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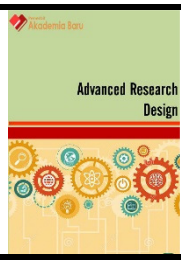

Integrating technological pedagogical and content knowledge in computer programming courses: Issues and challenges

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ABSTRACT

The purpose of this study is to explore the issues and challenges in integrating technological pedagogical content knowledge (TPACK) for computer programming courses. This study employed the triangulation method of the case studies and Grounded Theory (GT). Twenty-five computer programming educators were interviewed via online such as e-mail, media social's chatting and messaging application like WhatsApp and Telegram. The main issue discovered in this study is the misconception in using technology for teaching and learning computer programming. Besides that, there were two major challenges found in this study. The challenges are the instructors were not able to explore the rapid development of technology and this may cause the lack of technological pedagogical knowledge among them. They also showed the lack of knowledge about pedagogy and assessment for teaching and learning computer programming that relevant to the programming content. The research that has been done showed that TPACK model is very suitable to guide exploration about how educators make use of technology appropriate to the pedagogy and content. However, the exploration that has been done has limitation on how educators integrate student's assessment on affective and instructional design implementation with TPACK. Therefore, this paper suggesting for the future study, in order that more exploration should be doing about how assessment on student's affective and instructional design would be integrate with technology, pedagogy and content knowledge via TPACK model.

Keywords:
Pedagogical issues, programming and programming languages, teaching/learning strategies, improving classroom teaching, authoring tools

1. Introduction

Malaysia, as a developing country is not exceptional in empowering the education sector in line with technological modernity. In achieving the goal, Malaysian government through the Ministry of

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Higher Education (MHE) plays a key role to produce quality education that makes full use of technology in all courses given in higher education [1]. Some of these, educators were asked to use educational technology such as an online teaching tools like online seminars and videos[2,3]. Moreover, in shaping effective teaching and learning, technology should be integrated in better ways as that suggested by Mishra and Koehler [4] via the notion of technological pedagogical and content knowledge (TPACK).

2. Teaching and learning in computer programming courses

Computer programming is part of the important components of software interactions that very important for development applications. According to Pine [5], computer programming tells computers on how to do an operative work. Pine also stated that big tasks need to be divided into smaller tasks and those smaller tasks should be divided into the smallest forms which finally make a computer informed about what tasks need to be done. In addition, the programming is solving problems arising from computer programming algorithms manipulated through creative processes developed during the programming process [6]. Therefore, computer programming, in general is written commands to inform a computer to do tasks in order to solve problems.

In pursuing modernization, the rapid development of computer technology and communication have increased the need to use sophisticated software applications among users. However, the programming skills techniques has yet to be fully implemented as an essential element for the development of applications [7]. Moreover, knowledge and modern programming skills also required to meet the increasing user demand for computer applications that are dynamically across a variety of platforms and devices [8]. Following that, knowledge and computer programming skills should be given to all students in computing field in Higher Education Institutional [9]. However, the programming courses are always recognized very difficult and challenging for students and educators because of the rapid development of technology [9,10]. Regarding that, what exactly is the reason of challenging in teaching and learning programming should be explored deeply. This paper has explored the issues and challenges of teaching and learning programming in either appropriate to the rapid development of technology that influences the teaching and learning of computer programming.

3. Technological pedagogical and content knowledge (TPACK)

The very suit models that can be used to integrate technology into teaching and learning in computer programming courses was Technological Pedagogical and Content Knowledge (TPACK). Mishra and Koehler [3] established the notion of TPACK which originated from the previous notion of Pedagogical Content Knowledge (PCK) by Shulman (1986). They added the element of technology into the PCK framework and proposing the notion of technological pedagogical and content knowledge or TPACK. The TPACK framework includes seven knowledge bases for teaching and learning regardless of subject matter. Figure 1 shows the TPACK notion.

In general, an integrated teaching and learning with technology could produce effective teaching. Several studies have been made of TPACK by researchers, and they found that integrating TPACK into teaching and learning succeeded to increase students' understanding [11–13] and gave different outcomes to students' learning by compared it with the traditional approach [14,15]. Noting that the young generation now closely related to information and communication of technology (ICT), so that the technology integration is getting more obvious [17,18]. Thus, whenever technology, pedagogy,

and content are fully integrated by relevant, the effective approaches of teaching and learning were created.

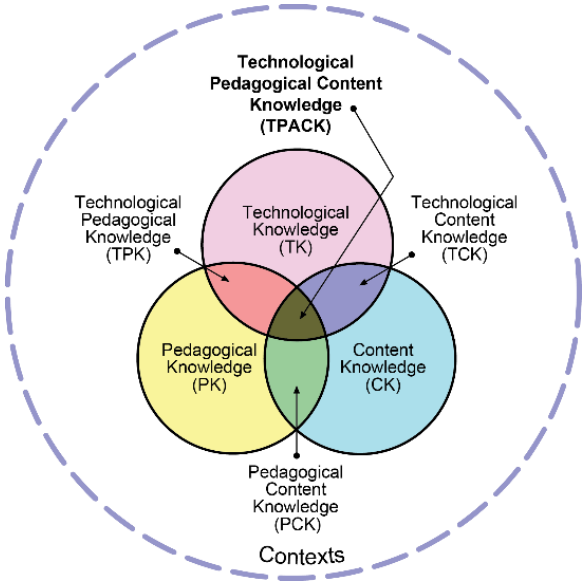

Fig. 1. The TPACK Framework by Mishra and Koehler [19]

Nonetheless, there also some failure stories about TPACK in computer programming areas. Yadav and Korb [20] found that the TPACK failed to be integrated in teaching and learning programming due to the failure of educators who showed limited knowledge and skills on how to use technology, pedagogy, and programming content relevantly. The rapid advancement of technology nowadays gives greater challenging to education field like computer programming courses to integrate technology into teaching and learning [21]. The abrupt changes in technological knowledge and programming language cause educators to revamp the curriculum of the programming courses often [22] but the educators failed to cope with those changes [23], [24]. Moreover, not all educators knew that they possessed those limitations [22–24]. In addition, educators should creative to be able to possess high knowledge about technology, pedagogy, and content via understanding the basic how they works together[27,22,24]. In this respect, the challenges of integrating them together must be explored before expecting that educators can teach effectively, and this could be explored using TPACK model.

4. The research objective and the significance of the study

This study aimed to explore issues and challenges faced by educators when integrating technology into teaching and learning in computer programming courses. The used of TPACK model is suitable to explore the issues and challenges from view of three elements of technology, pedagogy and content knowledge and how they should have integrated successfully. The research question is: *What are the issues and challenges faced by computer programming educators in terms of content knowledge, pedagogy knowledge, technological knowledge, pedagogical content knowledge, technological content knowledge, and technological pedagogical knowledge?*

The answer of this question were contribute to new knowledge on how the TPACK model works for computer programming courses as well as bringing new insights of how educators and students faced challenges in using technology in teaching and learning. Since TPACK model is a very general

notion which can be applied for any subject matters, this study provided new insights on how the model is applicable in computer programming courses in Malaysia.

5. Research methodology

5.1 Methodology

This study used case study design in according to utilized understanding phenomena in a deeper sense. This design fits with this research since the research question used the question of "what" and attempted to get an in-depth explanation of issues and challenges in using TPACK for teaching computer programming courses.

5.2 Data collection and data analysing technique

Semi-structured interviews were used as data collection technique and was conducted among twenty-five participants. The grounded theory (GT) approach was used when analysing the data. Glaser and Strauss [28] stated that grounded theory is a technique to manage research data in a systematic way and structured until producing themes which can explain a process of phenomena, activities, behaviours, and interaction bounded by contexts.

5.3 Participants

All participants are computer programming instructors who have experience of teaching programming between one to twelve years. They all were selected using purposeful sampling specifically the convenient sampling. Table 1 shows their details.

Table 1
Participants' Position, Teaching Experiences and Qualifications

Position	Teaching Experience	Qualification	Total Participants
Lecturer	12 years	Master of Computing	3
Coach	9 - 11 years	Bachelor of Electrical Engineering	5
Lecturer	8 years	PhD in Computer Engineering System	3
Lecturer	7 years	PhD in Software Engineering	4
Lecturer	6 years	Master of Information Technology	3
Lecturer	2 - 5 years	Bachelor of Computer Science	5
Coach	1 - 3 years	Bachelor of Computer Engineering	2
		Total Participants	25

6. Data analysis

Data were analysed based on seven elements of TPACK model: content knowledge, pedagogy knowledge, technological knowledge, pedagogical content knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical and content knowledge. This exploration is pivotal to explain factors which contribute to the strengths and weaknesses in integrating TPACK in teaching and learning of computer programming. The data was coded using open coding, axial coding, and selective coding on purpose to refine and differentiate the categories that found from data analysing [29]. Coding was made based on deductive codes from works of literature and inductive codes that found from raw data. Issues and challenges faced by those participants were explored intensively in each construct.

7. Finding and discussion

Data were analysed to answer the research question: What are issues and challenges face by computer programming instructors in terms of content knowledge, pedagogy knowledge, technological knowledge, pedagogical content knowledge, technological content knowledge, and technological pedagogical knowledge?

7.1 Content knowledge (CK)

CK refers to participants' knowledge on subject matter delivered to their students. They need to master contents related to programming such as the concept of programming, the theory of programming, explanation on doing programming, and practices of programming to enhance skills. Data indicate that the principal issue on a subject matter of programming is the failure of participants to master the knowledge on computer programming. Even though some participants were aware that subject matter on programming is crucial, they faced challenges in mastering the computer programming knowledge. This problem closely relates to problem-solving content in the programming.

However, the participants said that they organized their instructional materials in systematic ways, interactive, and attractive. However, some of them admitted that they did not understand some topics in programming subject which causes to their inability to master the content because it is truly hard to understand computer programming which includes many aspects of learning it such as programming problem solving, programming syntax and algorithm. The problem became worse when some of the participants have no experience on working with software development industries. These problems always happen and become the challenges for those participants.

Based on previous studies, it is true that computer programming knowledge is really tough to be understood but in this research, finding shows more details about what causes this matter. Yurdugül and Aşkar [30] suggest that instructors need to truly master the programming knowledge before teaching to their students because the knowledge itself is very complex for students to understand. Similarly, finding of this study shows that students really need guidance from educators who should be experts in all knowledge regarding programming. All participants admit that if they failed to be experts in programming content knowledge, it is hard to teach students effectively. This will bring about undesirable learning outcomes in computer programming such as low scores in examination or incapability of doing programming in real world settings like developing computer applications for industries.

7.2 Pedagogical knowledge (PK)

PK refers to types of pedagogies used to support effective teaching. Archambault and Barnett [12] espoused that educators need to do research on teaching strategies in specific topics to better prepare them for quality teaching. Unfortunately, participants in this study demonstrate that they highly relied on their teaching experience as educators. They usually use theory teaching, practical work, interactive instruction, giving assignments, automation teaching, using visualizer, and students' presentation. Generally, all of these approaches create active learning. Nonetheless, participants indicate that they were comfortable in using similar approaches to teaching and less thought about effectiveness of those approaches.

The foremost concern is on how they could stimulate students' interests in learning programming. Participants in this study faced challenges in fostering students' interests because they

are less capable on exploring appropriate pedagogies for students which make students feel that programming is really gruelling. Some participants claimed that they used effective teaching strategies for students while students still have low achievement in programming. This situation may create tension between educators and students as they raise the question of why students still do not understand what is being taught by educators even though they are using teaching methods that have been effective in their opinion.

7.3 Technological knowledge (TK)

TK includes knowledge on types of tools, devices, or software which can be integrated to help or facilitate educators [31]. Finding indicates that most educators assumed that they possessed good TK. However, some of them admitted that the rapid advancement of technology makes them struggled to fully integrate technology. Participants are cognizant of the existence of technology, but they could not understand and integrate technology. The reason is because they need to learn all recent technology in a short time compared to previous years, and the rapid advancement of technology gives them no opportunity to learn each new technology. They also stated that they got less support in terms of infrastructure and need to use their own money to purchase recent technology tools.

Based on the interviews, most participants have a high awareness and knowledge on basic learning technologies like Internet use, e-mail, and cloud storage and even have knowledge on recent software. However, due to fewer supports in terms of money for purchasing, they tend to use pirate software which is unethical and is illegal. Educators should always educate students to use genuine software instead of pirate to respect intellectual property. This research found a similar finding where most students in technology area tend to use pirate software due to their educators' practices of using those products. This situation is not a good thing when technology grows in rapid ways and users tend to choose fake products or software. Therefore, it is crucial to teach educators and students to use genuine products to educate them about copyrights as well as giving strong supports to educators in terms of facilities and money for purchasing products. Besides that, this situation makes assessments of students' affective difficult because educators are also involved in similar problems.

7.4 Pedagogical content knowledge (PCK)

PCK is integration between content knowledge (CK) and pedagogical knowledge (PK). It is about knowledge base of teaching which covers curriculum, assessment, and pedagogy for specific subject matter [32]. Participants in this research stated that they knew suitable pedagogy to teach computer programming like demonstration, simulation, project assignments, and practical work. However, those stated pedagogies did not give a good teaching impact. This claim is supported by students' scores in the examination told by those educators, which were low and also students' feedback on their interests toward computer programming. The students' feedback is collected by their educators via teaching feedback form.

Techers as participants were not aware about their deficiencies on skills to use suitable pedagogies which fit with the computer programming area especially on computer programming problem solving. Educators actually faced problems to use the problem solving approach which brought to students' perceptions that computer programming is hard. Some responses from the participants are:

"Computer programming is actually about problem solving skills, but it is not easy to implicitly teach problem solving in computer programming courses."
"When students failed to understand those problem solving concepts, computer programming courses will be hard."

Kunimune and Niimura [33] stated that creative problem solving can be taught together with programming. However, the finding of this research shows that problem solving approaches in teaching computer programming needs a special approach to be used as a pedagogy. The failure of educators to teach computer programming using problem solving approaches causes to students' failures in the courses. The finding of this research also found that educators agreed by saying that mistakes in selecting suitable pedagogy in teaching programming caused to students' failure in understanding programming problem solving concept.

7.5 Technological content knowledge (TCK)

TCK is defined as the knowledge in particular technologies which are suitable for particular content knowledge [34]. Most of the participants understood the PCK domain by saying that technology can support content learning among students. Nonetheless, most of them were not sure about suitable technologies for teaching programming. They admitted that they still failed to integrate technology with programming contents.

Participants revealed that technological tools provided by administrators of the program were not suitable and were outdated due to the fast changes in the subject contents. Besides that, the rapid changes of technology and content domains in teaching brought to difficulties on integration of those two knowledge. Some participants state that computer programming would always change due to rapid advancement of technology. This finding is consistent with Mosses [35] that state technology also brings changes to programming language approaches. All of these challenges require solutions to benefit technological tools in meaningful ways to support students' learning in programming courses.

7.6 Technological pedagogical knowledge (TPK)

TPK means knowledge on how teaching and learning could change when particular technologies used with some approaches [34]. It covers pedagogical knowledge (PK) and limitations of various technological tools to teach programing effectively by using suitable pedagogical approaches. Participants believed that technology can help their instruction in terms of delivering contents. Nevertheless, they were unable to fully integrate technology and pedagogy. Two examples are given:
"There are many websites which can help me teach programming, but I am not skillful to use them even though I knew that they can help students to do programming in hands-on ways during classes."
"I faced a problem to use digital portfolios in teaching computer programming, though I knew how to use those tools which may assist my instruction."

Participants' problems are due to rapid changes of technology and high costs in using those tools. They even just wanted to use simpler technologies without exploring up-to-date technologies for teaching programming. For instance, one of the participants said that:
"I just wanted to use the latest technologies if only they are available for me. I can always use them, but it takes longer time to learn."

Most participants tended to use the cheaper and the simpler technologies for teaching programming. This study revealed that administrators did not provide the latest technologies for those educators. This caused to the use of presentation technology like teleconference as the only

tool for instruction because it is available for those educators. The tool is beneficial in terms of long-distance learning between educators and students. However, those participants felt that the tool was actually a burden to them because they need to learn how to use it while some of them are not technology savvy.

Following that, educators need to be creative and always put effort to explore the latest technologies in teaching and learning. In fact, previous studies has stated that educators require training to understand TPK to ensure that they can integrate suitable technology and pedagogy [11], [33–35]. Besides that, TPK needs to be understood in terms of how it is constructed and reconstructed in the TPACK model [39]. From this study, it is clear that participants faced challenges in using suitable technologies for programming courses, but they did not take action to solve those challenges due to time constraints as one of them said that,

"we are very busy and have no time to explore the latest technology for teaching programming."

7.7 Technological pedagogical content knowledge (TPACK)

TPACK is effective integration between particular technology, pedagogy, and content knowledge for teaching and learning [31]. This study discloses that participants showed a lack in selecting and using suitable technology for specific pedagogy and content. They possessed deficiencies in mastering the required technology and had put no concern on their teaching effectiveness with respect to technology selection. They also put no effort to add knowledge on technological pedagogical knowledge by saying that:

"It is not easy to teach students from the Y-Generation. They very rely on technology even though technology is just technology. Students need to put efforts and interests to learn programming."

"Even though educators use technology, it is not meaningful to students if students have no interests to learn. When this happened, we as educators can do nothing."

Those challenges on integrating TPACK for teaching programing are due to time constraints to learn the newest technology, expensive software, lack of training to apply technological and pedagogical knowledge, no focus and no interests as well lack of motivation. Participants admitted that they did not fully master TPK and TK, which cause to students' perceptions that educators lack of credibility for teaching programming. Participants also indicated that infrastructures were not fully available like debugger which can impede programming instruction process.

In addition, participants had misconceptions about TPACK. This study revealed that technology integration takes a longer time to be understood and mastered in terms of their suitability for pedagogy and content of programming. Participants also worried about technology by saying that:

"If I always used technology for teaching, then how students may think?"

"If we always used technology, students can never think wisely due to high reliance on technology. Technology, in this case, would reduce students' cognitive ability."

Due to these misconceptions, participants had less motivation to integrate technology into teaching and just used technology because of the administrators' enforcement. Participants, in this case, merely looked at cost issues and technology affordances even though not all technology needs to be paid with expensive prices. For instance, in video production, a participant felt that it is costly though all educators at university levels have got a valid license of the Microsoft Office 2013 where the software has the Microsoft PowerPoint which can be used to develop videos of teaching with features like slides recording, screen recording, audio recording, and video trim. In general, the main issue in teaching and learning using the TPACK model is the educators' misconceptions about technology and less efforts were put to know technological tools which are affordable for them.

Besides technology, problem solving skills also are critical elements in computer programming from the viewpoint of programming content. The problem solving skills is the initial process in the development of computer application [33], but many students did not understand and apply problem solving skills in developing their programming abilities [37,38]. Failures in mastering those skills will bring to difficulties in mastering other processes in computer programming activities [39,40].

Based on the above reasons**,** integrating technology into teaching and learning of computer programming courses needs to be studied along with creative problem solving skills Law, Lee, and Yu [44]. Law et al. (2010) added that the integration can increase educators' and students' motivation in the teaching and learning process. In their study, Jerome [45] found that teaching and learning via the online mode changed students' learning approach and surprisingly the approach increase students' achievements. The study suggests that the difficulties in teaching students in computer programming courses could be solved by integrating technology with creative problem solving skills.

8. Conclusion and recommendations

Based on issues and challenges that were identified, several conclusions and suggestions are made. The main issue was the misconception of technology among participants about the use of technology in teaching and learning of computer programming. The following issues were educators, as the participants had less capacity to explore technologies that advance rapidly and this brought to little technological knowledge and pedagogical knowledge as well as unsuitable assessment on teaching and learning to teach computer programming courses.

8.1 Content knowledge

Educators failed to master knowledge on computer programming. This is a big issue raised from this study because their mastery on content knowledge will determine their capabilities to teach effectively. All educators need to fully master knowledge on computer programming by closely following the advancement of the latest computer programming language and the application to industries. They could attend non-formal courses on computer programming, expand their experiences by actively participating in open source programming projects, and become active in informal learning via online course about programming exclusively for educators.

8.2 Pedagogical knowledge

The educators put no concern on their pedagogical approaches which were ineffective. They put no effort to explore diverse pedagogical approaches to solve students' problems who cannot fully understand computer programming. Educators need to cultivate creativity and interests to explore effective pedagogy so that students will not always think that computer programming as a hard subject. Indeed, appropriate pedagogies are crucial for teaching computer programming effectively by creatively selecting suitable methods for teaching especially for a complex topic like programming.

8.3 Technological knowledge

The educators failed to understand and master suitable technology for teaching programming. This was due to challenges in getting affordable prices and in following the rapid changes of technology. Even the educators used pirate sources due to expensive subscriptions to use technology. Therefore, administrators need expose educators with practical courses on using up-to-

date technologies. Educators also could explore alternative software like open source which is free to use or with a minimum cost. This is certainly better than using pirate sources which is unethical and illegal. Moreover, using those pirate sources will definitely give bad impacts like virus spreading and damaging computer operation.

8.4 Pedagogical content knowledge

The issue regarding PCK is there is no congruous blend between the teaching pedagogy used by educators with the content of computer programming. This analysis is carried out based on educators' revelation that they teach programming in one-way manner due to the complexity of the teaching content itself, which burdens them to choose suitable pedagogy to fit the content. Besides, research analysis also discovers that the teaching pedagogy used is not able to assist students solving computer programming problems due to their sole dependency on notes given by lecturers. Thus, this research suggests the use of online programming nature to be combined with classroom teaching to assist the pedagogy, as online programming learning method has been widely introduced.

8.5 Technological content knowledge

The issue regarding TCK is the technology used by educators is not suitable with the teaching content intended to be delivered to students. This is due to rapid change in the technology that supports programming teaching that causes most educators to be left behind. Educators' lack of knowledge on technology and its suitability with teaching content has become a huge issue in computer programing education. Thus, this research would suggest that educators should be more proactive in consistently equipping themselves with the recent knowledge of the evolving technology.

8.6 Technological pedagogical knowledge

The issue regarding TPK is the integration of technology and pedagogy that incurs high cost, as well as the reluctance of educators to explore the most current technology that could be used to aid pedagogy. In fact, the main challenge faced by educators is when the technology provided by administrators is seen to be burdening and doesn't help assisting their teaching. On this point, the suggestion that could be offered is the educators themselves have to boost their intrinsic motivation to discover technology while being creative when using it. Educators shouldn't take the technology provided by the administrators for granted by simply using it due to the obligation, but to deeply explore the available advantage so that the technology which is meant to assist educators won't be burdening to them.

In general, this research suggests that programming educators should be given deep knowledge regarding TPK and carry out action research or 'lesson study' to discover how the integration process of TK and PK is carried out efficiently, and work on the improvements from time to time. In accordance with that, the technology used must also be equipped with debug infrastructure, so that when this problem occurs during programming class, the ready infrastructure could handle it. However, the use of this technology will incur cost. Thus, the administration should realize the need of such costs when technology shall be used in the teaching and learning.

8.7 Technological pedagogical content knowledge

The next issue is in TPACK domain, involving technology integration in teaching and learning as a whole. Among the issues are time constraint and misunderstanding. Due to the misunderstanding towards the function of technology, educators face a lot of problems which are seen as the challenge they have to take on. The educators feel that they do not have sufficient time to learn the ever-growing technology. This causes the loss of interest in integrating technology in teaching and learning process.

Other than that, the loss of interest in continuing technology integration in teaching and learning is when the technology is used with the wrong teaching content due to educators' misunderstanding towards the topic and the concept of technology used. However, these challenges actually depend on the attitude of the educators themselves. The educators who have problems with technology usually do not have initiative in going further. This attitude should be eliminated as it will lead to students' failure in mastering the content intended to be delivered to them.

Other than the description above, educators must also inculcate the positive attitude so that they will constantly be technology literate. Technology literacy among educators could definitely increase their knowledge from time to time so that they could be ready to handle all challenges in teaching computer programming based on technology. This requires them to explore pedagogy to suit the course content. In the context of computer programming, educators should master the programming course content so that they could determine the most suitable pedagogy that suits the technology used. Even though these issues and challenges have been discussed in previous studies in various fields [43,44], these issues continue to happen due to insufficient research on TPACK in computer programming field. As for example, educators must first explore suitable teaching medium as pedagogical elements for science and technology educators. While educators also state that problem solving is the most important content in the teaching of computer programming. So, the teaching requires specific methods in integrating the teaching of problem solving into the content of computer programming. Hence, if the pedagogy suits the content, the teaching and learning of computer programming could attract students' interest and become effective.

Besides technology, problem solving skills also are critical elements in computer programming from the viewpoint of programming content. The problem solving skills is the initial process in the development of computer application [33], but many students did not understand and apply problem solving skills in developing their programming abilities [37,38]. Failures in mastering those skills will bring to difficulties in mastering other processes in computer programming activities [39,40]. Based on the that reasons**,** integrating technology into teaching and learning of computer programming courses needs to be studied along with creative problem solving skills [7,40,41]. The integration can increase educators' and students' motivation in the teaching and learning process. Therefore, this study suggests that the difficulties in teaching students in computer programming courses could be solved by integrating technology with creative problem solving skills along programming content.

Finally, it could be concluded that the findings of this research not only have revealed the issues and challenges in the integration of TPACK in computer programming, but also have successfully discovered few solutions. Other than that, this research's output also gives a huge impact in computer education since this research can be a guideline in designing more effective computer programming courses by integrating TPACK in the planning of computer programming lessons. However, there are limitations while carrying this research that requires further studies in the future. One of the limitations is this research in general is based on seven TPACK domains. Suggested future researches would be the discovery of TPACK in more detailed aspects that involve the aspects of assessment on students' affective and teaching designs for computer programing courses. This is due

to TPACK's potential to be used as lesson procedure especially in term of affective and assessment. Besides, further research is necessary to ensure TPACK is suitable to be combined with teaching design in a particular context.

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