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ANALYSIS REVIEW ON CHALLENGES AND SOLUTIONS TO COMPUTER PRORAMMING TEACHING AND LEARNING

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Programming is creating or writing set of instructions that tells a computer to perform a task. Basically, programming is an important part in Computer Science as it is used to give instructions to the computer to understand and thus solve the problem. Hence, programming is a must-have skill for Computer Science students, especially dealing with technology that is evolving every day. However, there are challenges and difficulties facing by novice programmers in learning programming. This is due to the fact that most students find programming subjects difficult to learn and understand which results in not getting good grades in exams. Although various efforts have been taken to improve the learning and teaching process of programming subject, Computer Science teachers still face challenges to help students in mastering their programming skills. Therefore, this paper contributes to assisting novice programmers and teachers in enhancing their learning and teaching quality. Thus, this study aims to identify the factors contributing to the challenges and difficulties in teaching and learning programming and to review proposed solutions to overcome those challenges.

Keywords: Computer Science, programming, teaching and learning, novice programmers

1. Introduction

Many studies have been conducted on the teaching and learning of computer programming courses (Aureliano, 2013; Johnson et al., 2020; Reynolds, 2008; Wahab et al., 2020). This is because computer programming is one of the important courses for computer science students. By learning programming, students will indirectly have skills such as problem solving (Casey, 1997), design, strategic thinking (Soloway, 1993) and skills of mastering technological equipment (Davidson, n.d.). The computer programming course consists of two parts, namely the theoretical and practical parts that involve activities such as learning the features of a programming language, designing programs and understanding programs (AbdelRahman et al., 2016; Ala-Mutka, 2004).

Computer programming courses were introduced at the beginning of the semester and these students are novice programmers. Novice programmers lack knowledge and skills compared to expert programmers. Educational research has been done to study the characteristics of novice programmers, among them are limited programming knowledge, allocate little time during the process of planning and testing the code and are not aware of their own deficiencies (Ala-Mutka, 2004). Moreover, novice programmers are often faced with misunderstandings and even misconceptions such as related to variable initialization, iterations, conditions and pointers (Lahtinen & Ala-mutka, 2005).

Computer programming however is complex as well as cognitively challenging which has given rise to issues such as high failure rates and difficulty in understanding concepts (Sarpong & Arthur, 2013). This also contributes to the high dropout rate despite being taught at the initial stage of computer introduction courses (Koffmann & Brinda, 2003). Hence, this paper aims to identify those challenges and solutions that can be applied among teachers and students to ensure novice programmers can master the concept of programming precisely and thoroughly.

The next section will discuss the challenges and difficulties in teaching and learning the programming course to novice programmers based on the literature review.

2. Overview

Programming is the process of writing a set of instructions that tell a computer how to perform a task. The set of instructions is called programming language that allows programmer to communicate with the computer. Example of the programming languages including Java, C++, Python, Pascal, C, and PHP. The component of programming languages are syntax, semantics and pragmatics. Syntax can be referred to as a structure of a language, semantic refers to the meaning of the language while pragmatics refers to a way of how the language is practically used (Othman, J., Ahmad, J.I., Abdul Wahab, N., Che Jan, N.Y., Abd Wahab, Z.I., 2019).

Programming is used to give order that is translated from human language to computer language that can assist people in performing their job. Programming is proficiency nowadays that can be considered as a valuable asset globally (Jovanov et al., 2016). This is due to the demand of apps nowadays in many areas such as in learning, surfing, playing games, GPS, etc (Ristic & Urosevic, 2020). Therefore, teaching and learning programming becomes popular and attracts everyone eyes.

Indeed so, learning programming language is quite tough, hard and difficult for beginner or novice programmer to understand the core concept of programming (Bergin & Reilly, 2005). It involves a specified skills and expertise of the syntax of the particular programming language being used (Vadas & Curran, 2005). Novice programmer with lack of programming experiences mostly often facing problem in developing and creating their own codes. Other than that, teachers also facing difficulties in delivering programming subject. Previous literature found few factors contributing to the challenges and difficulties facing by novice programmer and teachers. Moreover, the solutions to overcome those challenges also stated in previous studies.

3. Challenges to students and teachers

This section will discuss the challenges or difficulties experienced by students in order to assist the instructor of the programming course.

The first challenge faced is in terms of the teaching approaches used by the instructors. The high percentage of student intake for each study session has had an impact on class size resulting in non - personal teaching methods (Gomes & Mendes, 2007; Oroma et al., 2012). Programming is not an easy subject to learn as it requires an understanding of abstract concepts. Therefore, immediate feedback to students is required. However, this could not be achieved due to the class size factor. Apart from that, teaching strategies are also very important. The current programming language is based on object-oriented programming. Therefore, due to paradigm shift, contemporary teaching strategies are no longer relevant and effective for problem solving and implementation methods (Cheah, 2020). In addition, students still maintain the same learning techniques as in high school; spoon feeding (Hegazi & Alhawarat, 2016). Next is the instruction and knowledge of the instructor (Sentance & Csizmadia, 2017). Teachers feel less confident in their subjects especially when there are differences in students 'programming experiences. According to Isong (2014), the lack of experienced programming teachers also disrupts the students' learning process. In addition, the use of inappropriate analogies and misunderstandings of concepts will result in students 'inaccurate understanding (Qian & Lehman, 2017).

The next challenge is the method of study used. Students tend to use inappropriate learning strategy such as reading and memorizing programming code that will hinder them to solve problems (Hegazi & Alhawarat, 2016; Oroma et al., 2012). This in turn can lead to plagiarism or dependence on other group members. Hence, if students do not do the assignments on their own then they will not necessarily achieve a sufficient level of programming skills (Konecki, 2014). Furthermore, students make less effort to be competence in programming. With a large class size, it requires students to work on their own and have strong determination (Ahmadzadeh et al., 2015).

In addition, students 'abilities and attitudes are also major challenges to the teaching and learning of programming. The main challenge is the deficiencies of problem-solving skills through algorithmic thinking (Medeiros et al., 2019). Oroma et al., (2012) stated students are weak at the level of analysis and design. Apart from that, knowledge in mathematics and logical is also very

crucial in programming courses. Many students do not have adequate mathematical and logical thinking abilities. According to AbdelRahman et al., (2016), a strong understanding in discrete mathematics, logic and set theory is very important for programming courses because poor performance in this section is a strong indication that they will fail in the curriculum later. In addition, students attitude such as easily lose enthusiasm and interest in programming also contribute to the programming teaching (Isong, 2014).

Next is the nature of programming. Programming requires a high level of abstraction (Ercan & Sale, 2020). The problem faced by students is lack understanding of abstract programming concept (Gomes & Mendes, 2007). Thus, students need to understand how computers operate in order to write program instructions to obtain the desired output. Moreover, programming languages also have complex syntax. This is because they are developed not for learning purposes but for professional use. According to Shivers (2008) novice programmers are more obsessed with syntax and as they become more sophisticated, then they focus more on the semantic elements of the programming language used. Therefore, in addition to formulating problems, novice programmers also need to know about the syntax rules of a programming language. Beside syntax, students also find it difficult to understand the terminology used (AbdelRahman et al., 2016). Students also face details that are not directly involved related to solved problems such as libraries and memory management routines (Mow, 2008) .

The last challenge is in terms of psychological effects on students such as lack of motivation and having a negative perception of programming. Motivation is very important and should be taken into consideration by teachers because it impacts the learning process (Medeiros et al., 2019). To maintain student motivation, teachers need to choose appropriate teaching methods. Negative perceptions affect students' attitudes towards learning computer programming where they consider programming difficult and enough if it is just a marginal pass. Assignments are preferred to be done in groups which then results in low self-efficacy (Cheah, 2020). Apart from that, the unpleasant experience of interaction with the computer such as computer breakdown or data loss is also a challenge to students. As a result, they are always faced with problems that cannot be solved, causing “learned helplessness”. (Mow, 2008).

4. Solutions to students and teachers

To overcome the challenges in learning programming, few solutions have been identified where several approaches can be taken from the point of view of teachers and students themselves. For beginner students or novice programmers who are facing difficulties in writing a complete program, one of the simple approaches that can be taken is to study and test complete existing programs (Gomes & Mendes, 2007). Basically, this will help them to understand how the programs work and function before they start to write the program from scratch.

Other than that, novice programmer or beginner student can analyze programs that include logical errors (Gomes & Mendes, 2007). After a lot of analyzing those errors, they will be familiar with the pattern and format to solve the errors through their own experiences. On top of that, (Safei ,Shibghatullah & Mohd Aboobaidar (2014) stated that providing automated programming error feedback throughout problem solving exercise can improve student self-construct learning process. These include syntax error messages, solution template mismatches and others. Yet, as for online learning environment where student starts facing difficulties in correcting those errors, groundwork, and preparation to check and correct errors after writing the program is really needed (Jung, 2021). Besides, in the initial stages, students can try to complete incomplete programs based on the problem domain given (Gomes & Mendes, 2007). By implementing this kind of exercise, student can motivate themselves to write the program instead of waiting to start from the beginning which may demotivate them.

In addition, with modern technology in learning nowadays, student can learn the fundamental of programming on their own through interactive website and online video tutorials with a lot of

programming examples and practices provided there. (Layona et al., 2017). Thus, in general, they can have the overview and overall idea of programming before they get started to write the codes.

Furthermore, student can start the programming with simple problem-solving exercise relating to what interest them. (Gomes & Mendes, 2007). For the initial stage, students must put the interest first instead of learning the technical part in programming such as syntax and grammar.

On the other hand, teachers should also play their roles to provide long-lasting student supervision by motivating the students to get them interested, thus student got their own initiatives to do the programming activities (Gomes & Mendes, 2007). Moreover, with the motivation given to the students, teachers also must play their responsibilities to ensure students will not giving up solving problems and take part in tasks that will make them learn (Crossing, 2013).

In addition, to cater all students with different learning style and capabilities, teachers should have different presentation format and teaching approach (Gomes & Mendes, 2007; Sentance & Csizmadia, 2017). This is because some students can easily grab the knowledge, but some are not. So, teachers must explain in different ways to make sure all students are on the right track, and nobody left behind. Although the teacher is an expert in programming, but the teacher should be sent for training before starting to teach programming, so that he can convey the concept of programming clearly to the novice programmer (Marcolino & Barbosa, 2017; Sharma et al., 2016). By attending the training, teachers can be aware of how to tackle students' problems in programming, hence can improve students' ability in mastering programming.

Furthermore, in the early stage, teachers should focus on problem solving and algorithm development as an alternative of programming language syntax itself. Teachers can share a simple problem domain to grab student interest and in problem solving (Gomes & Mendes, 2007). Other than that, to attract student to the programming environment, teachers must provide playful situation by using multimedia tools to generally make student aware of the important of programming in the community, thus, to make them understand the programming design and concept precisely (Annamalai & Salam, 2017; Gomes & Mendes, 2007; Konecki, 2014; McKeown, 2004). Also, Sim & Lau (2019) presented that game can improvise students' knowledge and skills on the programming through output visualization or memory visualization. Most of the students enjoyed programming in audio-visual programming environment (Herrmann & Bucksch, 2014).

Then again, problem solving cognitive skill is very important in programming course (Cheah, 2020). It was understandable that student must understand the problem and know the steps should be taken in programming environment (Oroma et al., 2012; Popat & Starkey, 2019). Therefore, teachers should give more problem-solving practice to student, including the exercise activity at the end of the practice to make sure student are really understand the problem, solutions, and programming concept (Gomes & Mendes, 2007).

Likewise, teachers should spend extra time for face-to-face session with student to have good engagement with them. Students can easily refer to their teachers and feel free to ask questions. Moreover, in the labs rooms teachers can give students more examples and exercise, and allow them to discuss about the example given and come up with the solutions (AbdelRahman et al., 2016). Hence, with the motivation, support, and engagement, they put their interest to the subject and indirectly they are bonded to the subject matter by mastering problem solving and logical thinking skills in programming. Thus, increase face-to-face session and practical lab hours is one of the solutions that can be taken by teachers which can increase student achievement in problem solving and logical thinking skills (Ismail et al., 2020; Lopez-Pernas et al., 2021; Oroma et al., 2012).

Another step that can be taken by teachers in teaching programming to the beginner is they should take peer assessment approach. This approach allows learning process by asking students to evaluate the others work and their work. Through this approach, students can learn from their previous mistakes, identify their strengths and weaknesses, and learn to aim their learning appropriately with targeting not to repeat the same mistakes. This situation will get the students to be motivated, confident, and comfortable in their programming learning environment with peers (Al-Khalifa & Devlin, 2020; de Raadt et al., 2007).

As an overall, these solutions and approaches that can be used by teachers and students could to some extent help raise the enthusiasm, confidence, and interest of novice programmers in programming. Perhaps the introduction to programming through audio-visual approach makes them

interested and indirectly leads them to explore the field of programming in more depth. In fact, with the introduction of simple problem solving makes them fearless and confident to continue to focus on the field of programming.

5. Discussion

Novice students who learn programming for the first time often face problems to understand the concepts of programming would be very tough, difficult, frustrating, and demotivating (Pillay & Jugoo, 2005). The goal of this paper is to identify the challenges faced by teachers and students in teaching and learning programming, respectively. This paper also provides few solutions and approaches that can be taken by teachers and students as steps to overcome those challenges, not only to ease student in learning programming but it helps teachers a lot in teaching programming as well as shown in Table 1.

Table 1: The summary of challenges and solutions in teaching and learning programming

Challenges	Solutions
Non -personal teaching methods (Gomes & Mendes, 2007)	<ul style="list-style-type: none"> Teachers should increase face-to-face session and practical lab hours (Ismail et al., 2020; Lopez-Pernas et al., 2021; Oroma et al., 2012). Teachers should take peer assessment approach (Al-Khalifa & Devlin, 2020; de Raadt et al., 2007).
Teaching strategies (Cheah, 2020)	<ul style="list-style-type: none"> Teachers should have different presentation format and teaching approach to cater different student with different learning style (Gomes & Mendes, 2007)
Teachers' poor knowledge content (Sentance & Csizmadia, 2017)	<ul style="list-style-type: none"> Teachers need to attend training especially in mathematical and logical skills before teaching programming (Marcolino & Barbosa, 2017).
Inappropriate learning strategy (Hegazy & Ghorab, 2015)	<ul style="list-style-type: none"> Student should do a lot of programming practice to get familiar with programming environment Student have to study and test complete existing programs (Gomes & Mendes, 2007).
Lack of effort to acquire programming competencies (Gomes & Mendes, 2007)	<ul style="list-style-type: none"> Student learn the fundamental of programming on their own through interactive website and online video tutorials
Deficiencies in problem solving skills (Medeiros et al., 2019)	<ul style="list-style-type: none"> Teachers give students more examples and exercise, and allow them to discuss about the example given and come up with the solutions (AbdelRahman et al., 2016).
Deficiencies in mathematical and logical knowledge (AbdelRahman et al., 2016)	<ul style="list-style-type: none"> Teachers increase face-to-face session and practical lab (Lopez-Pernas, Gordillo, Barra, & Quemada, 2021; Ismail, Ismail, & Hasim, 2020; Oroma, Wanga, & Ngumbuke, 2012).
Programming demands a high level of abstraction (Ercan & Sale, 2020)	<ul style="list-style-type: none"> Teachers need to learn suitable pedagogies for delivering programming to novice programmers that relate to algorithms, syntax, semantic and the advancement of computational skills (Konecki, 2014; Sentance & Csizmadia, 2017)
Programming language have a very complex syntax (Ahmadzadeh et al., 2015)	<ul style="list-style-type: none"> Teachers should use a variety of teaching methods to adapt to the different learning styles of students so that they will more easily understand the concept of programming including the syntax and semantics while reducing fear of programming (Konecki, 2014).

	<ul style="list-style-type: none"> Teacher should be sent for training before start teaching programming (Marcolino & Barbosa, 2017; Sharma et al., 2016)
Students have no motivation (Medeiros et al., 2019)	<ul style="list-style-type: none"> Teacher should provide long-lasting student supervision to motivate them (Gomes & Mendes, 2007) Teachers must ensure students will not giving up solving problems (Crossing, 2013) Teachers can use multimedia and games in teaching programming (Sim & Lau , 2019; Herrmann & Bucksch, 2014).
Negative perceptions (Cheah, 2020)	<ul style="list-style-type: none"> Teachers should motivate the students to get them interested, and not giving up (Gomes & Mendes, 2007)
Unpleasant experience of interaction with the computer (Mow, 2008)	<ul style="list-style-type: none"> Teachers can provide playful situation by using multimedia tools to make them understand the programming design and concept precisely in an enjoyable environment (Annamalai & Salam, 2017; Gomes & Mendes, 2007; McKeown, 2004)

6. Conclusion

This paper contributes to assist novice programmers and teachers in enhancing their learning and teaching quality. This is done by identifying the factors contributing to the challenges that they may face. Among the challenges faced during the teaching and learning process of programming subjects are the teaching approach used, students' learning methods, students' abilities and attitudes, the nature of programming subjects and the psychological impact on students. From there, proposed solution from previous researchers were identified to help teachers and students or novice programmer to take it as the approach to overcome those challenges. The proposed solution for students is to study and test existing programs, analyze programs to detect errors such as syntax or logic and solve problems using incomplete programs not from scratch. While teachers can use solutions such as motivating students, using different teaching approaches and presentation formats, focusing on problem solving and algorithm development, attracting students by using multimedia equipment, allocating more time for face-to-face sessions, using peer assessment approach and so on. In the future, we plan to study the different teaching approaches used for programming subjects. Learning programming is a complex task, therefore the teaching approach is very important to ensure that the teaching and learning process takes place effectively.

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