

Of late, a variant of AR technology – mobile augmented reality (MAR) technology – is making its presence equally important for training and learning purposes. The appeal of MAR to educators lies in its mobility as learning applications can be accessed using the ubiquitous mobile devices, namely hand phones. Learners can now gain access to learning materials and contents anywhere, anytime on their “palms”. Arguably, the mobility of this technology will transform the way in which learners learn in this new millennium. In developed nations, MAR learning applications are being used in many learning contexts [16], [17], [18], which has improved students’ learning performance and motivation [19]. Nonetheless, the use of this technology in Malaysia is almost non-existent. Even in the western countries, some scholars have cautioned their wholesale adoption in schools, and one of these concerns is that some of these applications were developed without any strong theoretical underpinnings [20].

In light of this revelation, research on the use of such technology in the Malaysian educational context needs to be addressed to help improve the learning of ICT Competency among fresh non-IT (non-technical) undergraduates in universities. Unresolved, this can introduce serious implications in their careers later, as technology is pervasive in the working realm. Nevertheless, integrating technology in learning activities is not as simple as one might think, as there are pitfalls that lie along its path that could result in serious consequences. Factors influencing such integration, such as gender, age, academic background, and ethnicity, have been reported to be detrimental to the successful use of technology in education. For example, Samsudin and Rafi [21] found that male students were able to adapt a digital learning environment more efficiently and learn more efficaciously in such an environment. Arguably, such gender imparity may resurface in other technology-enabled learning settings, such as learning that uses MAR technology.

In light of the above revelations, the researchers formulated two research objectives to guide the study as follows:
a) To develop a learning application based the mobile augmented reality technology that can help students learn collaboratively.
b) To examine the impacts of learning method and gender on students’ performance in learning a topic of ICT Competency course.

Two research questions were formulated to address the above research objectives as follows:
a) Will there be any significant difference in the learning performances between participants who used CoMARLA and those who used similar application on the Personal Computers (PCs)?
b) Will there be any significant difference in the learning performances between female students and male students?

2.0 RESEARCH METHOD
The research method of study was based on a quasi-experimental research that used the pretest posttest control group research design. The following are the details of the research method of the study:

2.1 Participants
The study sample consisted of 120 first-semester social science majors, who were selected from two intact classes of the first author. Stratified random sampling was used to divide the participants into two groups, namely the experimental and control groups, to ensure both females and males were proportionately represented. The experimental group comprised 23 males and 37 females, and the control group 22 males and 38 females. The mean age of the participants was 19.

2.2 Research Instrument and Instructional Materials
Both groups were given a set of instructions, detailing the purpose of learning and expected learning outcomes. They were also provided with learning materials related to the topic of learning. For the experimental group, the participants were allowed to use their mobiles on which the learning application (CoMARLA) was installed. For the control group, they were allowed to use the personal computers in a computer laboratory on which a similar application was installed. Learning performances were measured before the learning session and after the last learning session using the Computer System Unit Test Items, which is a paper-and-pencil test, comprising 50 multiple-choice questions.

3.0 The Development of the Collaborative Mobile Augmented Reality Learning Application (CoMARLA)
The development of the mobile learning application was based on the constructivist principles as propounded by Moshman’s (as cited in Dalgarno) [22] interpretation of constructivism, namely endogenous, exogenous, and dialectical principles. Endogenous constructivism stresses the importance of learner exploration during learning. Exogenous constructivism underscores the imperative of direct instruction, but with a strong emphasis of learners actively constructing their own knowledge representation. Dialectical constructivism plays the important role to facilitate the interaction among learners, their peers, and lecturers. With such interpretations, the onus is on the lecturer to create the constructivist-learning environment using appropriate learning contents, features, materials, and facilities. For example, in CoMARLA learning application, materials that draw on the endogenous standpoint are the multimedia contents, such as 3D objects, audio narration, demonstration videos. To invoke exogenous learning, instructional sheets, guidelines, and cognitive tools are available to help knowledge construction. Finally, materials that tap on the dialectical view consist of collaboration and support tools, such as Facebook and Google doc. These tools serve as the communication platform of CoMARLA learning tools, of which learners could partake in discussion sessions to solve a given task. With such a platform, learners could immerse in an iterative communication loop as proposed by Obikwelu and Read [23]. The framework that helped guide the development of the learning application is shown in Figure 1.
The development of the Collaborative Mobile Augmented Reality Learning Application (CoMARLA) was carried out by using the web-based augmented reality (AR) development system, Aurasma Studio, which also hosts a diverse array of AR contents online. When accessing Aurasma’s website, users can use the various features available to develop AR contents using various templates. The developed AR contents can be uploaded to the system’s server as cloud contents, which can be downloaded to users’ device. These AR contents can be quickly accessed, shared, and distributed among users with some of the novel features, such popular hashtags based on trend or sharing templates, as depicted in Figure 1. Having this quick search and precise search of relevant contents helps students in their learning process as it can proceed without any delays or interruptions. Interestingly, such AR contents can be accessed by any devices that have internet connectivity, such as the mobile phone, thus expanding the learning envelope that makes learning more pervasive and all encompassing.

3.1 Procedure
In this study, carrying out the experimental research entailed three stages that were carried out in a sequence. First, the participants were pre-tested for learning performance measure using the Computer System Unit Test Items. Then, the participants were divided into the control and the experimental group that were exposed to conventional and CoMARLA leaning, respectively. Finally, on the last learning session, they were post-tested for the same measures using the same research instrument used in the pre-testing.

4.0 RESULTS
Using the SPSS (Version 21.0), the data collected were analyzed to yield both the inferential and descriptive statistics. Specifically, the univariate Analysis of Covariance (ANCOVA) was carried out to test if there were any significant differences in learning performances attributed to learning method and gender. The participants’ learning performances were tested through the multiple-choice test. Before the learning sessions, the experimental group’s mean score of learning performance was 63.20

Figure 1 The theoretical framework for the development of CoMARLA
(SD = 1.86), and the control group’s mean score was 61.53 (SD = 4.48). After the learning sessions, the experimental group’s mean score of learning performance was 81.80 (SD = 5.71), whilst the control group’s mean score was 72.99 (SD = 2.85). Table 1 summarizes the detailed learning performances of the participants based on the learning method and gender.

Table 1 Learning performances based on learning method and gender

| Group                  | Gender      | Pre-testing | Post-testing |
|------------------------|-------------|-------------|--------------|
|                        |             | Mean | SD   | Mean | SD   |
| Experimental (using CoMARLA) | Female (n = 37) | 63.84 | 1.94 | 79.28 | 4.94 |
|                        | Male (n = 23) | 62.17 | 1.14 | 85.83 | 4.48 |
|                        | Total (N = 60) | 63.20 | 1.86 | 81.80 | 5.71 |
| Control (using PCs)    | Female (n = 38) | 61.74 | 4.76 | 73.21 | 2.69 |
|                        | Male (n = 22) | 61.18 | 4.04 | 72.61 | 3.14 |
|                        | Total (N = 60) | 61.53 | 4.48 | 72.99 | 2.85 |

An analysis of covariance was performed to examine whether there were any main effects and interaction effect attributed to the learning method and gender. The result of the analysis is shown in Table 2. A 2x2 ANOVA with learning method (CoMARLA, Conventional) and gender use (female, male) as between-subjects factors revealed the main effects of learning method, F(1,115) = 158.62, p = .001) and gender, F(1,115) = 15.74, p = .001. In general, participants who used CoMARLA outperformed those who used the conventional method. Similarly, male participants tended to outperform their female counterparts. These main effect was qualified by an interaction between learning method and gender, F(1,115) = 22.94, p = .001, which is best exemplified by Figure 2. Male participants who used the mobile learning application tended to perform better than those male participants who used PC learning application. However, such differential performance was not observed for female participants, as they performed equally well in both learning methods.

Table 2 Tests of between-subjects effects

| Source                | Sum of Squares | df | Mean Square | F     | Sig.  |
|-----------------------|----------------|----|-------------|-------|-------|
| Corrected Model       | 2935.701       | 4  | 733.925     | 47.036| .000  |
| Intercept             | 2033.150       | 1  | 2033.150    | 130.302| .000  |
| Covariate             | .466           | 1  | .466        | .030  | .863  |
| Group                 | 2475.078       | 1  | 2475.078    | 158.624| .000* |
| Gender                | 245.598        | 1  | 245.598     | 15.740| .000* |
| Group * Gender        | 358.010        | 1  | 358.010     | 22.944| .000* |
| Error                 | 1794.390       | 115| 15.603      |       |       |
| Total                 | 723466.500     | 120|            |       |       |
| Corrected Total       | 4730.092       | 119|            |       |       |

* p < .001
5.0 DISCUSSION AND CONCLUSION

This study revealed several interesting, promising results. Firstly, the findings showed that participants who learned using the mobile application on their mobile phones achieved higher learning performance than those who used similar application on PCs. Secondly, male participants tended to make significant gain in learning compared to their opposite gender. Thirdly, and interestingly, male participants attained differential learning performances based on the learning method that they used. Specifically, male participants learned more efficaciously with the use of CoMARLA than those male participants who used similar application on PCs. No such differential performances were observed among the female participants. Clearly, these findings will have some implications on the current teaching and application development practices.

From the teaching perspective, the use of such mobile augmented reality application can help improve student learning by engendering an effective environment that fosters collaborative learning. Students can use their mobile devices with greater flexibility and mobility to communicate and discuss with their peers, as well as with their instructor. This improved mobility can enrich students’ learning experience as they can gain access to and make use of relevant learning materials or contents anywhere, anytime. Thus, such a mobile application can be effectively used in independent (informal) learning contexts, in which students on the go will be able to practice and rehearse learning activities no matter where they are. Given that such application supports a diverse range of multimedia contents, learning can become more intense and entertaining, which appeals to students from a wide spectrum of educational background. Obviously, such mobile application can be a potent tool to help learning both in the formal and informal setting.

As observed, male students have a strong proclivity for learning in technology-enhanced learning environments. In contrast, female students do not have, or may not have developed, such a tendency for such learning setting. In a sense, the former can be viewed to be “technology-oriented”, whereas
the latter “technology-neutral”. This finding is consistent with other findings, which in general show male superiority in various learning situations that used an array of technology tools. Many researchers assert that such superiority is not due to biological factors but social factors. More importantly, this particular finding may have some serious implications on the teaching practice, affecting both students and instructor. In today’s realm, technology is practically everywhere and peoples, particularly the youth, are so accustomed to using technological devices. Naturally, students will expect that they can use appropriate tools or applications in their learning activities. Failing to fulfil this high expectation can result in low morale among students, thus forfeiting their rights to have a significant learning experience. For instructors, they will face many challenges in adopting such a mobile learning tool in their classes. As demonstrated in this study, female students, as compared to male students, tend to be less receptive to new, innovative learning method. Contentiously, they are not as highly excited as their opposite counterparts to try new technology in their learning. Such a misplaced perspective needs to be corrected to ensure female students too can capitalize on novel learning using appropriate technological learning applications. Thus, the onus is on instructors to guide and motivate students, especially female students, to use such new learning tools.

In summation, the findings of this study provide important insights into the understanding of the immense educational potentials of mobile augmented reality learning tools in learning. The mobile application had been demonstrated to be more effective than its cousin, which ran on the PC platform. However, for such a learning tool to be effective, its development has to be based on a strong footing. Only the use of relevant, contemporary theoretical framework can help realize such a strong, stable foundation. More studies are needed to examine the impact of this technology on learning by focusing on other related factors, such as age or computer skills, in other learning contexts.
References

[1] Thomas, B., & Watters, J. J. (2015). Perspectives on Australian, Indian and Malaysian approaches to STEM education. International Journal of Educational Development, 45, 42-53.

[2] Zylka, J., Christoph, G., Kroehne, U., Hartig, J., & Goldhammer, F. (2015). Moving beyond cognitive elements of ICT competency: First evidence on the structure of ICT engagement. Computers in Human Behavior, 53, 149-160.

[3] Liu, X., Toki, E. I., & Pange, J. (2014). The use of ICT in preschool education in Greece and China: A comparative study. Procedia-Social and Behavioral Sciences, 112, 1167-1176.

[4] Nincarean, D., Alia, M. B., Halim, N. D. A., & Rahman, M. H. A. (2013). Mobile augmented reality: The potential for education. Procedia-Social and Behavioral Sciences, 103, 657-664.

[5] Ngang, T. K., Nair, S., & Prachak, B. (2014). Developing Instruments to Measure Thinking Skills and Problem Solving Skills among Malaysian Primary School Pupils. Procedia-Social and Behavioral Sciences, 116, 3760-3764.

[6] Stanisavljević-Petrović, Z., Stanković, Z., & Jevtić, B. (2015). Implementation of Educational Software in Classrooms – Pupilś Perspective. Procedia-Social and Behavioral Sciences, 186, 549-559.

[7] Hafizul F. H., & Samsudin.K. (2012). Mobile Learning Environment System (MLES): The case of android-based learning application on undergraduates’ learning. International Journal of Advanced Computer Science and Applications, 3(3), 63-66.

[8] Hassan, H., Said, C.S., Johan, R., Fabil, N., Hanif, A.S., Mailok, R., & Hashim, M. (2008). Pembinaan Perisian Multimedia Pintar Teknologi Maklumat KBSM. Project Report. UPSI, Tanjong Malim.

[9] Mohamad, A.J., Lakulu, M., & Samsudin, K. (2016). The development of a mobile application for kindergarten early reading: Challenges and opportunities. Journal of engineering and applied sciences, 11(3), 380-383.

[10] Samsudin, K., Nazre, A.R., Jamilah, H., Sairabanu, O.K., & Norasikin, F. (2010). Effects of training method and gender on learning 2D/3D geometry. Journal of Computers in Mathematics and Science Teaching, 29(2), 1-14.

[11] Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2014). Horizon report 2014 - Higher education edition. Austin, TX: The New Media Consortium.

[12] Hafizul F. H., Samsudin, K., Norhisham, M. N., Ashardi, A., & Che Soh, K. (2012). The Making of IT Teachers: Lesson Learned from Animation-Enhanced Training. The GSTF International Journal on Computing, 2(1), 41-45.

[13] Craig, A. B. (2013). Understanding augmented reality: Concepts and applications. Amsterdam: Morgan Kaufmann.

[14] Rafi, A., & Samsudin, K. (2010). Impact of spatial ability training in desktop virtual environment. In Mukerji, K., & Tripathi, P (Eds.) Cases on Transnational Learning and Technologically Enabled Environments, (pp. 180-189). Pennsylvania, USA: IGI Global.

[15] Wang, X., Kim, M. J., Love, P. E. D., & Kang, S. C. (2013). Augmented Reality in Built Environment: Classification and implications for future research. Automation in Construction, 32, 1-13.

[16] Chang, G., Morreale, P., & Medicherla, P. (2010, March). Applications of augmented reality systems in education. In Society for Information Technology & Teacher Education International Conference (Vol. 2010, No. 1, pp. 1380-1385).

[17] Li, R. J. (2010). Integrating Interactive Software with Inquiry instructions to perform instructions on the concepts Phase of the moon for ninth graders (Doctoral dissertation, Master thesis, National Changhua University of Education, Taiwan, ROC).

[18] Ma, J. Z. (2008). Teaching Effects of 3D Animation Applied to Science Learning in the Fourth Graders: The Case of Moon-Phase Conception (Doctoral dissertation, Master thesis, National Taitung University, Taiwan, ROC).

[19] Radu, I. (2014). Augmented reality in education: a meta-review and cross-media analysis.
[20] Kirner, T.G., Reis, F.M.V., & Kirner, C. (2012). Development of an interactive book with Augmented Reality for teaching and learning geometric shapes. Information Systems and Technologies (CISTI), 1-6.

[21] Samsudin, K. & Rafi, A. (2010). Training in technologically enabled environments: Do training method and gender matter? Journal of Cases on Information Technology, Special Issue: Information Technology for Enhanced Learning and Understanding, 12(3), 89-98.

[22] Dalgarno, B. (2001). The Potential of 3D virtual learning environments: a constructivist analysis. Retrieved from the Charles Stuart University, Australia website: http://www.usq.edu.au/electpub/e-jist/docs/Vol5/No2/Dalgarno/Final.pdf [23] Obikwelu and Read, 2012

[23] Fischer, S., Oget, D., & Cavallucci, D. (2016). The evaluation of creativity from the perspective of subject matter and training in higher education: Issues, constraints and limitations. Thinking Skills and Creativity, 19, 123-135.

[24] Dalle Mura, M., Dini, G., & Failli, F. (2016). An Integrated Environment Based on Augmented Reality and Sensing Device for Manual Assembly Workstations. Procedia CIRP, 41, 340-345.