Impact of Puzzle-based Learning Technique for Programming Education in Nigeria Context

Solomon Sunday Oyelere[a], Friday Joseph Agbo[a], Ismaila Temitayo Sanusi[b]
{[a]School of Computing, [b]hilosophical faculty} University of Eastern Finland, Joensuu, Finland
{solomon.oyelere, fridaya, ismaila}@uef.fi

Abdullahi Abubakar Yunusa[c], Kissinger Sunday[d]
{[c]Department of Curriculum Studies & Edu Tech, [d]Department of Mathematics, Computer Science Unit} Usmanu Danfodiyo University Sokoto, Nigeria
{[c]abdullahi.yunusa@udusok.edu.ng, [d]sundaykissy@gmail.com}

***Abstract*—This paper investigates the impact of puzzle-based learning technique (PbLT) for teaching introductory programming in the context of Nigeria. The participants in the study were computer science students at Usmanu Danfodiyo University, Sokoto, Nigeria. The study adopted the quantitative research method. The study shows that PbLT has a positive impact on the students' understanding of introductory programming. In addition, the students confirmed that MobileEdu-Puzzle learning application was supportive and easy to use. Nonetheless, the result revealed that information technology infrastructure especially internet connectivity is a major challenge that may hinder the use of mobile learning technologies such as MobileEdu-puzzle. The overall outcome shows that PbLT holds a lot of promise towards enhancing students learning experiences.**

Keywords—computer science education, puzzle-based learning, MobileEdu

I. INTRODUCTION

Computer science courses are usually considered difficult for students [1]. A special case of concern for students of computer science is the programming courses. In Nigeria, the practice of teaching and learning computer science has recently witnessed a paradigm shift from conventional face-to-face teaching to a more technology-driven approach. This paradigm shift is made possible with the advancement in technology and the introduction of innovative methods such as program visualization, games and puzzle-based learning approaches [2].

According to Melero et al. [3], games are used as a potential tool for learning in the technology-enhanced learning domain, capable of fostering students' motivation, increasing the learning effects, making learning meaningful to students and creating a learning culture [4], [11]. This idea of introducing games as a tool to enhance teaching and learning has existed for decades [5] and has been applied in different fields such as mathematics and engineering [5]. However, the application of puzzle-based learning technique (PbLT) in the field of computing education is a concept that is evolving. Besides, according to Falkner [6], PbLT is a technique conceived to motivate and retain computer-engineering students and to address the challenge of shortage of skilled ICT workforce that can fit into the present-day market place that requires graduates with the capacity to solve real-life problems of innovation in a changing environment.

The evaluation of the use of MobileEdu application in the context of Nigeria is required to ascertain its impact on the students of computer science. Consequently, this study will evaluate the students' learning experience with the PbLT and determine its impact with MobileEdu-puzzle in an introductory programming class. To achieve the objective of this study, the following questions are considered. RQ1: What are the reflections of students about the features of MobileEdu-puzzle? RQ2: What impact does PbLT have on students of computer science?

II. METHODOLOGY

A. The Place of MobileEdu in this Study

The decision to adopt MobileEdu-puzzle as the learning platform in this study was a deliberate attempt based on the following reasons. The first reason is the fact that MobileEdu-puzzle was developed for computing education in the same context, Nigeria [12]. Being a contextualized solution to help in teaching and learning of computing courses including programming, it is apt to conduct the study with this platform to collect data that are relevant to the objectives of our study. Second, the use of MobileEdu-puzzle in this study provides the opportunity to collect feedback from the students on the usefulness and relevance of the intervention, intended to aid teaching and learning of computing courses in Nigeria [10].

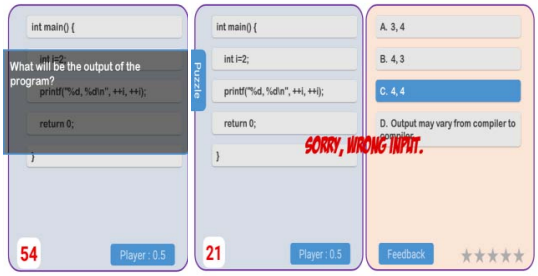

Fig. 1. *MobileEdu-Puzzle showing the programming task and feedback*

Besides, MobileEdu-puzzle is open source software where access to it is free and can be downloaded and distributed among users without any cost.

B. Research Design and Sample

This study adopted a quantitative research method. Creswell, [8] described the quantitative research approach as a technique of collecting data by using instruments that can be assigned numerical values and analyzed using simple descriptive statistical tools such as frequency counts and percentages. During the design of this study, MobileEdu-Puzzle was used as the case study to allow the teachers and students to have practical experience of PbLT. After installing the application on their phones, the students were given sufficient time to familiarize with the features and menus of the application. Next, after the practical session was to administer a 5-point Likert-scale questionnaire on undergraduate students of computer science at Usmanu Danfodiyo University, Sokoto, Nigeria. Fifty-one (51)

2161-377X/19/$31.00 ©2019 IEEE
DOI 10.1109/ICALT.2019.00072

students participated in the study**.** Consent was sought from the university authority, and the students before conducting the study.

C. Procedure for Data Collection

Due to the way the data collection and the learning sessions were organized, our data collection happened completely in-situ. This method, therefore, avoids many of the potential issues related to ex-situ data collection schemes, where the act of collecting data may influence the behavior of the participants. The teacher first, guided the students to install MobileEdu on their smartphones and created user's account. Afterward, the students engaged in learning introduction to computer programming course via the puzzle-based learning platform. The next activity was the administering of the questionnaire.

III. RESULTS

A. Students perception about MobileEdu and its features

Regarding the possession of a workable smartphone, the result shows that all the students that participated in the study had a functional smartphone because one cannot participate in the study without having a functional smartphone. Table 1 shows the descriptive statistics of the students' responses regarding the visual interface design of MobileEdu, such as user-friendliness.

TABLE 1. RESULTS OF MOBILEEDU SYSTEM AND THE DESIGN FEATURES (N=51)

Items	M	SD
MobileEdu is very easy to use	3.90	1.25
I could not use MobileEdu because I do not have access to the internet	3.61	1.54
MobileEdu enhanced my ability to browse the internet on my smartphone	3.86	1.37
I learnt better with the MobileEdu App according to my pace	3.88	1.28
The menus and icons respond swiftly to touch	3.92	1.26
Mobile learning should be encouraged	3.88	1.26
Mobile learning apps can motivate learning	4.00	1.18
Characters in the app are legible	3.82	1.21
Organization of information is consistent	3.67	1.19
I am easily distracted learning on mobile	3.49	1.10
I would recommend it to a friend	3.71	1.40
Overall, I am satisfied with the design and interface of the app	3.96	1.23

The responses regarding whether MobileEdu is easy to use shows that the students found MobileEdu easy to use (M=3.90; SD=1.25). Regarding whether the students' learning was enhanced with the use of MobileEdu, most of the students (M=3.89; SD=1.28) acknowledged that MobileEdu helped them to learn better at their pace. Similarly, the design features—menus and icons— of MobileEdu received a positive response from the students. For example, with M=3.92; SD=1.26, the students indicated that the icons respond to touch effectively. In addition, the students also responded positively concerning the legibility of characters on MobileEdu. Regarding the motivation to learn, the students after the practical experience of learning with MobileEdu responded that mobile learning apps such as MobileEdu are capable of motivating learning. The result, however, shows that about half of the students (M=3.49; SD=1.10) are easily distracted by learning on mobile devices. In general, students are satisfied with the design of MobileEdu interface (M=3.96; SD=1.23). They are also positive about their learning experiences with MobileEdu and would be willing to recommend it to friends as a learning platform.

B. Impact of puzzle-based learning on students using the MobileEdu-puzzle

This section presents the descriptive statistics regarding the impact of puzzle-based learning on the students especially in the aspect of computing education.

TABLE 2. DESCRIPTIVE STATISTICS OF STUDENTS' RESPONSES REGARDING THE IMPACT OF PBLT (N=51)

Items	M	SD
MobileEdu-Puzzle was very useful in my understanding of the concepts in computer programming	4.20	1.15
I covered more topics in IP with MobileEdu puzzle	3.61	1.17
It enabled me to have a passion for programming because of the inclusion of puzzles in the programming course.	3.82	1.09
I wished all other courses adopt the puzzle-based learning Model	3.90	1.15
I enjoy writing computer programs using smartphones	3.78	1.19
Using MobileEdu puzzles for programming will definitely improve my performance in the course	3.90	1.15
The programming questions that followed the contents were relevant and adequate	3.92	1.15
The programming questions were not easy to answer	3.59	1.17
Explanations and examples in the app make learning easier	3.98	1.23
Organization of the information in the app is consistent	3.59	1.20

The students demonstrated Puzzle-based learning by attempting some introductory programming task on MobileEdu-puzzle. The analysis of the survey after use shows that PbLT enhances their understanding of programming concepts (M=4.20; SD=1.15). The details are presented in Table 2B. Similarly, the students responded positively to the question of whether PbLT encourages and motivates them to learn computer programming. For example, M=3.82, SD=1.09 agreed that PbLT increased their passion for programming education. In the analysis, the students expressed that the programming questions were not easy to answer, (M=3.59, SD=1.17). However, the flow and sequence of puzzles questions presented to the students while learning programming concepts, according to the analysis were well structured, connected to each other and relevant (M=3.92, SD=1.15). In addition, the responses to the open-ended questions in the last section of the instrument as explained above, allowed the students to give further reflections, thoughts, and observations regarding the MobileEdu-Puzzle app and use of PbTL-based technique in introductory programming. Some themes from their textual reflection involved internet usage and subscription, users' guide, and system flexibility. On the use of the internet, one of the students wrote: "MobileEdu is a good application but I would prefer if the app can work offline so that I do not need to pay for the internet subscription."

Regarding the users' guide, few of the students commented that it will be a good option to have a user's guide provided on the app for novices to learn about the functions and menus before engaging in the learning itself. This comment is relevant to the students because they feel that the ability to navigate the app easily also help to motivate the novices to use. Similarly, some of the students, however, commented that the frequent switching between the embedded games and puzzles could cause distraction. Regarding the level motivation for programming provided by PbLT, 90.2% indicates positive, which means that this technique can make the learning experience of programming education among computer science students interesting.

IV. SUMMARY OF FINDINGS AND DISCUSSION

This study aimed to investigate the perception of students regarding the use of MobileEdu-puzzle and the impact of puzzle-based learning technique. The results presented above delineate some important perception of the students, which are discussed in this section. The study shows that the students found MobileEdu easy to use. The perceived ease of use of a system is important in facilitating the acceptance

of a system within the user's community. This theory has been discussed by researchers of the technology acceptance model, [9] to be a key variable in evaluating the viability and sustainability of technology. Similarly, the menus and icons of MobileEdu were acknowledged, function perfectly, and responded swiftly to touch. In addition, many of the students (71%) were pleased with the design interface of MobileEdu, which makes it user-friendly.

Regarding the learning experience of the students, the result shows that the majority of them (72%, M=3.88) acknowledged learning at their pace. Besides, they also responded positive to the organization of learning content on MobileEdu. According to the results, MobileEdu is considered by the students to motivate learning. This motivation to learn is possible since students can engage the system using the puzzles, socializing with friends, messaging with each other, sharing learning resources via MobileEdu app. It is also interesting to discover that students encouraged the use of mobile learning in their classes and recommends it to other students and institutions.

However, many of the students who collected the app from friends via file-sharing software could not use MobileEdu effectively. Their reason, according to the result was due to lack of access to the internet. This reason could be either that the students cannot afford to subscribe to internet on their smartphones or they experienced poor internet connectivity while using MobileEdu. In the same vein, some of the students (M=3.49) admitted being distracted while learning on the mobile phone. The reason for the distraction remains unclear but we infer that since smartphones have several features that operate independently and simultaneously, these features are capable of causing distractions to the students.

Regarding the impact of PbLT on students of computer science, the results from the evaluation of using MobileEdu-Puzzle as the case study shows that students' understanding of programming concepts are enhanced. For instance, 54.9% of the students (M=3.61) responded to cover more topics in introductory programming using the MobileEdu-Puzzle. In particular, the majority of the students acknowledged that PbLT motivates their passion for learning programming. MobileEdu-Puzzle has a feature that allows for immediate feedback to a learner on any task. This feature helps to engage the learner for an interesting and rigorous learning experience. In tandem to Thomas, et al. [7], students (M=3.59, SD=1.17) responded that the programming problems in MobileEdu-Puzzle were not easy to answer. However, the majority of them (M=3.98, SD=1.23) acknowledged that the explanation and examples that precede each task made learning programming easier. The overall perception of the students regarding the use of PbLT for introductory programming shows that the technique is appropriate for computer science students especially those who have no background of programming experience. In addition, the responses to the open-ended questions allowed the students to give further reflections, thoughts, and observations regarding the MobileEdu-Puzzle app and use of PbTL-based technique in introductory programming. Some of their responses suggest thus:

i. Provide a way one can use the application offline without having to subscribe to the internet. This suggestion is relevant considering the context where internet facilities are not provided for students free of charge. Moreover, many of the students cannot afford the cost of internet subscription since there are other educational demands.
ii. Provide a quick guide on MobileEdu-Puzzle that gives a tutorial on how to use it features, menus, and buttons.

These suggestions are relevant to guide the future improvement of MobileEdu-Puzzle that properly suite the context of the developing countries.

V. CONCLUSION

Puzzle-based learning technique is an approach of teaching that is gradually gaining research interest. Particularly in introductory programming [8], this study has shown that it enhances learners experience. The study also shows the viability of MobileEdu-Puzzle as a mobile learning tool that can be adopted for teaching of introductory programming at the higher education institution. Some of the responses from the student's experiences while using MobileEdu and their recommendations serve as part of our future work. Based on the findings of this study, the following recommendations are provided. (1) Future research should develop more PbLT as an intervention for teaching complex subjects such as computer programming in higher education institutions. (2) Educators should adopt PbLT in their classes to enhance learner's experience (3) Leadership of higher education institutions and relevant stakeholders should consider the use of mobile learning, and increase capital investment in the provision of internet infrastructure to enhance students learning. This study is not without limitations. One of the limitations is the fact that the study concentrated mainly on measuring student's perception regarding the use of MobileEdu-Puzzle, and Puzzle-based learning technique for leaning of introductory programming. Future research should consider expanding the scope of the participants such as the educators, and courses. In addition, only the quantitative method was used to collect data from the students, which is a limitation in the study. Future research should consider the mixed method approach to validate the responses from the participants.

REFERENCES

[1] S. A. Kurkovsky, "Improving Student Motivation in a Computing Course for Non-Majors," in *Proceedings of the 2006 International Conference on Frontiers in Education*, Las Vegas, Nevada, USA, 2006, pp. 1-7.

[2] C. Kazimoglu, M. Kiernan, L. Bacon, and L. Mackinnon, "A serious game for developing computational thinking and learning introductory computer programming," *Social and Behavioral Sciences, sciencedirect-Procedia*, pp. 1991 – 1999, 2012.

[3] J. Melero, H-L. Davinia, and J. Blat, "Towards the Support of Scaffolding in Customizable Puzzle-based Learning Games," in *DOI:10.1109/ICCSA*, June 2011.

[4] C. Lee and M. Chen, "A computer game as a context for non-routine mathematical problem solving: The effects of type of question prompt and level of prior knowledge," *Computers & Education*, vol. 52, no. 3, pp. 530-542, 2009.

[5] B. Parhami, "Motivating computer engineering freshmen through mathematical and logical puzzles," *IEEE Transactions on Education*, vol. 52, pp. 360-364, 2009.

[6] N. Falkner, R. Sooriamurthi, and Z. Michalewicz, "Puzzle-based learning for engineering and computer science," Computer (Long. Beach. Calif)., vol. 43, no. 4, pp. 20–28, 2010.

[7] C. Thomas, M. Badger, E. Ventura-Medina, and C. Sangwin, "Puzzle-based Learning of Mathematics in Engineering," Eng. Educ., vol. 8, no. 1, pp. 122–134, 2013.

[8] J. W. Creswell, Research Design: Qualitative and Quantitative Approaches. Thousand Oaks. CA: Sage.1994.

[9] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology", MIS Quarterly, Vol. 13, No. 3, pp. 319-340, 1989.

[10] S.S. Oyelere, J. Suhonen, T.H. Laine. Integrating Parsons programming puzzles into a game-based mobile learning application. In the Proceeding of 17th Koli Calling International Conference on Computing Education Research, ACM, pp. 158-162, 2017.

[11] S.S. Oyelere, "Design and Development of a Mobile Learning System for Computer Science Education in Nigerian Higher Education Context. Doctoral thesis at the University of Eastern Finland, 2017.

[12] S.S. Oyelere & J. Suhonen, "Design and implementation of MobileEdu m-learning application for computing education in Nigeria: A design research approach," IEEE, pp. 27-31, 2016.