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Identifying efficient determinant factors affecting students' achievement in learning computer programming

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Abstract

This research investigates factors affecting perceived satisfaction, usefulness, self-regulation, and achievement in a computer-programming learning environment. The findings will be useful to educators and administrators to create learning environments, which positively affect learners' attitudes and behaviors. One hundred university engineering students were asked to answer a questionnaire after three months of studying a computer programming course. Pearson bivariate correlations and multiple linear regression analysis were applied to analyze the data. The results show that perceived satisfaction can be determined by the interactive learning environment and perceived usefulness. Perceived usefulness is a determinant factor of perceived satisfaction. Learners' perceived satisfaction, perceived usefulness and an interactive learning environment are determinant factors of perceived self-regulation. Memory strategy, which can be predicted using perceived efficacy, perceived anxiety and usefulness, is shown to affect computer-programming achievement. Perceived self-regulation and the use of memory strategies can be improved through students' realization of perceived usefulness. However, the data do not show that the improper use of mobile applications such as Facebook, Line, and YouTube affect computer-programming achievement.

Keywords: *self-regulation, satisfaction, usefulness, memory strategy, mobile phone and tablet use, computer programming, achievement*

1. Introduction

Computer-programming courses are important for computer science, information technology and engineering students. Computer programming is taught at thousands of universities throughout the world. Self-regulated learning assists students to learn effectively and perform better (Zimmerman, 2002). Self-regulating learners are characterized as committed participants who can efficiently manage their own learning activities, including organizing and preparing learning contents, monitoring their learning processes, and holding positive motivational beliefs about their capabilities and the value of learning (Artino & Stephens, 2009). Self-regulated learning is an active and constructive process whereby learners set goals for their learning based on experiences and the contextual features of the current environment (Pintrich, 2000). A self-directed or self-organized process that enables learners to raise and develop self-awareness of their strengths and weaknesses in learning is known as self-regulated learning (Chaiwiwatrakul, 2016). Self-regulation is related to self-efficacy, anxiety, interactivity, satisfaction with and usefulness of the system (Cigdem, 2015). Self-regulated learning benefits students because it improves their chances of success both inside and outside the classroom. Learners need to be self-regulating because, after they graduate, they will work in companies on projects where they will have to resolve problems by themselves. Reading electronic documents or books and using interactive menus as well as using error information from programming development tools to make corrections are important skills for students learning computer programming. Although there are many programming development tools and computer languages available, some of them do not provide useful interactive menus and debugging tools. Selecting an appropriate programming development tool can help to create an effective learning environment. Users can interact through graphical user interfaces, which have replaced command line input. In the modern programming environment, software components such as Button, CheckBox, CheckedListBox and ComboBox allow learners to realize the practicality of writing a computer program easily. An easy-to-use graphical user interface can affect learners' self-efficacy and satisfaction. This work aims to obtain valuable information on improving a computer-programming course. Factors that may affect achievement in a computer-programming learning in a classroom will be studied.

2. Literature survey

2.1 Elements of developing effective learning

To improve learning outcomes, Liaw and Huang (2007) suggested that four elements should be considered when developing learning environments: useful environmental characteristics, environmental satisfaction (positive learning attitudes), effective learning activities, and individual learning characteristics. Useful environmental characteristics, such as interactive learning environments, can be developed to create a high-level communicative learning environment that allows learners to share and retrieve useful information. Improving environmental satisfaction improves learning attitudes and behavioral intentions towards learning. Moreover, self-regulated activities and an interactive environment to share knowledge enhance opportunities for effective learning. Personalization is a characteristic of learners, which includes the capability to undertake self-efficacy activities and the capability to control learning progress. On the other hand, perceived anxiety is a negative personalization characteristic that affects satisfaction towards learning.

Previous studies (Sun, Tsai, Finger, Chen, & Yeh, 2008; Tsai, 2009), have perceived anxiety as having a negative relationship to perceived usefulness. Studies by Bouhnik and Marcus (2006), Liaw and Huang (2007), and Motiwalla (2007) commented that two factors (environmental characteristics and individual learner characteristics) should be considered when studying perceived usefulness in learning. Figure 1 shows factors influencing the development of a computer-programming learning environment.

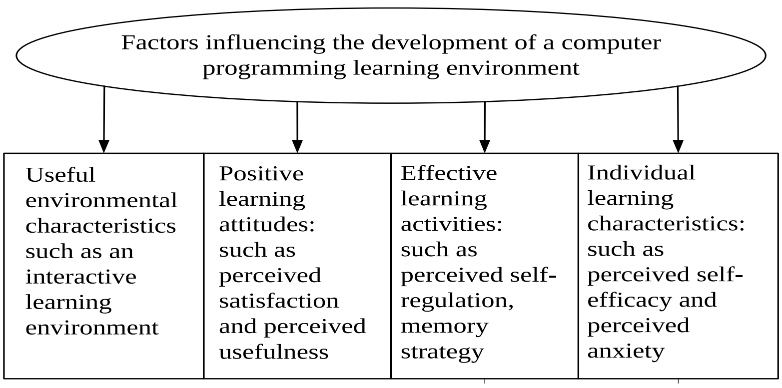

Figure 1 Factors influencing the development of a computer-programming learning environment

Based on the studies by Liaw and Huang (2013) and Ekhlas & Shangarffam (2013), a 4-tier model, as illustrated in Figure 2, was proposed to identify the efficient determinant factors of self-regulation, achievement, and improper mobile device use in a computer programming classroom.

It is hoped that this research will help educators to create appropriate learning environments and provide relevant programming development tools, which will positively affect learners' affective and cognitive factors.

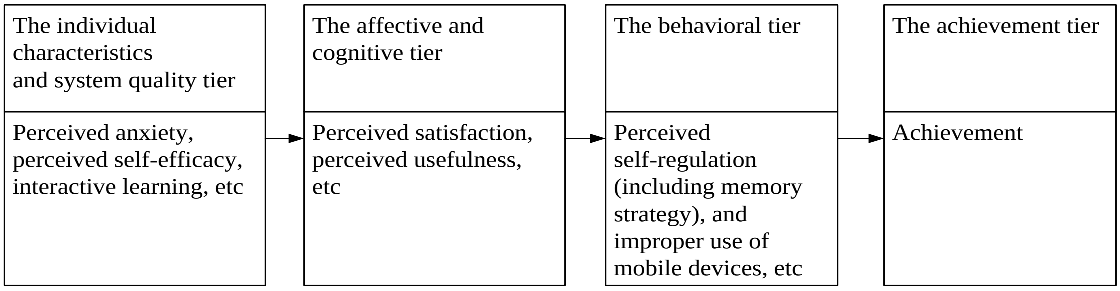

Figure 2 Learning factors based on a 4-tier model

2.2 Perceived self-efficacy

Self-efficacy refers to the degree to which an individual is confident that he or she can perform a specific task or achieve a specific goal (Bandura, 1997). This confidence, or lack thereof, has an influence on choice of activities, degree of effort expended, and persistence of effort. Indeed, perceived self-efficacy is a learner's belief that their performance can be improved through achievement-related behavior. The level of perceived self-efficacy might be used as a reliable indicator to predict a learner's achievement (Askar & Davenport, 2009). When students learn from computer-programming examples, thinking about how to solve new programming problems and practice writing programs, they can perceive enhancement in self-efficacy and how effective students consider themselves to be when faced with programming tasks. Self-efficacy refers to "belief in one's capabilities to organize and execute the course of action required to produce given attainments" (Bandura, 1997). Perceived self-efficacy can be correlated with achievement-related behaviors such as skills performance, motivation, and choice of activities (Bandura, 1986). People who perceive themselves as self-efficacious will persist in their efforts longer and more actively. Self-efficacy is a factor, which affects educational motivation. In a study using multiple regression analysis, the results showed that the classroom-learning environment, institutional support, and academic self-efficacy explained 30% of the variance of motivation to study (Thomas, 2015). Previous studies have suggested that a higher degree of perceived self-efficacy leads to improved learning performance and better behavioral retention in e-learning environments because learners are more likely to have a more positive attitude towards learning in such environments (Torkzadeh, Chang, & Demirhan, 2006; Liaw, 2008; Chu & Chu, 2010). In other words, learners' self-efficacy can affect learners' attitudes, their ability to acquire skills, choice of activities, and willingness to continue on a course of action. Sharma, Dick, Chin, & Land (2007) stated that perceived self-efficacy is an essential factor, which increases learners' self-regulation.

2.3 Perceived anxiety

Perceived anxiety refers to an unpleasant emotional state or condition characterized by tension, apprehension, and worry (Spielberger, Gorsuch, & Lushene, 1970). General feelings of anxiety have been associated with broad work-related outcomes, such as stress and feelings of work overload (Ganster & Schauebrock, 1991), as well as beliefs about one's ability (Ghiselli, Campbell, & Zedeck,1981). Computer anxiety is characterized as an affective response and has been defined as a fear of using computers (Chua, Chen, & Wong, 1999), specifically an emotional fear of potential negative outcomes such as damaging the equipment or appearing foolish. From an information-processing perspective, the negative feelings associated with high levels of anxiety divert cognitive resources from task performance (Kanfer & Heggestad, 1999). Participants with a high degree of computer anxiety might perform poorer than those with little or no computer anxiety (Liaw & Huang, 2013).

Several studies, which explored the relationships between computer anxiety and Internet usage, have found that computer anxiety is negatively related to students' use of the Internet (Barbeite & Weiss, 2004; Durndell & Haag, 2002).

Perceived anxiety towards the Internet is a fear or apprehension that individuals experience when using the Internet (Presno, 1998). Furthermore, using the Internet presents risks, such as the potential for exposure to viruses and spyware, or invasions of user privacy (Barbeite & Weiss, 2004). In computer programming, learners may feel anxious when a development tool reports errors. Various studies, which have investigated the relationships between Internet anxiety and Internet use, have found that perceived anxiety was negatively correlated with students' use of the Internet (Chou, 2003; Joiner, Brosnan, Duffield, Gavin, & Maras, 2007). In e-learning environments, perceived anxiety has had a negative relationship to learners' motivation, and self-regulation (Tsai, 2009). Additionally, perceived anxiety has been found to be a negative predictor, which influenced perceived satisfaction towards e-learning (Sun et al., 2008).

2.4 Interactive learning environments

Communication or interaction (e.g., questioning, answering, discussing, debating, negotiating, etc.) can occur both between learners and teachers, and among learners in a learning environment (Liaw, 2004). At the beginning of a programming course, the teachers interactively engage learners in the problem solving process. As the course progresses, the students become more confident so they can tutor each other on how to write and debug programs. Furthermore, in an asynchronous learning environment, learners are not dependent upon instructors and can actively participate in their own learning. Learners are simultaneously active to conduct teaching and learning activities (Liaw, 2004). In asynchronous communication, learners work at their own convenience and control the pace of instruction. Synchronous communication occurs in real time, requiring instructors and learners to be simultaneously available for interaction. Prior e-learning studies have shown that an interactive learning environment is a crucial factor that results in positive attitudes such as perceived satisfaction, usefulness, and self-regulation in e-learning environments (Liaw & Huang, 2007; Sharma et al., 2007). This means that friendly interactive learning environments may enhance learners' self-regulation towards learning (Vighnarajah, Wong, & Kamariah, 2009). In computer-programming environments, human-machine interaction is very important because the system or computer language compiler interactively gives students feedback about incorrect syntax and other programming errors. Students can then use this interactive information to edit and debug their computer programs.

2.5 Perceived satisfaction and usefulness

Research has shown that learner satisfaction and usage are essential factors in assessing the success of learning systems (Delone & Mclean, 2003; Lewis, 2002; Virvou & Katsionis, 2008). Perceived satisfaction can be defined as user acceptance of information systems and the degree of comfort involved in using them. It can also be defined as the pleasure or contentment felt when a required or desired action is performed and the result is experienced (Shee & Wang, 2008). Satisfaction has been positively conceptualized as the aggregate of a person's feelings or attitudes towards the various factors that affect a certain situation. From an information system perspective, Doll and Torkzadeh (1988) defined satisfaction as the condition of taking an affective attitude towards a given system. Thus, a greater degree of satisfaction towards an information system implies a higher degree of willingness to use it. In the field of human-computer interaction, user satisfaction is usually visualized as an expression of affection gained from interaction. This means that user satisfaction is the "subjective sum of interactive experiences" influenced by many affective components in the interaction (Lindgaard & Dudek, 2003). In the past, many attempts had been made to measure user satisfaction. The results showed that user satisfaction was a complex construct and its substance varied with the nature of the experience or case. For example, in an e-learning system, user satisfaction was significantly influenced by system quality, system usability and content quality (Kim & Ong, 2005). Other e-learning research suggested that the use of rich media with more interactive functions could enhance learner satisfaction (Liu, Liao, & Pratt, 2009). Regarding the relationship between perceived satisfaction and self-regulation, previous studies by Kramarski and Gutman (2006), as well as Roca and Gagne (2008), concluded that perceived satisfaction and self-regulation were highly correlated in e-learning environments.

In most cases, usability is considered a decisive factor affecting educational effectiveness (Virvou & Katsionis, 2008). Usability has been defined as a quality or attribute that represents the ease of use of human-computer interfaces (Kneebone, 2003). Sharma et al. (2007) found that perceived usefulness was an essential factor that increased learners' self-regulation in e-learning environments. Tsai (2009) stated that increasing learners' perceived usefulness could enhance learners' self-regulation in e-learning. Additionally, perceived usefulness of the applications of smart wearable devices was a strong predictor of perceived usefulness of using these devices for disaster applications (Cheng & Mitomo, 2017).

2.6 Learner self-regulation

Educational research has focused on students' self-regulated learning skills for the acquisition of knowledge and academic success (Zimmerman & Schunk, 2001; Dabbagh & Kitsantas, 2004). Pintrich (2000) defined self-regulated learning as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment". Indeed, self-regulated learners are those who "direct their learning processes and attainments by setting challenging goals for themselves, by applying appropriate strategies to achieve their goals and, by enlisting self-regulative influences that motivate and guide their efforts" (Zimmerman, Bandura, & Martinez-Pons, 1992, p. 664). Self-regulated learners are more meta-cognitively, motivationally, and behaviorally active participating in their own learning process (Zimmerman & Schunk, 2001; Kramarski & Gutman, 2006). A high degree of self-regulation leads to greater engagement with the e-learning system. E-learning environments provide students with dynamic, interactive nonlinear access to a wide range of information represented as text, graphics, animation, audio, and video, as well as to self-directed learning in online communicative environments (Kramarski & Gutman, 2006; Vighnarajah et al., 2009). Dabbagh and Kitsantas (2004) found that learners needed to exercise a high degree of self-regulation to accomplish their learning goals in e-learning environments. Furthermore, self-regulated learners were more inclined to transfer knowledge from e-learning environments into real-world situations. Previous studies indicated that students who lacked good self-regulation were not as academically successful, while successful learners were more likely to be self-regulating (Zimmerman & Schunk, 2001; Chen, 2009). Therefore, one challenge for course designers and educators is to develop effective learning environments that encourage students to become active, autonomous, and self-regulated learners. What factors could influence self-regulation in e-learning? Sharma et al. (2007) stated that learners should possess the following self-regulatory attributes to enhance learning capability: 1) motivation in terms of goal orientation, 2) learner self-efficacy, 3) environment management, and 4) interaction when seeking help. Learner self-efficacy is a positive individual characteristic, whereas learner anxiety is a negative individual characteristic. Effective learning activity such as perceived self-regulation could be influenced by other factors such as individual learning characteristics, perceived self-efficacy, anxiety, the learning environment and, positive learning attitudes including perceived satisfaction and usefulness (Liaw & Huang, 2013). Learner achievement can probably be influenced by individual learning characteristics, positive learning attitudes and behavior such as perceived self-regulation and memory strategies used by learners. Ekhlas and Shangarffam (2013) showed that behavioral self-regulation strategies had a positive relationship to English reading, writing, speaking, and overall proficiency.

2.7 Memory strategies and learning achievement

Zimmerman and Martinez-Pons (1986) studied self-regulation strategies, which were important for successful learning. Zimmerman (1989) reported that self-regulated strategies were highly correlated with students' test scores. Ekhlas and Shangarffam (2013) studied the use of memory strategies, the four language skills, and overall proficiency. The use of memory strategies such as taking notes in a class and memorizing course content was important to successful learners. To write computer programs, students have to memorize the commands and syntax of a computer language. Engineering students learning computer programming often use memory strategies. Therefore, it is worthwhile investigating the effects of memory strategies on learning achievement in computer programming.

2.8 Mobile phone and tablet use

Studies on the use of ICT in learning (Panangalage, Virtusa, & Pasqual, 2008; Liaw & Huang, 2013) found that electronic mobile devices can be used to learn Mathematics. However, nowadays, many teachers may feel uncomfortable with the way that students use mobile phones and tablets in the classroom because it is difficult for them to teach their classes effectively due to distractions. Applications that students use in the classroom include Facebook, Line, and YouTube. They may be improperly used to communicate or chat with friends, play games or watch video clips. This behavior distracts students from course content and other activities provided by their teachers. Therefore, it is worthwhile exploring factors that can be used to predict the improper use of mobile phones and tablets, and find a method to reduce the improper use in the learning environment.

3. Research hypotheses

This study focuses on using a proposed 4-tier model to investigate factors affecting learners' perceived satisfaction, perceived usefulness, perceived self-regulation, memory strategies, smart phone and tablet use (improper use), and achievement, as shown in Figure 3. The research hypotheses were set, as shown in Table 1.

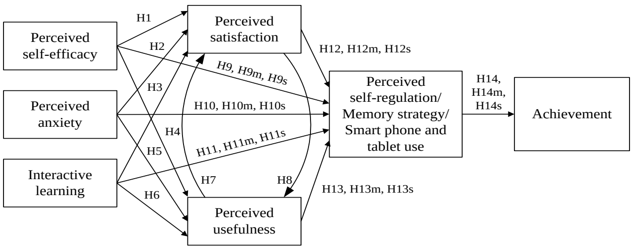

Figure 3 Research hypotheses

Table 1 Research hypotheses

No.	Hypothesis
H1	Perceived satisfaction of learning computer programming will be affected by perceived self-efficacy.
H2	Perceived satisfaction of learning computer programming will be affected by perceived anxiety.
H3	Perceived satisfaction of learning computer programming will be affected by interactive learning environments.
H4	Perceived usefulness of learning computer programming will be affected by perceived self-efficacy.
H5	Perceived usefulness of learning computer programming will be affected by perceived anxiety.
H6	Perceived usefulness of a computer-programming learning environment will be affected by interactive learning environments.
H7	Perceived satisfaction of learning computer programming will be affected by perceived usefulness.
H8	Perceived usefulness of learning computer programming will be affected by perceived satisfaction.
H9, H9m, H9s	Perceived self-regulation (H9), memory strategy (H9m), or smart phone and tablet use (H9s) will be affected by perceived self-efficacy.
H10, H10m, H10s	Perceived self-regulation (H10), memory strategy (H10m), or smart phone and tablet use (H10s) will be affected by perceived anxiety.
H11, H11m, H11s:	Perceived self-regulation (H11), memory strategy (H11m), or smart phone and tablet use (H11s) will be affected by interactive learning environments.
H12, H12m, H12s	Perceived self-regulation (H12), memory strategy (H12m), or smart phone and tablet use (H10s) will be affected by perceived satisfaction.
H13, H13m, H13s	Perceived self-regulation (H13), memory strategy (H13m), or smart phone and tablet use (H13s) will be affected by perceived usefulness.
H14, H14m, H14s	Achievement will be affected by perceived self-regulation (H14), memory strategy (H14m), or smart phone and tablet use (H14s).

4. Methodology

4.1 Participants

A questionnaire was distributed to one hundred randomly selected engineering students after they had attended a computer-programming course, for four hours per week for three months, during the last class before the final examination. Each student had a computer and the Microsoft Visual C# programming development tool was used throughout the course. The teacher gave the related course materials in advance. Each week, students were assigned to complete programming problems, such as computing a cone volume, sorting numbers and writing a simple web browser, in the class. To achieve the goal, students had to write programs, correct errors and derive correct outputs.

4.2 Instruments

The questionnaire was adapted from research by Liaw and Huang (2013). The questionnaire was used to measure eight factors consisting of 1) self-efficacy, 2) perceived anxiety, 3) interactive learning environment, 4) perceived satisfaction, 5) perceived usefulness, 6) self-regulation, 7) memory strategy and 8) the use of smart phones, tablets and applications. The memory strategy factor was revised based on Ekhlas and Shangarffam (2013). The part devoted to the use of the smart phones and tablets was newly developed for this questionnaire. The eight-factor questionnaire covered 37 items. Each item was rated using a 7-point Likert scale (1 = “strongly disagree” to 7 = “strongly agree”). The English language version of the questionnaire can be found in Section 9, the Appendix.

4.3 Data collection procedure

One hundred engineering students who enrolled in a computer-programming course were asked to fill out a Thai version of the questionnaire. The scores representing learners’ achievement were collected from the final examination.

4.4 Statistical analysis

To ensure the reliability of the questionnaire, Cronbach’s alpha coefficients were computed. Pearson bivariate correlations and multiple linear regression analysis were applied to find the relationships and the influences between factors. IBM SPSS Statistics Version 22 (Passport Advantage Customer: Rangsit University) were used to compute Cronbach’s alpha coefficients, Pearson bivariate correlations and multiple linear regression.

5. Results

5.1 Questionnaire reliability

For the construct validity test, three university lecturers considered whether each item on the questionnaire was appropriate for representing the construct (things) being measured. If any item was not agreed on by all the lecturers, then it was removed. After the elimination of the items, the reliability of each item and the whole questionnaire was computed. Finally, based on the values derived from the reliability test, some items were removed to obtain a reliable questionnaire. Overall Cronbach’s alpha coefficient for the questionnaire was 0.880. Cronbach’s alpha coefficient for each construct ranged from 0.868 to 0.938, as shown in Table 2.

Table 2 Cronbach’s alpha coefficients

Construct	Cronbach’s alpha coefficients
1. Perceived self-efficacy	0.938
2. Perceived anxiety	0.904
3. Interactive learning environments	0.897
4. Perceived satisfaction	0.900
5. Perceived usefulness	0.868
6. Perceived self-regulation	0.879
7. Memory strategy	0.884
8. Smart phone and tablet use	0.884

5.2 Relationships between factors

To investigate the relationships between factors, Pearson bivariate correlations (r) were computed. The results are shown in Table 3.

Table 3 shows positive relationships between the following factors: perceived self-efficacy, interactive learning environment, perceived satisfaction, perceived usefulness, memory strategy, and perceived self-regulation. Significant negative relationships were found between perceived anxiety and all other factors except the achievement score. Memory strategy had significant positive relationships with all other investigated factors except perceived anxiety, which had a significant negative relationship (r=-.344, $p<0.1$). The inappropriate use of mobile phones had a significant positive relationship to perceived anxiety (r=.349, $p<0.1$) and a significant negative relationship to perceived usefulness (r=.335, $p<0.1$) and memory strategies (r=-.208, *p*<0.5). Based on the relationships between the investigated factors and scores, student achievement had a significant correlation to perceived satisfaction (r=.205, *p*<0.5), perceived usefulness (r=.229, *p*<0.5), and memory strategy (r=.318, *p*<0.1). Perceived self-regulation did not show any significant relationship to students' scores.

Table 3 Correlations between factors

Tier	Factors	1	2	3	4	5	6	7	8	9
Learners' characteristics and/or system factors	1. Perceive self-efficacy	1								
	2. Perceive anxiety	-.236(*)	1							
	3. Interactive learning environments	.629(**)	-.293(**)	1						
Affective and/or cognitive factors	4. Perceive satisfaction	.521(**)	-.277(**)	.701(**)	1					
	5. Perceive usefulness	.423(**)	-.284(**)	.488(**)	.585(**)	1				
Behavioral factors	6. Perceive self-regulation	.601(**)	-.341(**)	.679(**)	.729(**)	.592(**)	1			
	7. Memory strategies	.425(**)	-.344(**)	.413(**)	.436(**)	.540(**)	.554(**)	1		
	8. Smart phone and tablet use	-.020	.349(**)	-.005	-.051	-.335(**)	-.172	-.208(*)	1	
Achievement	9. Score	.182	-.160	.189	.205(*)	.229(*)	.120	.318(**)	-.084	1

* Correlation is significant at the .05 level (2-tailed).
** Correlation is significant at the .01 level (2-tailed).

5.3 Learners' characteristics and system factors affecting perceived self-regulation

The results show that learners' characteristics and system factors consisting of perceived self-efficacy, and interactive learning environments affected perceived self-regulation. Multiple linear regression analysis was applied to illustrate the results, the values obtained from the analysis are shown in Figure 4.

The R^2 (R-squared) value, which is a statistical measure of how close the data are to the fitted regression line, was derived from the multiple linear regression analysis. The R^2 value of 0.511 shows learners' characteristics and/or system factors consisting of perceived self-efficacy and interactive learning environment can be used to determine perceived self-regulation.

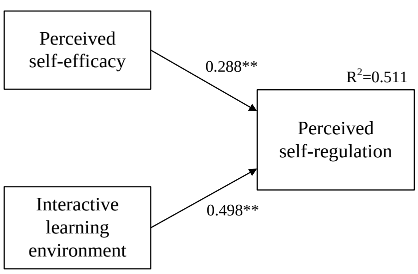

Figure 4 Learners' characteristics and/or system factors and perceived self-regulation in learning computer programming

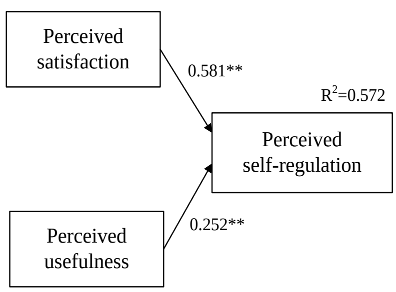

Figure 5 Affective and/or cognitive factors and perceived self-regulation in learning computer programming

5.4 Affective and/or cognitive factors affecting perceived self-regulation

Figure 5 shows that perceived self-regulation can be predicted by perceived satisfaction and usefulness.

The R^2 value indicates that these two factors effected perceived self-regulation and should be considered when promoting students' perceived self-regulation. The R^2 values (0.572 vs. 0.511) in Figures 4-5 show that affective and/or cognitive factors can better explain perceived self-regulation than learners' characteristics and/or system factors.

5.5 Combined factors affecting perceived self-regulation

Figure 6 shows the effect of learners' characteristics and/or system factors together with affective and/or cognitive factors on perceived self-regulation. Perceived self-regulation can be predicted using perceived self-efficacy, the interactive learning environment, perceived satisfaction and perceived usefulness (R^2=0.640). Perceived satisfaction can be determined by the interactive learning environment and perceived usefulness (R^2=0.569). Perceived usefulness can be predicted by perceived satisfaction (R^2=0.343).

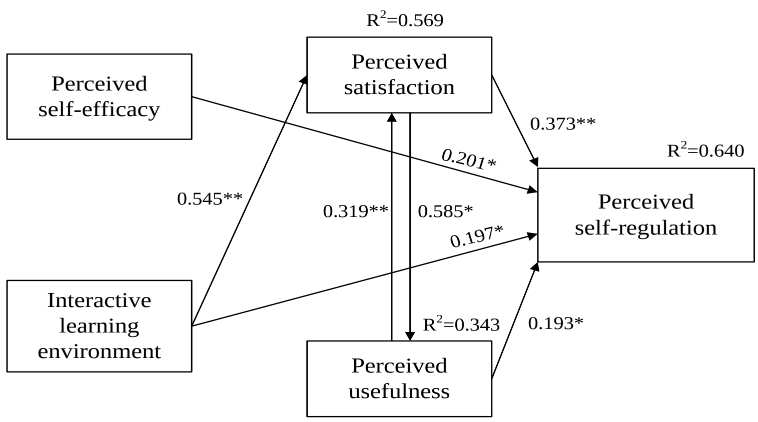

Figure 6 An efficient model to predict perceived self-regulation in learning computer programming

5.6 Factors affecting memory strategy and achievement

Figure 7 shows that perceived self-efficacy, perceived anxiety and perceived usefulness can be used to predict memory strategy (R^2=0.368) and memory strategy can be used to predict computer-programming achievement (R^2=0.101). The results show that memory strategy affects computer-programming achievement; however, it is not a very efficient predictor to determine the achievement because the obtained R^2 value is rather low.

To become more practical, teachers may encourage the use of memory strategies by increasing the students' perceived self-efficacy and perceived usefulness while attempting to reduce their perceived anxiety. Importantly, teachers should also encourage their students to rewrite programs by hand on paper and take notes during classes.

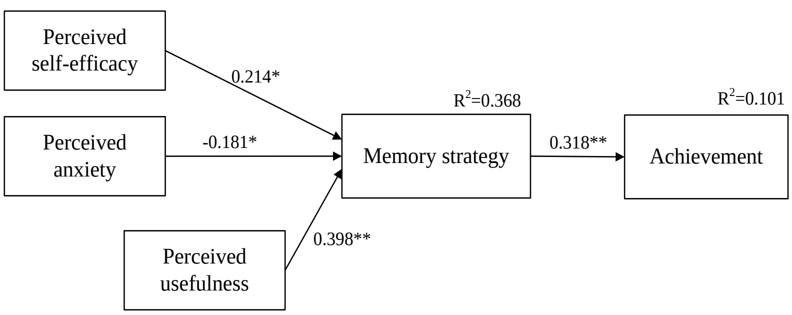

Figure 7 Factors affecting memory strategy and achievement in learning computer programming

5.7 Factors affecting smart phone and tablet use

Figure 8 shows that the improper use of smart phones and tablets can be predicted using perceived anxiety, perceived satisfaction and perceived usefulness (R^2=0.230). However, the data did not show that the improper use of mobile applications such as Facebook, Line, and YouTube affected computer-programming achievement.

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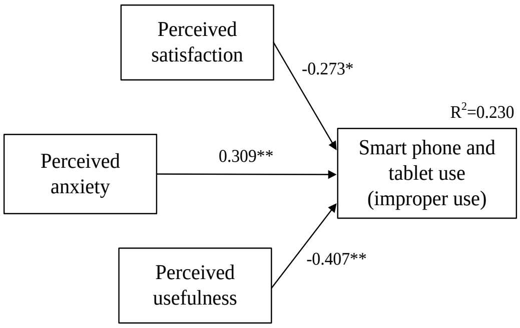

Figure 8 Factors affecting improper smart phone and tablet use in a computer-programming learning environment

In the past, teachers could use corporal punishment to discipline students, or they could order students to run around a school building and repeatedly shout a phrase, for example, "I will not use Facebook in the classroom again". Nowadays, parents do not expect teachers to implement physical punishments. To reduce the problem of improper smart phone and tablet use in the classroom, alternative practical ways are reducing students' anxiety and increasing their perceived satisfaction and usefulness.

5.8 Summary of accepted hypotheses

Based on the findings in Figures 6-8, a summary of the accepted hypotheses has been derived, as shown in Table 4. According to the results, to improve students' perceived satisfaction, we should promote interactive learning environments and perceived usefulness. Perceived self-regulation can be improved by promoting perceived self-efficacy, interactive learning environments, perceived satisfaction and perceived usefulness. Memory strategies can be enhanced by promoting perceived self-efficacy and perceived usefulness while attempting to reduce perceived anxiety. Promoting memory strategy use can help to improve students' achievement. The more anxiety the students experience, the more frequently they tend to use smart phones and tablets in the classroom. Improper use of smart phones and tablets can be decreased by promoting perceived satisfaction and perceived usefulness while finding ways to reduce perceived anxiety.

Table 4 Summary of the accepted hypotheses tests

No.	Hypothesis	β
H3	Interactive learning environments → Perceived satisfaction	0.545**
H7	Perceived usefulness → Perceived satisfaction	0.197*
H8	Perceived satisfaction → Perceived usefulness	0.585*
H9	Perceived self-efficacy → Perceived self-regulation	0.201*
H11	Interactive learning environments → Perceived self-regulation	0.197*
H12	Perceived satisfaction → Perceived self-regulation	0.373**
H13	Perceived usefulness → Perceived self-regulation	0.193*
H9m	Perceived self-efficacy → Memory strategy	0.214*
H10m	Perceived anxiety → Memory strategy	-0.181*
H13m	Perceived usefulness → Memory strategy	0.398**
H14m	Memory strategy → Achievement	0.318**
H10s	Perceived anxiety → Smart phone and tablet use	0.309**
H12s	Perceived satisfaction → Smart phone and tablet use	-0.273*
H13s	Perceived usefulness → Smart phone and tablet use	-0.407**

* Significant at the .05 level (2-tailed).
** Significant at the .01 level (2-tailed).

6. Discussion

In accordance with Liaw & Huang (2013), perceived satisfaction and usefulness affected perceived self-regulation in a computer-programming learning environment. This research agreed with this previous study and also found that self-efficacy was another factor that could be added to predict perceived self-regulation. However, perceived self-regulation had no significant effect on computer-programming achievement. This may be because the students had opportunities to use course materials and ask classmates or teachers while learning computer programming. On the other hand, while taking the examination, they were not allowed to use course materials or seek assistance. Usefulness was an important cognitive factor that affected self-regulation and memory strategies. The results support the findings of Mac Callum, Jeffrey & Kinshuk (2014,) who found that usefulness had a positive effect on behavioral intention. During computer-programming classes, if students felt that computer programming was useful, they paid attention while writing computer programs. However, when some students felt that learning computer programming was not useful or interesting, they tended to use social network applications on their mobile phones and tablets in the classroom. Although applying memory strategies had no significant effect on English skills (Ekhlas & Shangarffam, 2013), memory strategies had an effect on computer-programming achievement. The students who wrote programs on paper, took notes and attempted to memorize contents that the teacher emphasized, tended to get higher exam scores. The improper use of mobile applications such as Facebook, Line, and YouTube did not significantly affect computer-programming achievement. To tackle the problem, instead of punishing students, it is suggested that teachers encourage students to realize the usefulness of computer programming in a practical way to develop programming skills, which will eventually result in less negative side effects for both teachers and students.

7. Conclusion

This research has revealed factors that can lead to the design of an effective environment, which is suitable for learning computer programming. The proposed 4-tier model was used to investigate factors, which affected learning achievement. In addition, it was used to create more understanding of the factors that affected learners' attitudes, behaviors, and achievement. Perceived usefulness played an important role in determining self-regulation, memory strategy and the improper use of smart phones and tablets in the learning environment. Perceived self-regulation was affected by perceived self-efficacy, the interactive learning environment, perceived satisfaction and perceived usefulness. To raise achievement levels when learning computer programming, students' perceived self-efficacy, perceived anxiety, perceived usefulness and memory strategies should be taken into account while designing learning environments. The inappropriate use of smart phones and tablets can be alleviated by attempting to reduce perceived anxiety and explaining the usefulness of computer programming. However, no significant evidence was found that the inappropriate use of mobile and smart phone applications affected the students' computer-programming achievement.

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9. Appendix

Questionnaire items

Perceived self-efficacy

1. I feel confident when writing a computer program.
2. I feel confident when using the programming development tool menu.
3. I feel confident when using the programming development tool to compile and run a program.
4. I feel confident correcting the errors of a written computer program.

Perceived anxiety

1. I lack confidence when writing a computer program.
2. I feel anxious when using the programming development tool.
3. I am afraid to write a computer program.
4. I feel it is difficult to use the programming development tool.

Interactive learning environments

1. The programming development tool can interactively give information to help to correct the errors in a program.
2. My classmates' interaction can help me to learn computer programming.
3. My teacher's interaction can help me to learn computer programming.
4. The programming development tool can interactively help me to write a program more easily.
5. The interactive programming tool menus are easy to use.

Perceived satisfaction

1. I am satisfied with writing a computer program.
2. I am satisfied with learning computer programming.
3. I am satisfied with the functions of the programming development tool.

4. I am satisfied with the way that the programming development tool shows the output of a program.

Perceived usefulness

1. I believe that a computer program helps me to solve problems.
2. I believe that a computer program can give a useful result.
3. I believe the programming development tool helps me to understand computer programming and write a program more easily.
4. I believe that learning to write a computer program is useful.

Perceived self-regulation

1. I can write a program by myself.
2. The programming development tool is easy to self-regulate.
3. The programming development tool assists me in correcting program errors by myself.
4. I know how to understand the course content by myself.
5. I develop a plan to achieve goals such as being able to write a program by myself.
6. The programming development tool helps me to practice writing a program by myself.

Memory strategy

1. I write programs on paper.
2. I take notes while the teacher is lecturing.
3. I take notes on things that the teacher emphasizes.
4. I try to memorize things that the teacher emphasizes.

Use of smart phones, tablets and applications

1. I use the Facebook application in the classroom.
2. I use the Line application in the classroom.
3. I use the YouTube application in the classroom.
4. I play games in the classroom.
5. I take selfies and my friends' photographs in the classroom.
6. I use a smart phone or tablet in the classroom.