Exploring the Use of an Android based C/C++ Compiler in the Learning of a Programming Course by University Students

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ABSTRACT
The ever increasing demand for higher education has brought with it a number of challenges, key among them being insufficient equipment and instructional materials. Mobile learning offers an opportunity to mitigate some of the challenges faced by Institutions of higher learning through the principle of BYOD (Bring Your Own Device) which increases access to technology without incurring the cost of purchasing a device for each learner. This study sought to investigate the attitudes and opinions of learners towards the use on Mobile Devices in the learning of an undergraduate programming course offered in the second year of study. A blended learning approach was adopted in the teaching and learning programming which incorporated the use of a C/C++ IDE (Integrated Development Environment) and compiler for Android platform to solve programming exercises provided to the learners during the weekly lectures. A questionnaire was designed and used to collect data regarding the learners' attitudes and opinions towards the use of the Mobile Devices in the Programming class. The study showed that Mobile learning in a programming context is a preferred mode of study and brought about many benefits. Despite the benefits there is need to address challenges attributed to the devices and app usage so as to enhance the learning experience. The potential of Mobile learning is evidently immense given the willingness of respondents to use the devices and the apps more in the future. Results suggest that need for institutions of higher learning to explore available Mobile apps and see how best they can be used to facilitate teaching and learning.

General Terms
Mobile Learning

Keywords
Programming, Android, Mobile Compilers

1. INTRODUCTION
There has been an increase in demand for access and equity to Higher Education in Kenya and Africa at large which has been brought about by the increasing number of students graduating from secondary schools [25]. Increased enrolment numbers have directly impacted on the quality of education being offered by the institutions of higher learning. Mobile Technology provides a great potential that can be used to mitigate challenges currently faced by universities [24]. Mobile Learning has been viewed as a branch of ICT in education that involves use of Mobile Technology alone or in combination with other Information and Communication Technology to enable learning anytime and anywhere [22]. The definition fits very well with views of Keegan [27] who pointed out the importance of confronting two issues functionality and mobility when explaining Mobile Learning. El-Hussein & Cronje [5] sought to clarify the meaning by disassembling its components and rearranging them under three key concepts which include mobility of the technology, increased learner mobility and dynamism of the learning processes in the context of experiences in post-school education.

2. MOBILE LEARNING
Kraut [14] identified expanding the reach and equity of education, facilitating personalized learning, providing immediate feedback and assessment, enable anytime & anywhere learning as some of the key benefits associated with Mobile learning. Elias [6] pointed out this form of learning can also ensure the productive use of time spent in classrooms, build new communities of learners, supporting situated learning, enhancing seamless learning and assisting learners with disabilities. M-learning has also been viewed to carry the idea of e-learning a step further by adapting its content to handheld devices such as iPods, personal digital assistants, and smartphones [26]. Mobile Learning has also been found to provide relatively inexpensive m-learning opportunities, Multimedia content delivery and creation options by allowing allow sound, text, pictures, and video files to be downloaded to and uploaded from the device. In addition, they feature built-in speakers and, almost always, cameras [6].

In comparison with other forms of learning, Mobile learning provides a potentially more rewarding learning experience also improves levels of literacy, numeracy and participation in education amongst young adults [16]. It is evident from studies conducted that Mobile learning can be an efficient tool to complement traditional learning by providing many benefits. Kraut [14] recommended that policy makers need to take some actions in order to realize the benefits of Mobile learning key among them being formulation of policies, proving support and training to teachers, optimizing educational content for use on mobile devices among many other. It should not be lost to us that the key function of mobile devices is communication which according to Mehdipour & Zerehkafi [16] is a critical feature in a larger learning activity.

Despite the many benefits associated with Mobile Learning it is important to point out some limitation associated with this technology. Shudong & Higgins [19] classified the limitations into three main categories psychological - people have not become used to mobile phone learning , pedagogical - results are not easy to evaluate or follow-up [16] and technical - , small screen size, inconvenient input, small memory, and the lack of common standards. Technical

challenges have also been pointed out by Elias [6] who identified Device variability, slow download speed and limited Internet access while Lakshminarayanan, Ramalingam & Shaik [15] pointed out small screen sizes, inputting text data into the devices and limited memory as some of the challenges.

Other challenges associated with mobile learning include connectivity and battery life, meeting required bandwidth for nonstop/fast streaming, number of file/asset formats supported by a specific device, content security or copyright issue from authoring group, reworking existing E-Learning materials for mobile platforms [16]. Shuler [19] affirmed that mobile learning has a potential for distraction and may also contribute to unethical behavior. In their study Mehdipour & Zerehkafi [16] identified social and educational challenges that come with Mobile Learning which included accessibility & cost barriers for end users, learning outside the classroom, provision of support learning across many contexts, content's security or pirating issues, frequent changes in device models/ technologies/ functionality, development of a theory of learning for the mobile age among others. Lakshminarayanan et al. [15] reiterated that implementers of Mobile learning are likely to face number of challenges key among them educator involvement, learner interest, training, safety, security, maintenance and implementation cost.

3. MOBILE BASED COMPILERS

Attempts have been made to develop programming development environments for use on Mobile Platforms. Many of these mobile applications/compilers have developed to facilitate coding on mobile devices but also provide basic tutorials for the users. Access to these apps is through application stores available to specific mobile platforms. Presently the main stores include App Store for IOS, the Play Store for Android and the Windows Store for Windows [11] together with Amazon App Store and Blackberry world. The growth in use on Mobile apps is increasing and according to Khalaf & Kesiraju [28] only 10% of the time spent on mobile was spent in the browser, down from 14% in 2014 while the rest of the time, 90%, as spent in apps. It is imperative on educators to shift their focus on how best this apps can be used to enhance the teaching and learning processes.

Google search for Programming Compilers on Google play store Mobile apps for programming listed CppDroid - C/C++ IDE, C4droid – C/C++ compiler & IDE, AIDE- IDE for Android Java C++, Cxxdroid - C++ compiler IDE for mobile development, PascalGUI –Pascal compiler), Dcoder - Compiler IDE, Mobile C - C/C++ Compiler, Pydroid - Programming app to learn Python 2 among many others. On the other hand a Google search for Mobile Programming compilers available on app store listed Mobile C – a C/C++ Compiler, Python2IDE, C/C++ Program Compiler, C Compiler, Pico Compiler – Java 9 IDE, Jedona – Compiler for Java, Online Console Compiler that supports fifteen (15) programming languages etc.

4. PREVIOUS STUDIES

A number of studies have been carried out to investigate the use of Mobile Learning. Chen and deNoyelles [3] explored students' mobile learning practices in Higher Education with finding indicating that ownership of mobile devices is high and this supported learning that occurred outside the classroom with limited guidance from instructors. Mobile Learning in the teaching of Computer Courses has also been studied. Shen, Wang, Gao, Novak & Tang [17] investigated the use of Mobile Learning in a large Blended Computer Science Classroom and established that students felt comfortable and happy with the use of interactive mLearning in their computer science class. In both the studies learners have expressed the need for more access to academic resources on mobile devices to together with the support of integrating the technologies for learning purposes [3] [17].

Guo et al. [9] designed a learning system under mobile environment for an operating system course where Students were able to learn anytime and anywhere while on the other hand teachers able to make some necessary supplement to the contents of the courses. The findings from the study provided better understanding technologies for mobile learning with a view of introducing the pervasive computing and mobile advantages into the education [9]. A similar study was conducted with a view of creating a computer science or engineering course for M-Learning by developing seven strategies guided by theoretical bases for Mobile Learning which include Behaviorism, Cognitivism, Constructivism, Humanism & Cooperative learning with an emphasis on content preparation [1]. The seven strategies developed by Alshalabi & Elleithy [1] included incorporation of both synchronous and asynchronous learning mode, design of content according to learners' cognitive skills, incorporation of communication in the M-Learning system, considering the degree to which the groups worked together in the past so as to improve performance of tasks, incorporation of class lectures, homework assignments, Laboratory exercises and lastly Midterm or final exams.

Tillmann et al. [21] proposed the teaching of Computer Programming through the Mobile Devices with the belief students get instant gratification by sharing with friends what they are able to do and also handle their homework or additional practicing at all times. The aspect of sharing is supported by Khaddage & Lattenman [13] who investigated the attitudes of students and their perception of the effectiveness of Mobile apps for teaching and learning. The study established that accessing content, communication, and sharing information were the main uses of apps among learners [13]. The learning of Programming using Mobile devices containing multimedia content was found to create unique engaging and fun learning experience for students [21]. The support of active learning in computer science teaching for an engineering group of students was investigated by Valdivia and Nussbaum [23] who exploited the full potential of Computer Supported Collaborative Learning (CSCL) through the use of wirelessly interconnected mobile devices. Finding from the study indicated that the approach improved the performance and interest of students in the course and while on the other enhanced their greater ability to communicate. The purpose of this study was established the students' Attitudes and perceptions towards the Learning of C Programming using Mobile Devices.

5. METHODOLOGY

The study involved an undergraduate class in their second year taking a Computer Programming course in which a blended learning approach was adopted for two lectures that were offered.

Convenience sampling technique was used to select the respondents for the study which consisted of learners enrolled for the second year programming course. The choice of the sampling technique is on the basis that the respondents were recruited easily [11] and were made up of members of group that is intact [4]. Despite its limitation as pointed out by Etikan, Musa & Alkassim [7] and Farrokhi & Mahmoudi-

Hamidabad [8] convenience sampling was viewed as ideal given the situation involving a group of learners in a lecture room. The choice of the mobile compilers to be used was based on the preference of the learners since they were to be installed in their personal devices. Learners were also taken through basic functionalities of the android based C/C++ mobile compiler that was to be used to solve exercises provided.

The survey questions were developed, pre-tested and piloted based on guidelines suggested by Bowden, Fox-Rushby, Nyandieka & Wanjau [2] which provide the basis for establishing their meaning, using a criteria to gauge their appropriateness, selecting methods for undertaking study and lastly determination on their inclusion or not. The survey questionnaire included both closed and open-ended questions. Questionnaire items covered aspects frequency of app usage, level of comfort using the app, challenges associated with devices and the app. Other aspects examined included benefits of programming using mobile devices and opinions of future usage of app. Some questionnaires items were based on the likert scale which according to Joshi, Kale, Chandel & Pal [12] "is applied as one of the most fundamental and frequently used psychometric tools in educational and social sciences research". The analysis of the items using the likert scales were determined during their formulation and based on recommendations by Boone & Boone [29].

6. RESULTS

6.1 Demography

The study was conducted in a Bachelor Degree Second Year First Semester group whose demographic data is illustrated in the Table 1.

Table 1. Population by Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18 - 20	9	24.3	24.3	24.3
	21 - 23	28	75.7	75.7	100.0
	Total	37	100.0	100.0	

Table 2. Population by Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	22	59.5	59.5	59.5
	Female	15	40.5	40.5	100.0
	Total	37	100.0	100.0	

The population was made of 40.5% Female while 59.5% were male as shown in Table 2.

6.2 Use of Mobile Device

The study established that University students put their mobile devices to different uses which included Social media, photography, Gaming, Education, News, Entertainment, Communication and Management of finances. Use of Mobile Devices for educational purposes registered the highest percentage at 83.3%.

Table 3 illustrates the frequency of using the Mobile App for in the learning of Programming.

Table 3. Frequency of using of the Mobile App

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Always	11	29.7	30.6	30.6
	Very often	12	32.4	33.3	63.9
	Sometimes	12	32.4	33.3	97.2
	Rarely	1	2.7	2.8	100.0
	Total	36	97.3	100.0	
Missing	System	1	2.7		
Total		37	100.0		

Table 4. Level of Comfort using the Mobile app

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not Very comfortable	2	5.4	5.6	5.6
	Fairly comfortable	22	59.5	61.1	66.7
	Very comfortable	12	32.4	33.3	100.0
	Total	36	97.3	100.0	
Missing	System	1	2.7		
Total		37	100.0		

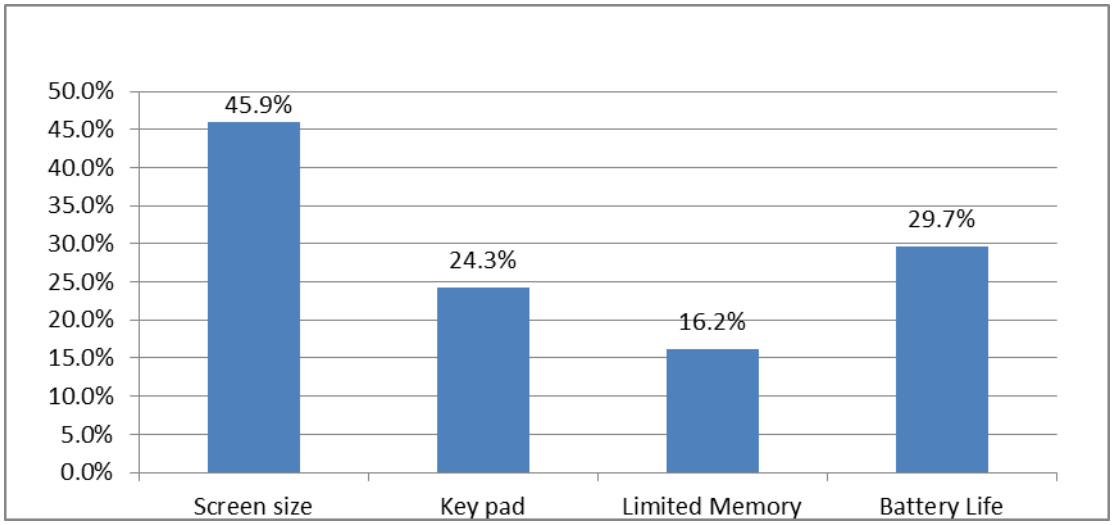

Figure 1: Technical Challenges associated with Mobile Devices

The study also investigated the level of comfort among learners while using the mobile Application and shown in Table 4.

Figure 1 illustrated analysis of responses regarding the technical challenges faced by the learners while using the Mobile devices in the learning of programming. In regard to the use of the Mobile App in the learning of programming a number of challenges were encountered and this ranged from Errors/Bugs, Installation, Incompatibility with other apps, difficulty accessing some functionalities and user distractions from other applications already available in the devices as illustrated by Figure 2**.** The respondents also gave their views on how beneficial the Mobile app was when used in the learning of programming and Table 5 gives a summary of the findings.

Views of respondents in regard to future use of Mobile app were also examined and Table 6 presents the findings.

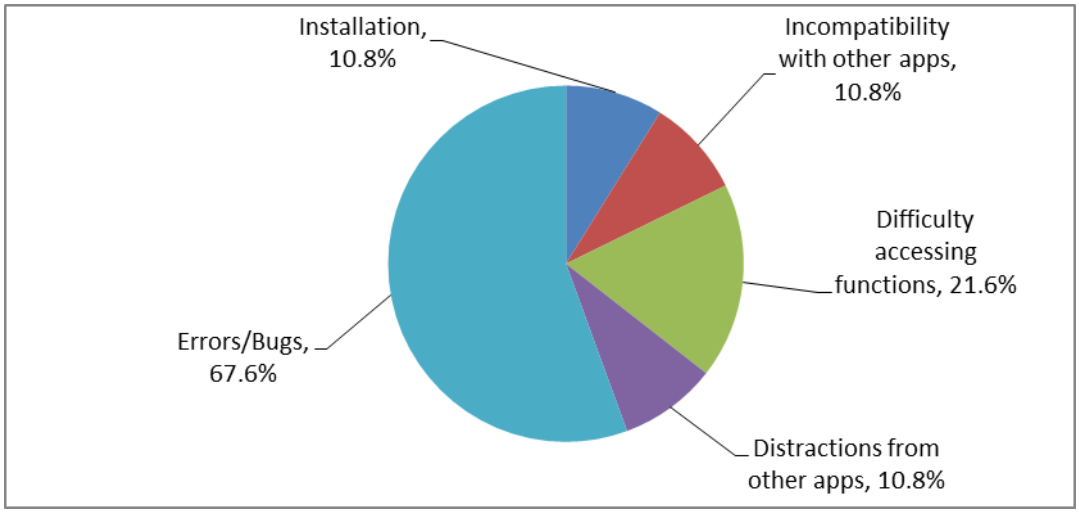

Figure 2: Mobile app Challenges

Table 5. Benefits of using the Mobile App

Benefit	**Strongly Agree**	**Agree**	**Undecided**	**Disagree**
Provides an inexpensive learning opportunity	37.84%	62.16%	0%	0%
Enables continuous and situated Learning	43.24%	43.24%	10.81%	2.70%
Improves level of participation in programming classes	48.65%	43.24%	5.41%	2.70%
Enables new learning opportunities	40.54%	45.95%	13.51%	0%
Improved overall success in programming	72.97%	18.92%	5.41%	2.70%

Table 6. Future plans in regard to Mobile Learning of Programming

Plan	Yes	Probably	Not sure	No
Willing to spend more time using the Mobile App	59.46%	32.43%	5.41%	2.70%
Willing to purchase a new mobile device to enhance learning of programming using apps	75.68%	10.81%	5.41%	8.10%
Believe Mobile Learning is the future	62.16%	27.03%	5.41%	5.40%

7. DISCUSSIONS

It is evident that high percent of learners at 86.3% use their devices for Education purpose as compared to other uses which included social media, photography, news, entertainment, communication and management of finances. The findings point out to the huge potential that Mobile devices possess when it comes to Learning opportunities. Table 3 presents results on the question on frequency of using the Mobile app with 29.7% of respondents indicating always while 32.4 % very often. Generally a high percentage of 97.2 % reported having used the app.

Level of comfort among respondents while using the app was positive with 32.4% being very comfortable while 59.5% were fairly comfortable. The high percentage could be attributed to the design of app. Only a paltry 5.4% were not very comfortable as shown in Table 4. Technical challenges associated with the Mobile Devices were also looked at with the results showing Screen size (45.9%), Battery Life (29.7%), Keypad (24.3%) and Limited Memory (16.2%) being viewed as key ones in that order as illustrated in Figure 1. Challenges associated with Mobile app ranged from Errors/Bugs, Difficulty accessing some functionality, Incompatibility with other apps to, Distractions from other apps and installation as illustrated by Figure 2. Errors/Bugs scored 67.6% which was attributed to programming errors (Syntax, Semantic and Run time) encountered while programming in C. There is need to address challenges associated with specific Mobile applications with a view of providing better learning opportunities.

Benefits brought about by Programming using the Mobile app included provision of an inexpensive learning opportunity, enabling continuous and situated learning, improving level of participation, enabling new learning opportunities and improving overall success in programming. Table 5 presents the data analysis and its evident each of the benefits received scores of greater than 85% cumulatively between Strongly Agree and Agree responses. The finding supports other studies conducted on the benefits of Mobile Learning [23, 6, 14].

Majority of the respondents were willing to spend more time the app, purchase a better device to enhance their programming learning experiences and believed that Mobile Learning is the future at Institutions of Higher learning. However it is important to relate this with the finding by Khaddage & Lattenman [13] who pointed that only 20% of respondents in their study were willing to pay for Mobile apps available for their devices.

8. CONCLUSION

The emergence of Mobile technology and its adoption by learners of institution of higher learning is evident from the finding of the study. The use of mobile devices for educational purposes is evident among learners and this affords immense learning opportunities that can be harnessed by the institutions. The shallow learning curve associated with the mobile application together with the willingness of learners to spend more time using it provides a ground for easier adoption of the technology thus enriching the learning experiences. The integration mobile technology in teaching will most definitely mitigate challenges faced by institutions of higher learning more so relating to provision of devices. Such initiatives will only be successful if well conceptualized and guided by existing learning theories. The study thus informs on the availability of many mobile applications both free and commercials for educational purposes, programming being one of them which educators can utilize to improve on their delivery of content. However there is need for more research that will focus on impacts of integrating the mobile applications in teaching and learning processes, formulation of frameworks among others as recommended by other studies [17, 3, 9].

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