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****Original Research****

THE USEFULNESS OF MOBILE COMPILERS FOR LEARNING COMPUTER PROGRAMMING

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Abstract
This study examines the usefulness of mobile compilers for learning computer programming in higher learning institutions in Tanzania. The study was conducted at the Institute of Accountancy Arusha (IAA) and Arusha Technical College (ATC). The study used a case study research design and adopted a quantitative approach. The study included 170 computing undergraduate students who were conveniently selected from the target population. A questionnaire was used as a method of data collection. The data collected were analysed and results were presented using descriptive statistics. The results of the study show that computing undergraduate students use mobile compilers for learning computer programming. In addition, the study indicates that mobile compilers offer significant benefits that allow students to learn computer programming using mobile technology. However, the results suggest that facilitators of the computer programming courses do not emphasize the use of mobile compilers for learning and self-practice.

Keywords: Computer programming, mobile apps, mobile compilers, mobile learning, mobile technology

1.0 INTRODUCTION

The world is moving from traditional computing technology to mobile computing (Iversen & Eierman, 2014). Furthermore, the invention of mobile devices, such as smartphones, tablets, and e-readers, has created new opportunities for the devices and mobile apps (Salmre, 2005). This means that most activities performed on computers are now definitely performed on mobile devices. As a result, software developers are also engaging themselves in the development of mobile apps.

The availability of mobile apps gives users flexibility in performing different activities on mobile devices in everyday life. There are personal and professional mobile apps that can be used for leisure and for promoting business. These apps are categorised as business, communication, education, entertainment, games, finance, maps and navigation, music, photography, shopping, sports, video players, and weather apps (Chawla, 2018).

The use of mobile apps in education provides an opportunity for instructors and students to improve teaching and learning inside and outside of the classroom (Luna-Nevarez & McGovern, 2018). Mobile apps provide room for increasing students' motivation, improving communication between instructors and students, individualising the teaching process, and working outside the classroom (Pribeanu, Gorghiu, Lamanauskas, & Slekiene, 2020). This means that mobile apps can make it easier for instructors to change the traditional teaching methodologies to digital learning. As a result, students will be more engaged in mobile learning that improves participation and learning experience (El-Hussein & Cronje, 2010).

Several studies have been conducted on mobile technology. For example, the study by Pribeanu, Gorghiu, Lamanauskas, and Slekiene (2020) concentrated on the opportunities and barriers of the use of mobile technology in the teaching and learning process. Another study by Luna-Nevarez and McGovern (2018) focused on the impact of digital magazines on student learning using a mobile app, Flipboard. Additionally, a research study by Mbise (2021) based on optimisation of information systems for mobile devices. Together with these studies, there are limited studies concerning the usefulness of mobile compilers for learning computer programming in higher learning institutions in Tanzania. This study fills this gap and contributes to the existing literature about the usefulness of mobile compilers for learning computer programming. In addition, the study examines the extent to which computing undergraduate students are familiar with the use of mobile compilers in computer programming. The study also investigates the usage of mobile compilers for learning computer programming and the benefits of the mobile compilers as a learning tool.

2.0 LITERATURE REVIEW

Mobile devices and mobile apps in education have increasingly gained popularity over recent years (Dias & Victor, 2017). The impact of these smart gadgets and apps cannot go unnoticed in the modern world by both instructors and students. Luna-Nevarez and McGovern (2018) argued that educators from all disciplines have to adopt mobile devices and mobile apps as instructional resources. Additionally, the devices and apps are the centre of mobile learning, allowing students to learn anywhere, anytime (Jumaat, Tasir, Lah, & Ashari, 2018).

2.1 Mobile Apps in Education

According to Luna-Nevarez and McGovern (2018), mobile apps have penetrated and become available to academics. The use of mobile apps in education has been accepted by students and paved a new way for instructors to engage them with more learning activities. Mobile apps have improved teaching and learning, communication, assessment, and participation in learning activities. Fully engaged students are likely to complete their undergraduate studies and even continue with postgraduate studies (Russell-Bennett, Rundle-Thiele, & Kuhn, 2010).

Mobile apps in higher learning institutions have created a new platform for learning known as mobile learning (Hlagala, 2015; Pribeanu, Gorghiu, Lamanauskas, & Slekiene, 2020). A study on mobile learning practices in higher education demonstrated that mobile learning improves learning by facilitating communication that extends outside the classroom between instructors and students (60%), students with other students (65%) (Chen, Seilhamer, Bennett, & Bauer, 2015). Moreover, the study observed that mobile apps make it easier to access coursework (72%) and increase the motivation to complete coursework (42%). However, despite the benefits that mobile apps offer, the study proposed that students and instructors require technical, logistical, and pedagogical support for integrating mobile apps in education (Pribeanu, Gorghiu, Lamanauskas, & Slekiene, 2020).

A research study on emotions and continued usage of mobile apps found that students are motivated to use mobile apps in their studies because of positive emotions and enjoyment (Ding & Chai, 2015). This research concluded that positive emotion is influenced by the perception of benefits offered by mobile apps. Also, the enjoyment of using mobile apps improves the participation and engagement of students in the learning process (Dias & Victor, 2017). The study also iterated that mobile apps are essential in the education sector, as mobile technology draws attention from every field.

The use of social media apps has positively affected the education sector (Raut & Patil, 2016). Social media apps provide instructors and students with the ability for sharing, exchanging, commenting, discussing and creating information and knowledge in a collaborative environment (Devi, Gouthami, & Lakshmi, 2019). The freedom of expression provided by the social media in learning groups can significantly improve the learning process. It was observed that most of the instructors had used social media in a class session (Moron, Seaman, & Tinti-Kane, 2011). This study also suggested that social media apps can be used as a teaching tool in higher learning institutions.

2.2 Mobile Compilers

The compiler is a software program that converts high-level language programmes into machine language (Deitel & Deitel, 2014). Therefore, a mobile compiler can be defined as a compiler installed on a mobile device that converts high-level language source codes into machine codes. It provides a source code editor, compiler, debugger and other programming utilities that can compile, run and debug programmes on mobile devices. With mobile compilers, students can write, compile and run programmes without a computer anytime, anywhere and on the movement (Apple Store, 2020).

Like other mobile apps, mobile compilers are available in app stores (Akinkuolie, Chia-Feng, & Shyan-Ming, 2011). These compilers are available as open-source, while others are commercially offered. Mobile users using different platforms, such as Android, iOS, and Windows Phone, can download mobile compilers from the dedicated app stores and install them on their devices (CRC Press, 2019).

Mobile compilers can be categorised as either offline mobile compilers or online mobile compilers (Pugoy, Habito, & Figueroa, 2016). The offline mobile compilers allow coding in the source code editor without connection to the Internet. An example of an offline mobile compiler is CppDroid. One of the main advantages of offline mobile compilers over online mobile compilers is that mobile users can code all the day as long as the device's battery is not down (CRC Press, 2019). Figure 1 and Figure 2 show the C++ program and its output in the CppDroid offline mobile compiler for Android.

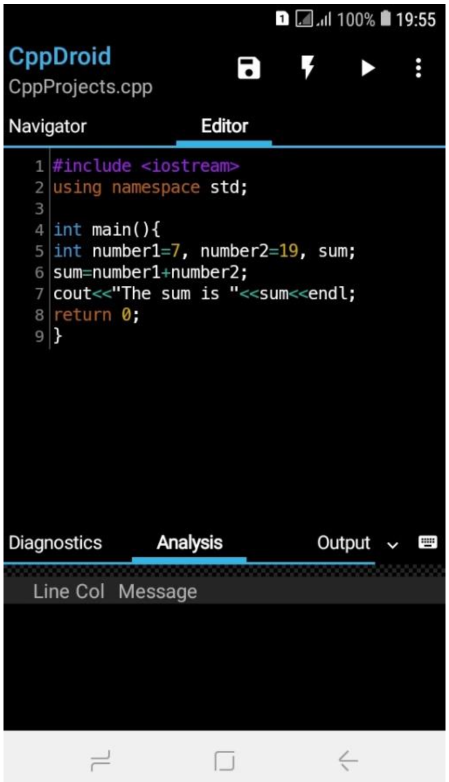

Figure 1: C++ program written in CppDroid for Android
Source: Author's Samsung Galaxy J2 Core Smartphone (2021)

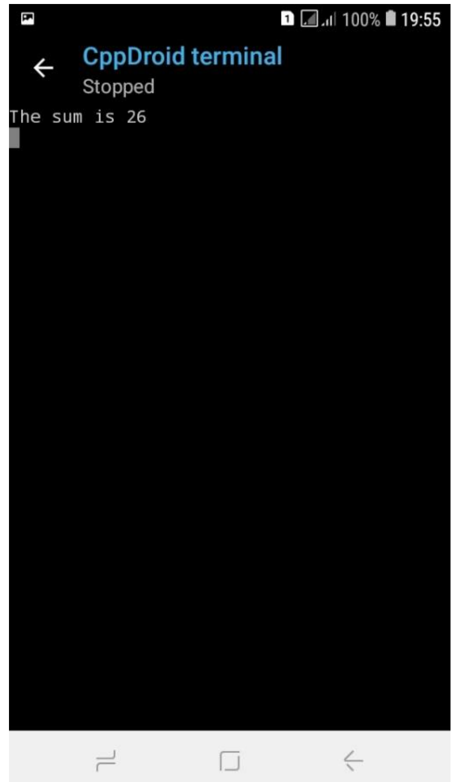

Figure 2: Output of C++ program written in CppDroid for Android
Source: Author's Samsung Galaxy J2 Core Smartphone (2021)

Contrarily, online mobile compilers require an Internet connection to write, compile, run, and debug programmes. When a mobile device is not connected to the Wi-Fi or the data mode is switched off, the mobile compiler is not available. Online mobile compilers use cloud computing by providing convenient tools that allow programmers to compile source code and execute it in online storage (Sharmila, 2017; Abdulla, Iyer, & Kutty, 2013). DCoder is a good example of an online mobile compiler. One of the primary advantages of the online mobile compilers is that no environment configuration is required to set it up. Figure 3 shows the Java application and its output on the same screen in the DCoder online mobile compiler for Android.

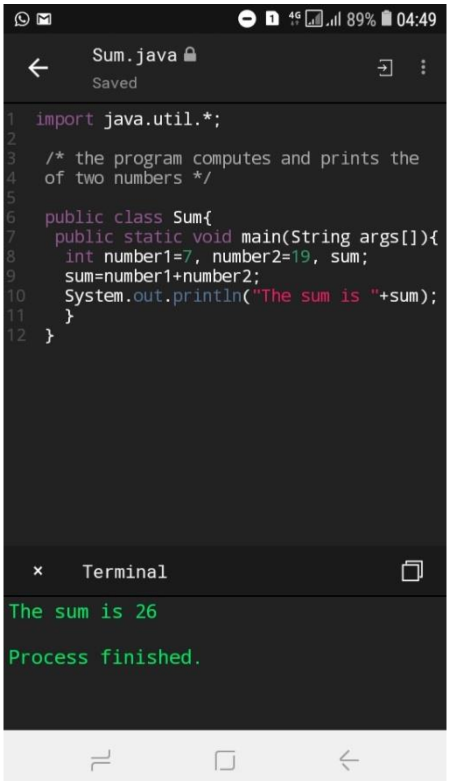

Figure 3: Java application written in DCoder for Android
Source: Author’s Samsung Galaxy J2 Core Smartphone (2021)

3.0 METHODOLOGY

A methodology is a set of principles, procedures and practices that controls the complete process of conducting the research (Marczyk, DeMatteo, & Festinger, 2005). This research study used the quantitative approach. The quantitative research approach allowed the researcher to follow scientific procedures of sampling techniques, data collection and analysis to ensure the validity and reliability of the study (Saunders, Lewis, & Thornhill, 2019).

3.1 The Study Area, Target Population and Sample Size

A case study research design was used in this study because it provided an opportunity for a thorough and in-depth examination of the usefulness of mobile compilers for learning computer programming (Creswell & Clark, 2018). The two colleges, IAA and ATC, were selected to represent higher learning institutions. The reason for choosing these colleges was that they offer similar computing undergraduate programmes and are located in Arusha, Tanzania. Additionally, the researcher lives in Arusha and as a result, the research costs and location were at the researcher's convenience.

The target population (N) of the study included 696 computing undergraduate students with at least one programming language skills enrolled in computer science and information technology programmes. Therefore, the researcher decided to set the margin of error (e) as 6%, confidence interval (p) as 95%, and z-score (z) as 1.96 to determine the sample size (n). Therefore, using the formula by Kothari (2004) as seen in Equation (1), 194 participants from the target population were involved in the study using the convenience sampling technique.

$$n = \frac{\frac{z^2 p(1-p)}{e^2}}{1+(\frac{z^2 p(1-p)}{e^2 N})} \qquad (1)$$

3.2 Data Collection

This study used an online questionnaire as a method of data collection. The questionnaire was designed using Google Forms and mailed to a sample of 194 respondents. In addition, the questionnaire's link was shared in students' WhatsApp groups to ensure that the respondents were conveniently reached. As a result, 170 respondents carefully filled in the questionnaire and became suitable for the study. Therefore, the response rate was 87.6%. This response rate was adequate for representing the target population (Taber, 2018; Lubua & Kyobe, 2019). The researcher chose the questionnaire because it allowed quick and easy collection and analysis of data. Furthermore, the researcher opted for an online questionnaire as a precaution to protect the researcher and respondents from the spread of COVID-19 (WHO, 2020).

3.3 Data Analysis

The data obtained from the questionnaire were analysed using descriptive statistics. Descriptive statistics "are used to describe the data collected in research studies and to accurately characterise the variables under observation within a specific sample" (Marczyk, DeMatteo, & Festinger, 2005). The researcher opted for descriptive statistics because they present quantitative descriptions in a manageable format. In addition, a frequency distribution was used to organise and summarise the research data to be analysed and interpreted easily (Marczyk, DeMatteo, & Festinger, 2005; Lubua & Pretorius, 2018).

4.0 FINDINGS

This section presents the research study's findings based on the main objective, which was to examine the usefulness of mobile compilers for learning computer programming. The first part of the section describes the demographic information of respondents. The second and third parts of this section present the findings of mobile compilers usage and the benefits of mobile compilers correspondingly.

4.1 Demographic Characteristics of Respondents

This research study involved 170 respondents from the computer science and information technology undergraduate programmes with experience of at least one programming language. 81.2% of the respondents were males, while females were 18.8%. The majority of the respondents were aged between 22 and 29 as they constituted 79.4%, while 14.7% fell into the age group of 14 to 21, and 5.9% was shared among the remaining age groups. No respondent was above 50 years old. Furthermore, a greater number of the respondents, 81.2%, were bachelor students while 18.8% were diploma students. Table 1 summarises the characteristics of the respondents.

Table 1: Characteristics of Respondents

Gender		
	Frequency	**%**
Male	138	81.2
Female	32	18.8
Total	170	100
Age Groups		
	Frequency	**%**
14 – 21	25	14.7
22 – 29	135	79.4
30 – 37	7	4.1
38 – 45	3	1.8
Above 45	0	0
Total	170	100
Program of Study		
	Frequency	**%**
Diploma	32	18.8
Bachelor	138	81.2
Total	170	100

Source: Author's Field Data (2021)

4.2 Mobile Compilers Usage for Learning Programming

In examining the usage of mobile compilers, respondents were asked different questions about the use of using mobile compilers for learning computer programming. Using a 5-point Likert scale from "strongly agree" to "strongly disagree", students were required to select the agreement level depending on their feelings about mobile compilers.

The respondents were asked if they were familiar with mobile compilers for learning computer programming. The findings revealed that 59.4% agreed or strongly agreed that they were familiar with the mobile compilers. On the other hand, 21.8% of the respondents disagreed or strongly disagreed that they were not familiar with mobile compilers. Meanwhile, 18.8% of the respondents remained undecided on the question.

The use of mobile compilers was also asked to assess if respondents use them for learning computer programming courses. The study indicated that 50.6% of the respondents agreed or strongly agreed that they used mobile compilers, while 33.5% disagreed or strongly disagreed with using mobile compilers. Additionally, 15.9% of the respondents stayed neutral on the same question.

The respondents were also asked whether they spent more time coding on mobile devices than on computers. The results revealed that 41.7% of respondents agreed or strongly agreed to spend more time coding on mobiles than on computers, while 42.9% disagreed or strongly disagreed on the same question. Furthermore, 15.4% of the respondents remained undecided on the question.

This study also observed that 34.6% of the respondents agreed or strongly agreed that lecturers included mobile compilers as learning tools in course outlines or in the teaching plans for programming courses, while 43% disagreed or strongly disagreed on the same question. Moreover, 22.4% of the respondents remained neutral on the question.

The response to encouragement from lecturers to use mobile compilers for learning programming courses was that 39.4% of the respondents agreed or strongly agreed. On the other side, 40% disagreed or strongly disagreed. Also, 20.6% of the respondents stayed neutral on the same response. Table 2 shows the summary of mobile compilers usage for learning computer programming.

Table 2: Mobile Compilers Usage for Learning Programming

	SA		**A**		**N**		**D**		**SD**		**Total**	
	Fr	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**
I am familiar with the mobile compilers for learning programming	44	25.9	57	33.5	32	18.8	19	11.2	18	10.6	170	100
I use mobile compilers to learn programming	34	20.0	52	30.6	27	15.9	35	20.6	22	12.9	170	100
I practise more on my mobile device than on computers	31	18.2	40	23.5	26	15.3	47	27.6	26	15.3	170	100
Lecturers include mobile compilers as a learning tool in course outlines/teaching plans	20	11.7	39	22.9	38	22.4	35	20.6	38	22.4	170	100
Lecturers encourage using mobile compilers to learn programming	24	14.1	43	25.3	35	20.6	33	19.4	35	20.6	170	100

Frequency (Fr), Strongly Agree (SA), Agree (A), Neutral (N) Disagree (D), Strongly Disagree (SD)

Source: Author's Field Data (2021)

4.3 Benefits of the Mobile Compilers

A larger percentage of the respondents, 67%, agreed or strongly agreed that mobile compilers improved their knowledge in studies. Contrarily, 20.6% of the respondents disagreed or strongly disagreed with the statement. The remaining participants, 12.4%, remained undecided on the same statement.

The study also indicated that the majority of respondents, 69.4%, agreed or strongly agreed that mobile compilers provided the flexibility that allowed them to code anywhere, anytime and on the go. On the other hand, 18.2% of the respondents disagreed or strongly disagreed, showing that they never experienced the flexibility of the mobile compilers. At the same time, 12.4% of the respondents remained neutral to this statement.

The respondents were also asked if coding in mobile compilers provided enjoyment to them. A good number of respondents, 59.4%, agreed or strongly agreed with this question. However, 21.8% of the respondents disagreed or strongly disagreed that enjoyment was not felt when coding on mobile devices. Meanwhile, 18.8% of the participants opted to stay undecided on the question.

The response to mobile compilers increases students' participation in learning computer programming, as it can be noticed that 67.1% agreed or strongly agreed. Nevertheless, 17% emerged against the statement by disagreeing or strongly disagreeing. The remaining respondents, 15.9% remained neutral to this statement.

The study also indicated that the majority of respondents, 66.5%, agreed or strongly agreed that mobile compilers motivated them to do self-study in computer programming courses. Contrary to the majority, 18.2% disagreed or strongly disagreed with the same statement. 15.3% of the respondents remained neutral to this statement. Table 3 indicates the benefits of the mobile compilers in computer programming.

Table 3: Benefits of Mobile Compilers

	SA		**A**		**N**		**D**		**SD**		**Total**	
	Fr	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**
Improves my programming knowledge in my studies	58	34.1	56	32.9	21	12.4	10	5.9	25	14.7	170	100
Provides flexibility as I can code anywhere, anytime and on the road	59	34.7	59	34.7	21	12.4	14	8.2	17	10.0	170	100
Provides enjoyment coding on my mobile device	45	26.5	56	32.9	32	18.8	18	10.6	19	11.2	170	100

	SA		A		N		D		SD		Total	
	Fr	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**	**Fr**	**%**
Increases my participation in learning programming	53	31.2	61	35.9	27	15.9	16	9.4	13	7.6	170	100
Motivates me to do self-study in programming	67	39.4	46	27.1	26	15.3	13	7.6	18	10.6	170	100

Frequency (Fr), Strongly Agree (SA), Agree (A), Neutral (N) Disagree (D), Strongly Disagree (SD)
Source: Author's Field Data (2021)

5.0 DISCUSSION

The results of this study indicate that most students are familiar with mobile compilers. These results mean that computing undergraduate students are aware that mobile compilers can assist in learning computer programming. These results are in line with a previous study that suggests that students' awareness of using ICT tools for learning is very high, and students have some necessary skills to use these tools for learning purposes (Tochukwu & Hocanin, 2017).

Furthermore, the findings of this study show that students use mobile compilers to learn computer programming. The findings mean that students use these compilers to learn and practise programming on their devices. These findings concur with other studies that claim that students use mobile apps in education (Ding & Chai, 2015; Hlagala, 2015; Luna-Nevarez & McGovern, 2018; Pribeanu, Gorghiu, Lamanauskas, & Slekiene, 2020).

Meanwhile, this study highlights that students spend less time coding on mobile devices than on computers. These results mean that mobile learning has not dominated the use of computers for learning computer programming. These results are consistent with the study conducted by Dias and Victor (2015), which claims that the number of mobile devices is outperforming computers, but there are still no signs that they will completely dominate the use of computers in education.

The findings suggest that most instructors do not include mobile compilers in the programming course outline or teaching plan documents. These findings mean that most instructors do not motivate students to use mobile compilers to learn computer programming courses. Additionally, the availability of useful mobile apps for facilitating students' learning is one thing; the other thing is an emphasis on use by instructors. Other studies comply with these findings that instructors lack awareness of the apps that can assist in teaching (Anza, Bibiso, Mohammad, & Berhanu, 2016; Shulman, 1986).

This study also demonstrates that mobile compilers for learning computer programming bring significant benefits to students. Mobile compilers improve students' programming skills in the field of study. These findings are consistent with previous research studies that state that one benefit of using mobile apps for academic purposes is increasing students' knowledge in their study (Chen, Seilhamer, Bennett, & Bauer, 2015; Ndume, Songoro, & Kisanga, 2020).

Furthermore, another benefit that the mobile compiler provides is the flexibility that allows students to code anytime, anywhere and on the movement. This result implies that students can learn and practise programming skills on mobile devices at their convenience rather than relying on computers. Geographical location, timetable and laboratory rules for college computer laboratories may slow the learning process. This result is supported by Jumaat et al. (2018) and Hlagala (2015), as the authors claim that mobile apps provide flexibility for students to learn anytime, anywhere.

The results also suggest that mobile compilers offer the benefit of enjoyment. Students' enjoyment directly impacts the way they absorb knowledge, as stated by Luna-Nevarez and McGovern (2018). This means that the enjoyment may positively or negatively affect the learning process. If a student enjoys learning, the cognitive absorption is increased. Otherwise, the cognitive absorption is decreased.

Similarly, the results claim that mobile compilers increase students' participation in learning programming. The study by Mercedes and Radel (2016) backs up this observation as it states that the use of mobile apps improves participation and encourages continuous learning. As a result, students actively engaged in coding on mobile devices are likely to improve their participation in learning programming as mobile compilers extend the learning experience beyond the traditional learning environment (Dias & Victor, 2017).

The results of this study show that mobile compilers motivate students to do self-study in computer programming courses. These findings mean that mobile compilers motivate self-study that allows students to learn computer programming from the comfort of their home, on the movement, on their own time, and at their own pace. These results align with previous research that suggests that mobile apps can motivate people to engage in good behaviours (Goodwin & Ramjaun, 2017). Furthermore, self-study promotes an independent study that engages students in learning and improves their performance (Kavuta, 2018).

6.0 CONCLUSION AND RECOMMENDATIONS

This study focused on examining the usefulness of mobile compilers for learning computer programming in higher learning institutions in Tanzania. In addition, the study concentrated on looking into computing undergraduate students' familiarity, usage, and benefits of the mobile compilers for learning computer programming. The results of this study show that computing undergraduate students use mobile apps for learning computer programming. The study also indicates that mobile compilers offer significant benefits that allow students to learn computer programming using mobile learning. These benefits are improved programming skills, increased flexibility, enjoyment, improved participation and self-study. However, the results highlight that facilitators of the computer programming courses do not emphasise the use of mobile compilers for learning and self-practice.

Based on the findings of this research, the author recommends that instructors should include a list of available compilers in a teaching plan document for learning a particular programming language. The list should consist of traditional, online, and mobile compilers to ensure that students know all programming tools before the teaching and learning process begins. Similarly, students are also recommended to use mobile compilers for learning and practice because of the benefits the compilers offer. The author also recommends that curriculum developers and policymakers integrate mobile technology in education to improve teaching and learning. Future research could be conducted in other education apps for improving the teaching and learning of other areas of computer science and information technology.

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