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Abstract

High failure rates appear to be a norm in introductory programming courses. Many solutions have been proposed to improve the high failure rates. Surprisingly, the solutions have not resulted in significant improvements to the performance of students in introductory programming courses. Instead, there appears to be a gap in understanding the relationship between self-efficacy, emotional engagement and the performance of students in introductory programming courses. Enjoyment, interest, and gratification were identified as three emotional engagement factors in introductory programming courses from prior literature and from focus groups. An online survey on 433 students in introductory programming courses showed that the students' programming self-efficacy beliefs had a strong positive impact on enjoyment, while gratification and interest had a negative impact on programming performance. These findings have implications for course instructors who design and deliver introductory programming courses.

Keywords self-efficacy, emotional engagement, introductory programming, programming performance

1 Introduction

The failure rates in introductory programming courses are alarming and is a major concern for educators since it is a mandatory course in Information and Communications Technology (ICT) related disciplines. Reports of failure rates between 30% and 50% (Bennedsen and Caspersen 2007; Quille and Bergin 2016) are common in the literature on programming research. The solutions that have been proposed to improve the failure rates have largely focused on improving the demanding cognitive load on students, while the behaviour of the students has not been examined extensively (Kanaparan, Cullen and Mason 2013) although the literature on learning theory suggests that there is a strong link between the behaviour of the student and their performance (Bresó et al. 2011; Schunk and Mullen 2012).

This research focuses on two behavioural factors: self-efficacy and emotional engagement since the literature on learning theory suggests that self-efficacy is one contextual factor that affects engagement, and engagement then affects the performance of the student (Appleton et al. 2006; Linnenbrink and Pintrich 2003; Schunk and Mullen 2012). Although self-efficacy is necessary for success in learning, the student may not necessarily be engaged in learning (Appleton et al. 2006). Instead, students that are engaged in learning are self-efficacious learners who strive to achieve their goals and be successful (Schunk and Mullen 2012).

This research then asks the following questions:

Research Question 1: What is the effect of programming self-efficacy on the emotional engagement of students in introductory programming courses?

Research Question 2: What is the effect of emotional engagement on the programming performance of students in introductory programming courses?

2 Theoretical Framework and Research Hypotheses

2.1 Programming self-efficacy and Social Cognitive Theory

Social Cognitive Theory (SCT) is a widely accepted and empirically validated model that explains human behaviour. The SCT framework is based on the premise that human beings have the ability to control their thoughts, feelings, motivation, and actions (Bandura 1986). The theory of self-efficacy is part of Bandura's SCT and self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura 1986 p 391). Self-efficacy is an independent variable in this research.

Several researchers have examined the influence of self-efficacy theory on programming students. One such research identified the factors that influence the self-efficacy beliefs of students in introductory programming courses (Zingaro 2014), while other researchers have examined the relationship between the student's self-efficacy beliefs and their programming performance (Kinnunen and Simon 2011; Ramalingam et al. 2004), and have reported positive outcomes. By contrast, research in the literature on learning theory largely examined the effect of self-efficacy on student motivation, learning, and performance (Phan 2011; Zimmerman, 2000) and have found that self-efficacy beliefs affects performance, perseverance to learn, and has the ability to alter behaviour (Yip 2012; Zimmerman 2000). This leaves a gap in understanding the self-efficacy and engagement behaviour of students in introductory programming courses in the ICT discipline.

2.2 Emotional Engagement and Student Engagement

Engagement is a multi-dimensional construct, and is the second independent variable in this research. Student engagement has emerged as a theoretical model for understanding which students are likely to fail, dropout from school, and for improving student motivation and achievement (Appleton et al. 2008; Christenson et al. 2012; Fredricks et al. 2004).

Engagement is defined as "the student's active participation in academic and co-curricular or school-related activities, and commitment to educational goals and learning…. student engagement drives learning; requires energy and effort; is affected by multiple contextual influences; and can be achieved for all learners" (Christenson et al. 2012 pp 816-817). There is general agreement that two of the engagement dimensions are behavioural engagement and cognitive engagement (Appleton et al. 2006; Fredricks et al. 2004; Linnenbrink and Pintrich 2003; Reschly and Christenson 2012). Evidence from existing literature on learning theory suggests that the third dimension of engagement is emotional engagement (Betts et al. 2010).

Of interest to this research is the emotional engagement dimension. Emotional engagement refers to the student's feeling, attitude, and perception towards learning, and the learning environment (Sheard et al. 2010; Yazzie-Mintz and McCormick 2012). Enjoyment and interest were identified as indicators of emotional engagement from the literature on learning theory (Appleton et al. 2006; Linnenbrink and Pintrich 2003; Reschly and Christenson 2012) and through a literature search on programming research in the ACM Digital Library and the ProQuest Computing databases.

Next, 4 focus groups were conducted in New Zealand and in Malaysia. The purpose of the focus groups was to validate the proposed indicators, and to identify other likely indicators of emotional engagement in introductory programming courses. There were between 3 and 5 participants in each focus group and each were between 45 and 60 minutes in duration. In total, 16 students who were mid-way through their introductory programming course participated in the focus groups. The students were asked questions that would prompt them to discuss their engagement behaviour when they were learning programming.

The focus groups were transcribed and then analysed using an inductive and deductive approach (Thomas 2006) which resulted in the identification and validation of the indicators of emotional engagement in introductory programming courses. As a result, enjoyment and interest were validated as potential indicators of emotional engagement in introductory programming courses, while gratification emerged as a third indicator of emotional engagement in introductory programming courses.

2.2.1 Enjoyment

Enjoyment "causes the subject to experience pleasure by causing occurrent beliefs which satisfy desires concerning the experience itself" (Davis 1982 p 240). The analysis from the focus groups confirmed that enjoyment was an indicator of emotional engagement in introductory programming courses. The following are quotes from the participants who appeared to enjoy learning programming:

> *"Because I really enjoy programming. Maybe I go so far as to say I have fun while doing it. " (CL, FG2)*

> *"...thoroughly enjoy programming... thoroughly hate doing essays" (CM, FG1)*

In the literature on learning theory, positive correlations were observed between self-efficacy and enjoyment (Mills et al. 2007), and that high self-efficacy results in pleasant emotions such as enjoyment (Putwain et al. 2013). Therefore, the following hypothesis is proposed:

H1: Self-efficacy beliefs in learning programming will have a positive effect on enjoyment.

In the research on learning programming, using the Alice programming environment increased enjoyment in programming (Bishop-Clark et al. 2007) and pair programming increased enjoyment in programming (Liebenberg et al. 2012; Maguire et al. 2014). In yet another study, Frenzel et al. (2007) found positive correlations between enjoyment and the academic performance of students. Therefore, the following hypotheses is proposed:

H2: Enjoyment in learning programming will have a positive effect on programming performance.

2.2.2 Interest

Interest is defined as "an emotion that arouses attention to, curiosity about, and concern with..." a discipline of study (Akbulut and Looney 2007 p 68). The analysis from the focus groups confirmed that interest was an indicator of emotional engagement in introductory programming courses. The following are quotes from the participants who appeared to have an interest in learning programming:

> *"I am interested because the code itself makes me very curious about what the outcome would be" (FA, FG4)*

> *"...programming is going to be my life...that's what I want to be when I'm finished..." (MH, FG1)*

Silvia (2003) suggested that self-efficacy affects interest indirectly, where "self-efficacy affects uncertainty about how the activity will resolve, which in turn affects interest" (p.239), while Linnenbrink and Pintrich (2003) argued that as the student develops expertise in a given task, his or her self-efficacy beliefs and interest increases. Additionally, Bandura (1997) suggests that a moderate level of self-efficacy is essential for sustaining interest in a given task, while Akbulut and Looney (2007), and Wiedenbeck et al. (2007) found a positive relationship between programming self-efficacy and interest. Therefore, the following hypothesis is proposed:

H3: Self-efficacy beliefs in learning programming will have a positive effect on interest.

McKinney and Denton (2004) and Wiedenbeck et al. (2007) found that interest is significantly correlated to programming performance. On the other hand, Sheard et al. (2010) suggest that a student's level of interest can vary across courses, with students reporting high interest in topics such as programming and computer networks. Further, in the literature on learning theory, Bye et al. (2007) found that interest is a strong predictor of motivation to learn. Therefore, the following hypothesis is proposed:

H4: Interest in learning programming will have a positive effect on programming performance.

2.2.3 Gratification

Interestingly, during the focus groups, gratification emerged as a new indicator of emotional engagement. In the literature on learning theory, research on gratification discusses "delay of gratification" and its effect on academic success. Delay of gratification is the "voluntary postponement of immediate rewards and persistence in goal-directed behaviour for the sake of later outcomes" (Mischel et al. 1989 p 933).

However, during the focus groups, the participants felt a feeling of immediate gratification when they were able to debug the errors in their program and were able to see the output of their program. For example, participant DI from Focus Group 2 explained that programming gave him an immediate sense of achievement compared to other courses. Similarly, participant RS from Focus Group 2 felt rewarded each time she achieved a milestone in her programming assessment but added that she did not feel the same way after she had completed the assessments for other courses. Participant CL from Focus Group 2 echoed similar feelings of gratification whereby he felt triumphant when he was able to solve a programming problem.

Therefore, for the purpose of this study, gratification is defined as students who experience "the feeling of receiving immediate rewards typically in the form of pleasure or satisfaction as a result of hard work". The interpretation of gratification in this study focuses on *immediate gratification* as opposed to *delay of gratification* which is a common outcome of learning in the literature on learning theory. The following hypotheses are proposed despite a lack of evidence from the existing research that suggests a relationship between programming self-efficacy and gratification, and a relationship between gratification and programming performance:

H5: Self-efficacy beliefs in learning programming will have a positive effect on gratification.

H6: Gratification in learning programming will have a positive effect on programming performance.

2.3 Programming Performance: The Dependent Variable

The dependent variable in this research, programming performance, was measured by the final grade that the students received at the end of their introductory programming course. The final grade provides and objective measure of the student's level of performance in the course by assessing their ability to program. Programming grade was proposed as the dependent variable in this research since evidence from prior research on introductory programming courses suggests that course grade is a strong indicator of success and is a criteria for progression to the next level of study (deBry 2011; Ford and Venema 2010).

2.4 Confounding Variables

Prior programming experience and learning ability which was measured by the high school/pre-University results of the students were identified as two potential confounding variables. The confounding variables did not significantly affect the performance of the students.

Figure 1 shows the research model for self-efficacy, emotional engagement, and programming performance. The hypotheses on the left side of the research model (H1, H3 and H5) seeks to address Research Question 1, and the hypotheses on the right side of the research model (H2, H4 and H6) seeks to address Research Question 2.

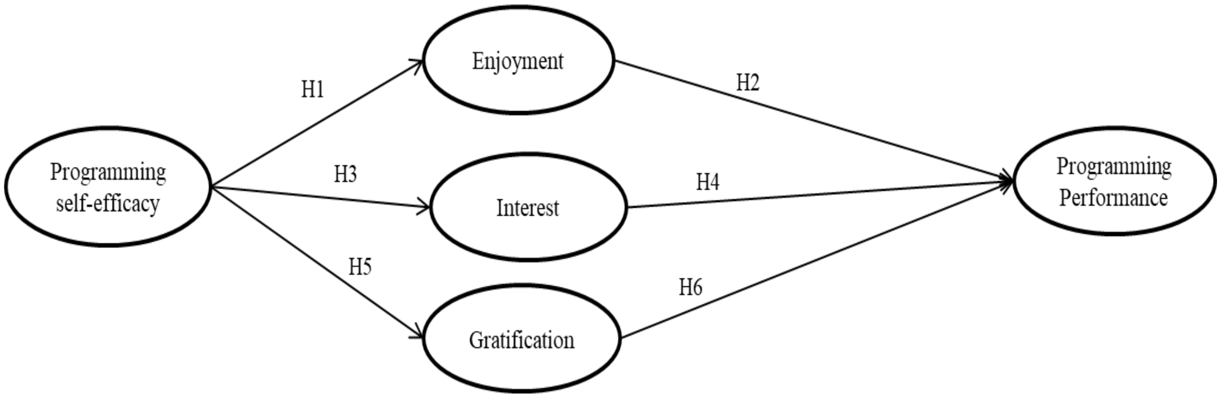

Figure 1. Research model for self-efficacy, emotional engagement, and programming performance

3 Methodology

The data for this study was collected using a cross-sectional survey. Self-reporting questionnaires was administered to the students in the final week of their introductory programming course. The items to measure programming self-efficacy was adapted from the programming self-efficacy scale that was developed and validated by Ramalingam and Wiedenbeck (1998), the academic self-efficacy scale (Bresó et al. 2011), and based on Bandura's (1986) three dimensions of self-efficacy: magnitude, strength, and generality. A 5-point Likert scale was used, ranging from 1 (not confident at all) to 5 (very confident). The items to measure interest and gratification were adapted from the findings of the focus groups and from the definition of the indicators, while the items to measure enjoyment were adapted from prior research that was conducted by Bishop-Clark et al. (2007). The survey instrument was subjected to a rigorous reliability and validity tests. A card sorting activity was performed to assess construct validity and to identify items that lack clarity (Moore and Benbasat 1991). A pilot study was then conducted and finally, an Exploratory Factor Analysis (EFA) was performed to assess the convergent and discriminant validity of the items in the survey.

The data was collected from two countries, Malaysia and New Zealand in order to ensure representativeness of the sample and to offer an international perspective to this study. A total of 10 institutions participated in the survey, 6 of which were from New Zealand, and 4 were from Malaysia. The questionnaire was designed and administered online. Table 1 shows the response rate by country. A total of 1093 students were invited to participate in the survey. The response rate was high. 43% (470) of the students from the sample population participated in the survey, of which 92.1% (433) of the responses were usable. Out of the 433 usable responses, 93.1% were male participants.

Country	Sample Population	No. of Participants	No. of Usable Responses
New Zealand	750 (68.6%)	225 (47.9%)	214 (49.4%)
Malaysia	343 (31.4%)	245 (52.1%)	219 (50.6%)
Total	1093	470	433

Table 1. Response Rate by Country

4 Results

The data was analysed using the variance-based PLS-SEM SmartPLS 3 software (Ringle et al. 2015) since the objective of this research is to predict and explain the constructs, and PLS-SEM is able to handle single-item constructs (Hair et al. 2014) such as programming performance. The analysis of the data was performed in two stages. The first stage involved the analysis of the measurement model, and the second stage involved the analysis of the structural model (Hair et al. 2014). The measurement model describes the relationships between the constructs and their corresponding indicators (Hair et al. 2014) by establishing the reliability and validity of the constructs. The path connecting the items to the constructs were measured reflectively, the composite reliability (CR), indicator reliability, and average variance extracted (AVE) were established for the measurement model (Hair et al. 2014). Table 2 presents the convergent validity of the constructs in the research model. A CR value of 0.7, AVE value of 0.5, and item loadings that are greater than 0.6 are acceptable to satisfy the convergent validity of the constructs (Hair et al. 2014).

Construct	**No. of Items**	**Loadings**	**AVE**	**CR**
Programming self-efficacy	22 items	.622 – .770	.511	.958
Enjoyment	3 items	.680 - .866	.625	.832
Interest	3 items	.684 - .890	.675	.860
Gratification	4 items	.618 - .875	.590	.850
Programming Performance	1 item	1.000	-	-

Table 2. Convergent Validity

Discriminant validity refers to how well a construct differs from the other constructs in the model through statistical comparisons (Hair et al. 2014). To satisfy the conditions for discriminant validity, firstly, the results of the Fornell-Larcker criterion and the cross-loadings of the items were examined. When evaluating the discriminant validity using the Fornell-Larcker criterion, the square root of a construct's AVE should be higher than any of the correlation with other constructs (Fornell and Larcker 1981). Table 3 presents the results of discriminant validity using the Fornell-Larcker criterion. The diagonal values that are highlighted in bold text represent the square root of the AVE, while the off-diagonals represent the correlations. The results of the Fornell-Larcker criterion confirm that the square root of a construct's AVE is higher than the correlations of the other constructs. The second condition for discriminant validity requires that the items should load more strongly on their construct than on other constructs (Hair et al. 2014). The cross-loadings of the items were examined and found to load strongly on their intended construct than on other constructs. Thus, the conditions for discriminant validity have been met.

Construct	Programming self-efficacy	Enjoyment	Interest	Gratification	Programming Performance
Programming self-efficacy	**.715**				
Enjoyment	.632	**.790**			
Interest	.572	.753	**.821**		
Gratification	.488	.542	.519	**.768**	
Programming Performance	.413	.314	.170	.142	**1.000**

Table 3. Discriminant Validity

The structural model tests the hypotheses in the research model and describes the relationships between the constructs (Hair et al. 2014). Figure 2 presents the results of the path analysis. The bootstrapping procedure was used to determine the significance of the path coefficients (Chin 1998). Five thousand (5000) bootstrap samples were used to estimate the PLS path model (Hair et al. 2014). The R2 values for the constructs determine the predictive accuracy of the model. The enjoyment and interest constructs exceed the moderate threshold predictive accuracy that was proposed by Chin (1998), while the predictive accuracy of the gratification construct and the programming performance construct were weak.

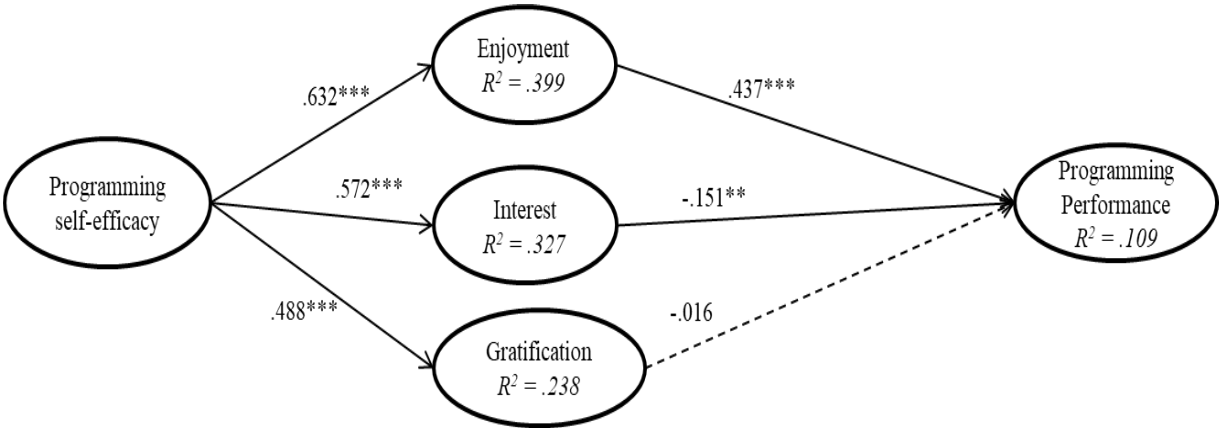

Figure 2. Result of path analysis

The results of the path analysis in Figure 2 show that H1 (programming self-efficacy -> enjoyment), H3 (programming self-efficacy -> interest), and H5 (programming self-efficacy -> gratification) are significant. A strong positive and significant relationship was found in path H2 (enjoyment -> programming performance), while the result of the path analysis for H4 (interest -> programming performance) showed a negative but statistically significant relationship. However, hypothesis H6 (gratification -> programming performance) was not supported.

The research model was tested for common method bias since the data for the independent and the dependent variables was collected using a single method (Podsakoff et al. 2003). An exploratory factor analysis (EFA) was performed on all the measurement items in order to control for common method bias. Common method bias may exist in a dataset if the majority (>50%) of the items load on one factor (Podsakoff and Organ 1986). The results of the EFA showed that the largest variance explained by an individual factor was 24.04%, suggesting that common method bias is not a problem in this research.

5 Discussion

This study proposed and tested a research model on programming self-efficacy, emotional engagement, and programming performance. Enjoyment, interest, and gratification were identified as three potential indicators of emotional engagement in introductory programming courses. Several key findings emerged from this research.

Our first finding suggests that the strong link between programming self-efficacy and the emotional engagement of students validates the importance of self-efficacy beliefs on human behaviour, and the importance of Bandura's Social Cognitive Theory within the context of students in introductory programming courses.

Second, the results showed a positive relationship between enjoyment and the programming performance of the students. This result supports the findings from the published literature on learning theory that found positive correlations between enjoyment and performance (Frenzel et al. 2007). By contrast, the second finding in this research extends the findings from prior research on computer programming, that when learning interventions such as pair programming (Liebenberg et al. 2012; Maguire et al. 2014) or when new programming tools are introduced (Bishop-Clark et al. 2007) to create a feeling of enjoyment, these could lead to better programming performance.

Third, the negative relationship between interest and programming performance contradicts our initial hypothesis and the findings from prior research which found positive correlations between interest and programming performance (McKinney and Denton 2004; Wiedenbeck et al. 2007). One plausible explanation for the negative relationship could be due to the participants in this research having different perceptions of interest. The items to measure interest in this research may have suffered from a lack of clarity since they appear to measure either value- or affect-related interest. Interest can be perceived to be value-related or affect-related, whereby affect-related interest is the emotions of the participants when performing a task, while value-related interest is the degree of importance placed on performing a task well (O'Keefe and Linnenbrink-Garcia 2014). Therefore, it may be possible that the participants in this study that had high affect-related interest, but low value-related interest had placed more importance on being engaged in learning how to program instead of performing well.

Fourth, despite a lack of evidence in literature, the relationship between gratification and programming performance was hypothesised as a positive relationship. However, the findings of this research revealed a weak negative relationship between gratification and programming performance. This finding suggests that although students felt gratified upon seeing that their program works and felt that they had performed well, their actual performance may not have been satisfactory. One plausible explanation could be that although the novice programmers were able to see the output of their program and were able to make their program work without errors, they may not have met all the requirements of the programming assessment that would lead to a better programming grade.

These four findings have implications for course instructors who are involved in the design and delivery of introductory programming courses. We argue that the cognitive demands of learning introductory programming may be managed by building the self-efficacy beliefs of the students and by embedding learning activities that are intended to invoke the feeling of enjoyment.

The Social Cognitive Theory (SCT) recommends that self-efficacy beliefs should be developed through enactive mastery, vicarious experiences, verbal persuasion, and/or physiological cues (Bandura, 1997). One way to apply the enactive mastery approach in order to build the self-efficacy beliefs of the students is by introducing weekly programming exercises. Weekly programming exercises enable students to practice writing programs so that they are able to improve their understanding. The feedback provided by the course instructor on the weekly programming exercises would enable the student to understand the source of the errors and how to overcome the errors, leading to increased self-efficacy beliefs in programming.

Further, we recommend that course intructors should embed learning activities that are intended to invoke the feeling of enjoyment. Using pair programming (Liebenberg et al., 2012; Maguire et al., 2014), introducing new programming tools (Bishop-Clark et al., 2007) and applying gamification techniques (Fotaris et al. 2016) are some examples from prior research on computer programming that have successfully engaged students in enjoyable activities when learning programming.

6 Conclusion

This research examined the relationship between programming self-efficacy and emotional engagement, and between emotional engagement and the programming performance of students in introductory programming courses. Data was collected from institutions that offer tertiary education in Malaysia and in New Zealand, which allowed for a large sample population and an international perspective of the relationship between programming self-efficacy, emotional engagement, and the programming performance of students in introductory programming courses.

The findings of this research showed a strong positive relationship between programming self-efficacy and the emotional engagement factors. Further, enjoyment was found to have a strong relationship with the programming performance of the students. By contrast, there was a negative relationship between interest and programming performance, and the relationship between gratification and programming performance was not statistically significant. Plausible explanations were offered to the negative and not significant relationships, and recommendations were made to increase self-efficacy beliefs and embed enjoyable learning activities in introductory programming courses. This research provides valuable insights to course instructors in the Information and Communications Technology (ICT) related disciplines who wish to understand the behaviour of students and improve the design and delivery of introductory programming courses.

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