University of Ibadan
Journal of Science and Logics in ICT Research

Supporting the Learning and Teaching of a Practical-Based Course using Mobile Phone Technology

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Abstract

The impact of mobile technology across various domains cannot be overemphasized. Mobile technology is revolutionizing the education sector, as students can now access the classroom and diverse learning resources from the comfort of their home using mobile phones. However, there is still a lot of gaps in the way mobile phones can be leveraged on to learn practical-based courses that require hands-on or laboratory work. This is because mobile phones are often constrained by the processor capability, small screen size and keypad. In this study, the concept of bit-sized learning was explored to support how practical-based learning can be driven on mobile phones. Consequently, an experiment/intervention was set up for 30 days. Results from the experiment show that students who used the full intervention improved in their learning with an average score of 66.67% with a standard deviation of 11.14. Those who didn't use or partially used the intervention had an average score of 51.18% with standard deviation of 15.63. Post experiment analysis was further carried out to understand users' experience with the use of mobile phone for practical-based learning. Results from this analysis show that mobile phone provides a platform for accessibility and flexibility in learning of a practical based course such as programming.

Keywords: *Mobile Learning, Mobile IDE, Programming, Usability Study, WhatsApp*

1. INTRODUCTION

Research has established that the learning of programming, which is a key and hands-on skill in computer science, requires frequent practice for a learner to become relatively skilled [1, 2]. Furthermore, these studies have established that the in-class lecture is not sufficient to help learners develop their programming skills [1, 2]. As a result, an outside-the-classroom intervention is required. [1, 2]. There are many existing technologies, both hardware and software, that can be good platforms on which this outside classroom intervention can be anchored. However, the accessibility of desktop computers outside classrooms in developing nations amongst learners is typically scarce [3]. Therefore, in this study, the mobile phone was adopted as the hardware technology to aid learning because of its ubiquity among learners [2, 4, 5].

Even though a lot of research has studied how mobile technology can support teaching and learning, there is still a gap with respect to how practical-based/hands-on learning for practical driven disciplines/courses can occur using mobile phones [2, 5]. In Computer Science discipline, a lot of programming integrated development environment used for software development are designed to run on desktop computers [2, 5]. This is because the mobile phone is limited or constrained in its screen size, computing resources, amongst others [6].

With the increase, penetration and affordability of mobile phones in Africa [7], it has therefore become necessary to study how mobile phones can be adapted to support the learning of programming, a practical-based skill that requires laboratory work. Specifically, this research explores how mobile technology can

Sakpere, A. B. (2021). Supporting the Learning and Teaching of a Practical-Based Course Using Mobile Phone Technology. *University of Ibadan Journal of Science and Logics in ICT Research (UIJSLICTR),* Vol. 6 No. 2, pp. 145-157.

support practical-based learning in the absence of desktop computers or a standard laboratory, as it is the common experience in Africa. This study was evaluated based on the learners' experience and usage of a mobile learning platform. Mobile technology shows promise in supporting learners, and can thus eliminate the constraints of limited practical knowledge faced by most learners in resource-constrained settings.

2. RELATED WORKS

Various disciplines in Science and Technology have used mobile technology to support their traditional teaching [8] [9] [10] [11] [12] [15]. Acikgul [11] investigated factors affecting the acceptance and use of mobile technology in learning mathematics. Results from their research indicates that there are direct and indirect effects of external/exogenous variables on acceptance of mobile phones to learn mathematics.

According to Lee [12], the use of Mobile Technology to support learning in nursing still seems to be in its early stage and as a result there is need for rigorous primary empirical studies to be conducted. In Engineering, mobile technology is perceived as a tool that can support education [13]. Jou et. al. [14] also noted how practical sessions in Engineering education are limited due to lack of equipment, control of toxic materials and risk of chemical reaction. To address this, Jou et. al. developed a mobile solution integrated into the cloud technology [14].

In the field of Computer Science, the study of Zaldivar et. al. [15] found out that mobile technology is the source of improvement of students' qualifications and their academic performance. However, many of the programming environments designed for practical in Computer Science are designed to run on desktop computers due to their size and consumption of power. To address this, Mbogo et. al. [2] developed a scaffold application that allows learners to be able to program/develop applications using their mobile phone. Even though these researches have shown that practical session has been supported to an extent on mobile technology, there is still the gap of adoption and usability in real-life. Many of these researches are based on empirical study that lasted for a limited period of time or a point in time.

According to Venkatesh [16], individuals' perception about adoption of a technology may change as they gain experience. Also Ackigual [11] has recommended the need for repeated studies to validate if a user's perception would change over time. To fill this gap, this research carried out an empirical study over a period of 2 years.

3. METHODOLOGY

Three major concepts used in this study to support outside classroom learning are: bite-sized learning, mobile programming environment and Social Media Platform. Participants recruited for this study were new to programming and data collected from the study was analysed.

3.1 Pedagogy mode: Bite-Sized Learning (30-30 Challenge)

According to Blue [17], we are living bite-sized lives: multitasking between work, socializing, family life etc. Therefore, learning particularly if done outside of the classroom has to be short and focused [26]. This informed the structure behind the 30-30 Challenge, an outside-classroom intervention proposed in this study, where learners of first year computer science in a university in Nigeria daily get a focused activity designed to keep them engaged on for a minimum period of 30 minutes. Most times, the participants even spend hours on the daily bite-sized activities.

Furthermore, Vizcaino et. al. [18] affirms that programming is characterised by being more practical than theoretical and so must be learnt "by doing" rather than memorising. As a result, the 30-30 challenge focuses majorly on practical learning. Figure 1 is an illustration of the concept of the bite-sized used in this study that enforces a practical-based learning through practice/doing.

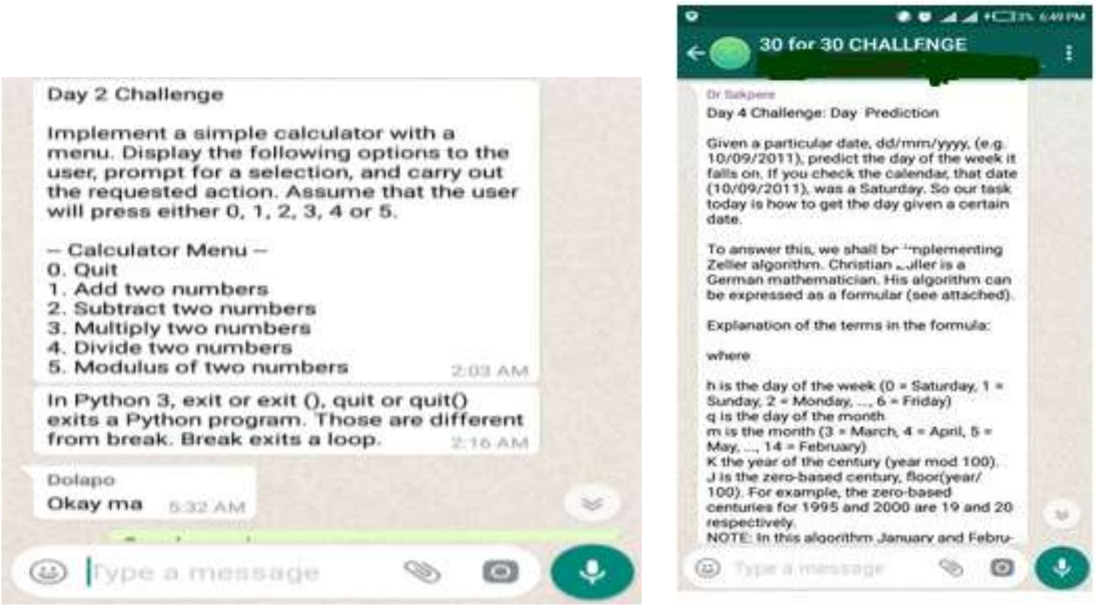

Figure 1: Example of a practical task/challenge that adopts the concept of bite-sized.

3.2 Pydroid: Mobile Programming Environment

Python is a high-level and general purpose programming language. It has been identified as best suited for teaching beginners [19], as a result, it was adopted in this study. The creation of Python application usually occur on Integrated Development Environment (IDE). Most of these IDEs such as Spyder, Phycharm, Anacoda run on desktop. Only very few run on mobile phones. Since the focus of our study is on how mobile technology can support practical-based learning, Pydroid[1], a Python IDE for Mobile Phone that runs android OS was adopted. Figure 2 depicts the sample code written in Python using Pydroid and its corresponding output.

[1] https://play.google.com/store/apps/details?id=ru.iiec.pydroid3&hl=en&gl=US

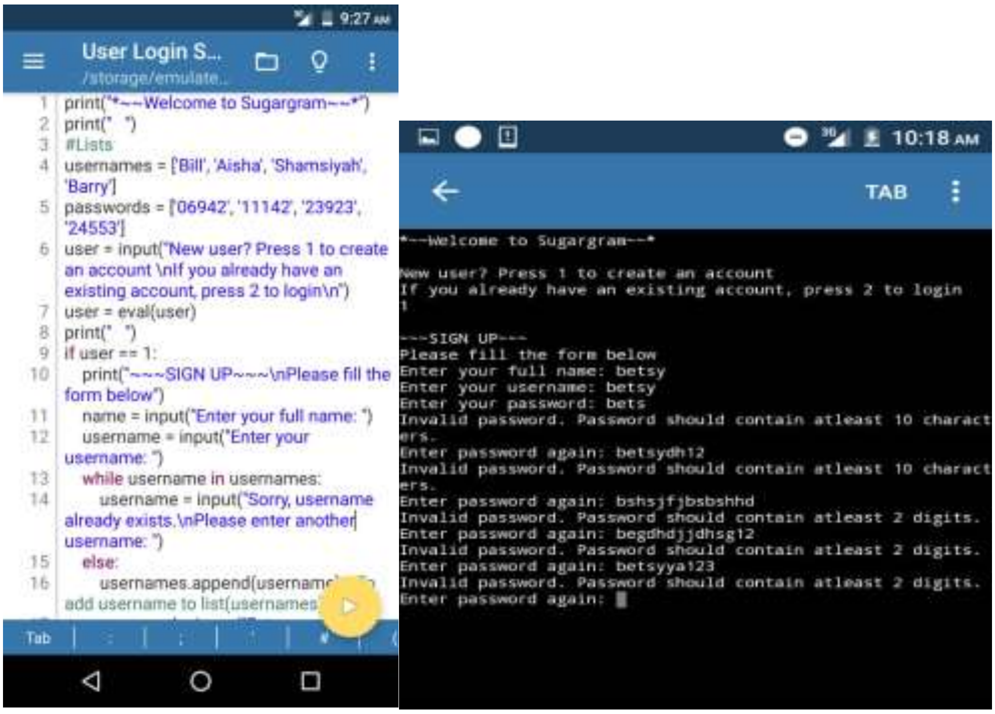

Figure 2: Sample Code and Corresponding Output using Pydroid

Figure 3: WhatsApp as a useful/substitute tool for collaborative learning

3.3 Social Media (WhatsApp): As a communication tool

WhatsApp, a social media platform was used to facilitate discussion. This was necessary because of the need to open communication channel between the lecturer and student outside of the classroom**.** In addition, the use of WhatsApp has been found to successfully support outside classroom intervention [5].

Development Environment (IDE). Figure 3 shows how WhatsApp was a useful tool for collaboration amongst students.

3.4 Participants

Since it was an outside the classroom intervention and not a substitute for the physical/face-to-face lecture, participation was made voluntary. We introduced this intervention 6 weeks into the semester, which is the middle of the semester, amongst the first year students of Computer Science in a university in Nigeria. The challenge had 2 phases. In the first phase basic programming practical tasks were tackled while the second phase tackled more advanced tasks. A total of 39 people participated in the first phase while a total of 10 people participated in the second phase. Two (2) senior students offered mentor support. After the 30 days challenge, the author still stayed in touch with the participants offering support as necessary. This article covers report that spans 2 years, experiment and post-experiment phases.

3.5 Data Collection

About 3000 chats (word count of 49,440) were generated over the period of 30 days and post-challenge period. In addition, blog posts written and ensuing comments were collected. Towards the end of the experiment, participants were asked to write reflective essays on their experience. According to Venkatesh [16], individuals' perception about adoption of a technology may change as they gain experience. In order to understand if users' experience changed over time, a post-experiment survey was conducted after about 30 months (2½ years).

4. RESULTS AND DISCUSSION

In this section, we present and discuss our findings on the appropriateness of the intervention. These were obtained from the group chats, reflective essay from participants, goodwill messages from industry experts, direct messages and one-one interaction with the participants. The post-experiment results of users' experience is provided.

4.1 Improvement in Skills

According to Vizcaino *et. al*, [19], programming must be learnt by doing and not memorizing. That informed why each day, there was a need to solve a problem/challenge. To know if their skills had improved, the researcher extracted and analyzed those chat thread (some are shown in figure 4) that show conversations amongst participants on how the intervention has improved their skills. The parameters they use to judge their improvement include fewer errors encountered, spending lesser time on tasks especially for those of similar complexity. In addition, participants' reflective essays and blog posts, were also analyzed. This further show that not only did participants skills improved but also their interest, enthusiasm and habit had been positively affected. It can be concluded that the idea of bite-sized learning which helped us to organize the challenge into a focused task to solve per day, was helpful in building enthusiasm in students without them necessarily feeling burdened or bored and ultimately cultivate a good programming / practical approach habit. Surprisingly, some of the students stretched themselves beyond the limit of 30 minutes for some of the tasks and did not feel discouraged to continue with the use of the intervention.

4.2 Engagement

The use of WhatsApp provided a platform for the students to engage with one another. Even though, WhatsApp has no IDE, it still did not limit the participants from using WhatsApp to get help with their codes or collaborate with other students. Figure 5(a) shows conversations amongst the participants on how to perform swapping in a simple manner while Figure 5(b) shows the facilitator helping a participant resolve errors in her code using WhatsApp. So it can be inferred that though WhatsApp is not primarily designed for writing programs or as a collaborative tool for program writing, it still provides a good platform that can be leveraged on for writing of programs or collaboratively used for discussion on a programming project or a practical task.

4.3 Comparison: Intervention Support Vs Non-Intervention Support & Comparative Evaluation

At the end of the experiment/challenge, a comparison was carried out between those who signed up for the intervention up to the final phase and those who didn't. The two groups were subject to the same assessment by giving them practical questions to solve within the same time frame. As shown in Figure 6, those who used the intervention till the end had an average score of 66.67% with standard deviation of 11.14 and those who didn't use till the end or signed up had an average score of 51.18% with standard deviation of 15.63.

In addition, as seen in Table 1, we compared our approach to similar studies that have used mobile phone as a platform to either learn or run practical for technical courses/discipline such as Computer Science. Our approach provides a more comprehensive study by studying mobile phone as a platform both for learning/teaching the theory and running programming codes for a practical/technical based course such as programming. In contrast, the Mobile Instant Messaging (MIM) approach [20] only studied mobile phone/Whatsapp as a platform for learning while Scafold approach [2] only provides a platform for running programming codes on mobile phone. Learners who participated in the MIM study still had to use desktop to run Structured Query Language (SQL) codes. Secondly, our study carried out a post-experiment evaluation after about 2 years to understand usability issues in an extensive manner.

These 2 key additions tend to give our approach more edge as a holistic usage of mobile phone for learning theory and running practical is key especially in developing world where functioning and standard computer laboratory is often not available. In the same vein, usability issues studied over a long period of time gives a more reflective and informative experience. We therefore conclude that the use of a holistic outside classroom intervention designed in a bite-sized manner and practical oriented has a significant improvement in the learning of a practical based course such as programming.

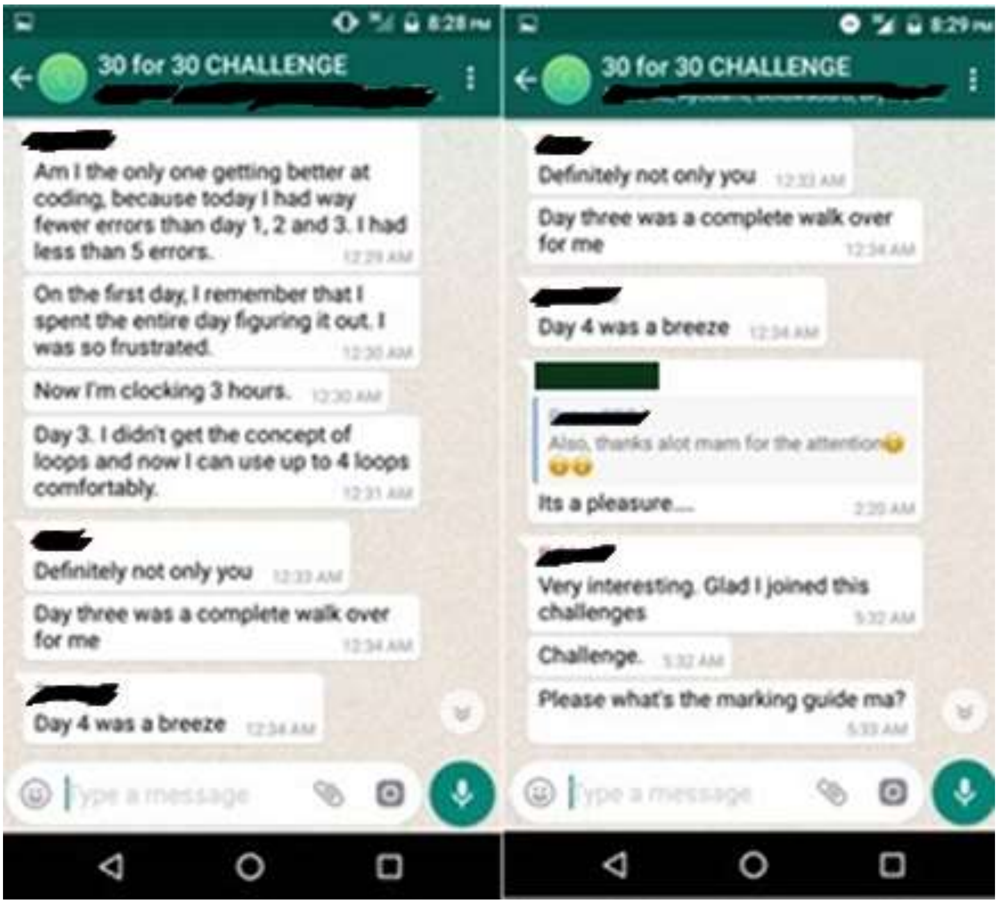

Figure 4: Group chat showing improvement

Table 1: Comparative Evaluation of our approach (3-fold) with Scaffold [2] and MIM[20]

Features	**Scaffold**	**MIM**	**Our approach (3-fold)**
Target Audience	Novice Programmer	Students who combine school with work	Beginners in Programming
Programming Language Supported	Java	Database/SQL	Python
Learning Theory	Constructivism & Scaffolding	Bite-Sized Learning	Bite-sized Learning
Lecture Type Supported	Practical Only (Basically a Tool for programming practical on mobile phone).	Theory only. WhatsApp was used for outside of classroom support. Students still had to use desktop to run their practical.	Both Theory and Practical. Social Media (WhatsApp) was used for Theory and Pydroid, a mobile IDE was used for Practical
Collaborative Learning	No	Yes through WhatsApp	Yes. WhatsApp was used as a collaborative platform.
Empirical Study Area	South Africa & Kenya	Hong Kong	Nigeria
Experiment Duration	2 Hours	A semester	30 days & Post Experiment after 2 years
Experiment Platform	Physical	Social Media	Social Media
Source of Mobile App used for Practical	In-House	None. Desktop was used for practical	On the Shelf

Figure 5: WhatsApp as a Useful/Substitute Tool for Engagement/Interaction amongst students (Participants) and the Instructor (Lecturer)

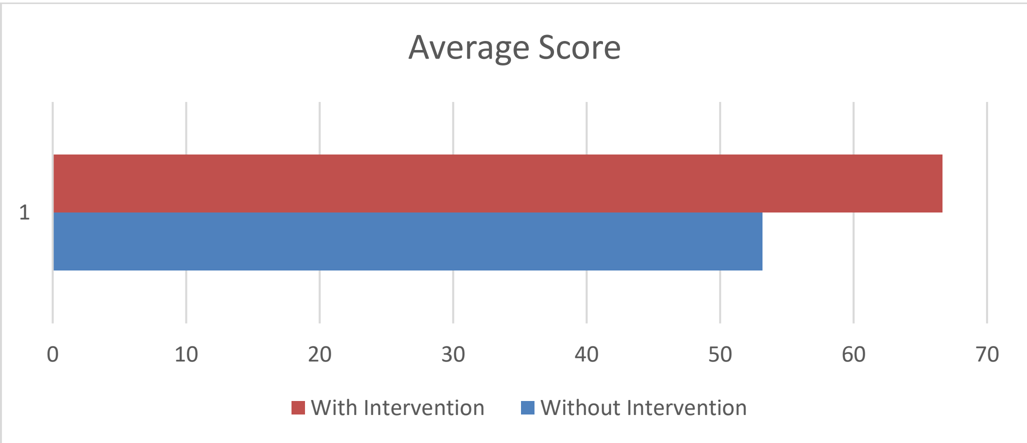

Figure 6: Comparison of those who used the intervention and didn't use it.

4.4 User Experience on Pydroid/Mobile Technology as a Programming Platform

User experience is referred to as experiences created and shared through technology (Marc). According to Venkatesh [16] individuals' perception about adoption of a technology may change as they gain experience. Also Ackigual [11] has recommended the need for repeated studies to validate if a user's perception would change over time. As a result, this research carried out an empirical study and post experiment evaluation after 2 years. A survey was used in the empirical study/post experiment survey to understand the experience of users on the use of mobile phone for programming. The survey was made voluntary and open to those who participated in the 30-30 challenge in 2018 and those who didn't participate but have used mobile phone for programming for a good period of time. A total of 16 people participated in the user experience study. From the response we gathered, the participants have been using mobile phone for programming for a period of 3 months – 48 months.

In order, to understand users' experience 5 Likert-scale questionnaire was deployed. The questionnaire was designed using Google forms and administered online. Four major usability metrics measured in the survey centres around ease of use/navigation, accessibility, flexibility and a feeling of being disadvantaged.

(a) Ease of Navigation

One of the most common rating or usability metrics is the ease of use [21]. The users were asked if they find it easy to navigate around the programming environment (IDE) on their phone. As shown in Figure 7, 43.8% agree (12.5% strong agree, 31.3% agree) that they find it easy to navigate on their phones using pydroid/mobile programming environment while 25% are neutral and 31.3% disagree (6.3% strong disagree, 25% disagree) on ease of navigating around programming environment on mobile device.

Even though the number of respondents that agreed is less than 50%, it's worth noting that the respondents in the agree cluster supersedes those in the disagree cluster. This implies that the ease of navigation on a mobile phone when used for programming/practical based course is still perceived to as being easy compared to being difficult.

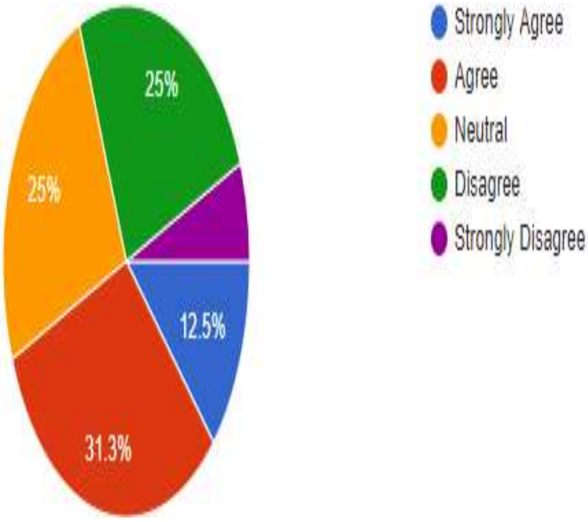

Figure 7: Users' Experience on Ease of Navigation using mobile phone for learning programming

(b) **Usability**

Usability has its root from two words "user friendliness" and "ease of use" [22]. According to Sauer [22], usability generally include objective outcome measured related to performance (e.g. learning rate) and also subjective outcome measured at the same time (e.g. satisfaction). Being able to save and retrieve codes is essential in programming and also helps for reusability.

As a result, the users were asked how easy they find saving and retrieving of codes. As shown in figure 8, 75.1% agreed (31.3% strong agree, 43.8% agree) that they find it easy to save and retrieve their codes using mobile phones while only 12.3% disagreed (including strong disagree). However it should be noted that those who disagreed only used mobile phone for programming once or few times.

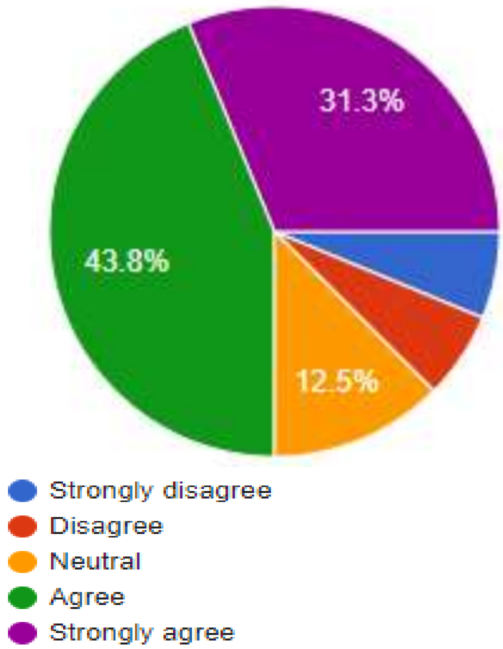

Figure 8: Users' Experience on usability provided by mobile phone for learning programming

(c) Flexibility

Mobile phone is known for its portability. So one of the study's interest was to know if the learners perceive that the portability of mobile phone gives platform for practical learning anytime without necessarily working in a physical laboratory or using a desktop computer. As shown in Figure 9, 81.3% agreed (37.5% strong agree, 43.8% agree) that the use of mobile phone gives them the flexibility to program anywhere and at any time while only 12.3% disagreed (including strong disagree). This metrics had the highest score. This implies that mobile phone is a good platform for ubiquitous learning of a practical-based subject.

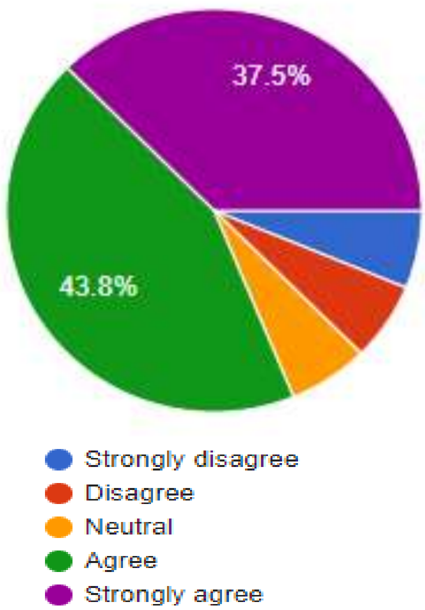

Figure 9: Users' Experience on Flexibility provided by mobile phone for learning programming

d. Disadvantaged

In order to understand if the students who learnt using mobile device felt disadvantaged compared to those who learnt using desktops, we introduced a metrics "disadvantaged" in order to understand their perception. As shown in figure 10, 50% of the respondents disagreed (including strong disagree) that they are disadvantaged when compared to those who use desktop to learn programming while 37.5% agreed (including strong agree) they feel disadvantaged and the remaining 12.5% are neutral. This implies that to a large extent, a good learning and technical experience can be derived using mobile phone in the absence of a physical laboratory or a desktop computer. Interestingly, 43.8% affirm that they would continue to use their mobile phones to program even when they get a desktop computer/laptop.

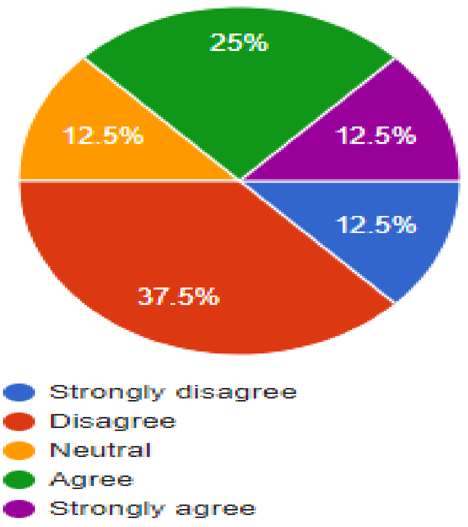

Figure 10: Users' Experience on whether learning programming using mobile phone is disadvantageous

4.5 Discussion on Technology Adoption

According to Kampunga *et. al.* [23], many newly created technological intervention are often not adopted in future or reuse. In order to understand the possibility of the adoption of this intervention in future, the Technology Acceptance Model (TAM) was considered. The theory behind TAM says that users are likely to adopt technologies based on its perceived usefulness to enhance their work/skill and ease of use, which means, it requires less physical or mental activity [24].

From the group chats and reflective essays, participants already stated that their programming skills have been enhanced as a result of the intervention and in addition the use of WhatsApp didn't requires extra mental or physical activity. Furthermore, a post-experiment survey was administered after over 2 years to understand users experience over time.

Result from the survey shows that 71.5% of them find it easy to use their mobile phone to save and retrieve their codes. 82.5% indicates that mobile phone gives them flexibility to code at any time because of the ubiquitous nature of mobile phones. Finally 43.8% affirm that they would continue to use their mobile phones to program even when they get a desktop/laptop while 31.3% indicated that they won't continue to use their mobile phone even when they get a laptop/desktop.

4.6 General Discussion

We began this study by pointing out that previous researches [1, 2] have noted that novice programmers need to be supported with an outside the classroom intervention in order to help them learn. However, in developing countries, many students do not have access to desktop or laptop. As a result, the use of mobile technology is explored since it's ubiquitous and its penetration rate amongst student in Africa is relatively high [7].

Vizcaino *et. al.* [18] affirmed that programming is best learnt by practice rather than memorizing. Also **[**25] noted that since we live in a bite-sized world, outside classroom intervention should also be bite sized, which will in turn improve productivity. That is each task should be focused and not overly too long. Based on this, a 30-30 intervention scheme was proposed, which entails that the participants get to solve a task for 30 minutes daily with much emphasis on learning by doing (practical/hands-on).

We adopted WhatsApp as a communication tool to support teaching/learning and Pydroid as mobile platform for coding. The reason for the use of WhatsApp is based on findings that WhatsApp is ubiquitous, can support learning [20] and could be cheaper (in terms of data consumption) to use than many Learning Management System (LMS) [5] or an could be an option in developing countries where LMS is often not adopted [4]. We introduced this intervention 6 weeks into the semester, which is the middle of the semester, amongst the first year students of Computer Science in a university in Nigeria.

Participation in the experiment was made optional, about 70% of these first year students participated in first phase of the study and about 20% participated in the 2nd phase. We chose Python as our programming language because Python is best suited for teaching beginners [17].

In order to measure the success of our intervention, we analyzed the chats (about 3000 with 49,440 words) that were generated and did a comparison of those who used the intervention and those who didn't. We also conducted a post-experiment survey after 2 years. Our analysis shows that learning by doing as noted by [1] enhances their programming skills. Even though the participants have been exposed to theoretical and practical aspects of programming language about 6 weeks before the intervention, they could only point to the intervention as what groomed and aided their understanding and skills. We also observed that even though WhatsApp was not primarily developed for teaching and learning especially for a technical and practical course like programming, the students were able to use it for collaboration on writing programs, seeking for help when they have errors and seeking for insights on how to write their programs.

Finally, we conducted a post-survey user experience after 2 years. Result of the post-experiment survey indicate that 82.5% of the respondents agree that mobile phone gives them flexibility to code at any time because of the ubiquitous nature of mobile phones.

5. CONCLUSION

This study examined the use of bite-sized learning, mobile programming environment and Social Media Platform to support outside of class learning for a practical based course such as programming. The study was carried out for a total duration of about 2 years. In summary, results from the empirical study show that the use of mobile technology can support the teaching and learning of a practical base course or skill such as programming. In addition, structuring contents in bite-sized chunks and learning programming by doing enhances concentration and hone ones technical skills.

For future work, we would like to do more evaluation. For instance, it would be interesting to compare the performance of the participants before the use of the intervention and after the use of the intervention. In addition, we would like to compare performances of those who used desktop and mobile phone as a platform for learning and running codes for a practical-based skill like programming.

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