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Examining the Relationship Between Components of the MUSIC Model of Motivation and Student Achievement in Computer Programming

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Abstract. Computer programming is often perceived as being difficult to teach and learn. Many researchers have investigated the most effective approaches to teaching computer programming, and the results of such investigations are inconsistent. Despite ongoing investigations into teaching approaches, researchers have not yet focused their studies on determining on which factors affecting student academic motivation educational researchers should focus when they implement pedagogical interventions. The research takes this inquiry forward by investigating the impact of student perceptions of the MUSIC model (i.e., empowerment, usefulness, success, interest, and caring) on learning programming, and by testing for any gender-based differences in those processes and outcomes. The participant body in this study comprised primarily of 97 'freshmen' male and female computer science majors and non-majors, gathered from three 8-week long project-based programming workshops. All of the participants took a coding test and filled out the MUSIC inventory before and after the programming workshops. Although all the motivation-related components of the MUSIC model are important, this study found that students' perceptions of usefulness, caring, and interest are significantly predictive of their learning successes. With regard to gender, the study found that there were no significant gender-based differences in their perceptions of the motivation-related components of the MUSIC model at the end of the study, while there were significant gender gaps in students' perceptions of success and caring at the beginning of the study. Recommendations for the design and implementation of computer programming courses are provided.

Keywords: pedagogical issues; gender studies; programming; MUSIC model; motivation

1. Introduction

1.1 Overview

There is no doubt that computer programming is one of the most important skills for students to learn in order to succeed in the 21st Century. Despite this, learning computer programming is often perceived as being difficult and challenging, even for computer science (CS) majors (Ali & Smith, 2014; Alshammari, 2018), and university introductory programming courses consistently have high dropout rates, especially from female students (Kanbul & Uzunboylu, 2017). The challenge arises from several factors with 'student interest and motivation' in learning programming being one of the most important (Piteira & Haddad, 2011). Learning computer programming requires a high level of motivation due to the challenges posed by abstraction in programming logic (Baist & Pamungkas, 2017; Gomes & Mendes, 2007), as well as the need to enhance student's conceptual, operational, and procedural knowledge (Çakıroğlu & Er, 2020).

In response to the challenges posed to computer programming students, educational researchers have investigated the most effective approaches to teaching computer programming. Such approaches include flowchart-based programing environments (Xinogalos, 2013); block-based programming languages (Adler & Kim 2018; Hsu et al., 2018); game-based learning (Combéfis et al., 2016); afterschool programs (Mouza et al., 2016); and robotics studies (Yamanishi et al., 2015). However, despite the different teaching approaches, there is still a need to determine on which factors in student academic motivation educational researchers need to focus when they implement an intervention.

1.2 Objectives of the Study

There is a strong relationship between motivation and academic performance, as motivation has a significant effect on learning discipline (Buzdar et al., 2017; Chik & Abdullah, 2018). Jones (2009) assumed that targeting the motivation-related components of the MUSIC model increases students' motivation, which leads to an increase in the quality of their learning. In computer science, computer programming is perceived to be difficult to teach and learn. Researchers in computer science education have used several theoretical models to maximize student levels of motivation in different learning settings. This study aims to investigate the relationships between students' academic motivation and their performance in learning computer programming. While many researchers seek answers about what makes the design of particular computer programming courses effective, this study takes the inquiry into computer science education one step further by investigating the relationship between students' academic motivation-related factors and their learning, to see which factors can be predictive of their learning outcomes.

2. Literature Review

2.1 Importance of Learning Programming

Learning computer programming is a fundamental aspect of computer application development (Cardoso et al., 2018), and it is an especially important skill in today's computerized world as it has been proven to improve students' creativity, planning skills, logic, and collaboration (Abesadze & Nozadze, 2020). In their study, Erümit et al. (2019) listed a set of advantages of learning programming, including developing problem-solving skills, enhancing cognitive learning and high-level thinking skills, increasing motivation, and improving creative thinking. Moreover, computer programming prompts the development of concepts, such as algorithms, and understanding the syntax, semantics, and complexity of a set of different languages (Piedade et al., 2020). However, despite the importance of learning computer programming, it is still perceived to be difficult and challenging for computer and non-computer science majors alike.

2.2 Motivation and Academic Performance

Students' motivation is associated with their academic achievement (Raman et al., 2018). According to Santana et al. (2018), student motivation is important to foster effective learning. Due to the importance of motivation in students' academic achievement, the literature includes different examples of initiatives in the field of computer science education that aim to enhance students learning of and motivation in computer programming. For example, Emre and Kiyici (2022) conducted a study on university students using robotics programming education and found it effective in enhancing their academic success and motivation. Papadakis (2020) found the use of App Inventor programming and game development as an alternative approach to have a positive impact on students' basic programming skills achievements, and motivation in a CS course. While using a mix of languages and tools, Santana et al. (2018) were able to raise students' motivation for non-major CS students.

The previously mentioned studies have shown research-based evidence of the impact of different instructional tools and strategies on students' motivation but have not investigated the impact of motivation-related factors that would make the use of each strategy effective. This article uses the MUSIC model of motivation as a theoretical framework to better understand on which factors CS instructors and educational researchers should focus when they implement pedagogical interventions.

2.3 Gender-Based Differences in Programming

When it comes to gender, the literature shows no gender gap in students' ability to learn computer programming, and some related topics, such as robotics (Alshammari, 2018; McDowell et al., 2003; Nourbakhsh, et al., 2004; Pioro, 2004). However, females across many countries are known to underestimate their abilities and rate themselves lower than males, despite the fact they perform better in some computer science topics (Finlayson, 2020). The perceived difficulty of programming often leads female students to lose their competence and sense of confidence (He & Freeman, 2010). Therefore, in addition to understanding students' motivation-related perceptions, there is a need to explore the roles that gender plays and its effect on students' perceptions of motivation and achievement in computer programming.

2.4 The MUSIC Model

The MUSIC model of motivation was designed by Jones (2009) to describe the implementation of academic motivation in instruction (Jones & Skaggs, 2016; Parkes et al., 2015). The model was developed based on multiple theories of motivation, and it consists of five components: e**M**powerment, **U**sefulness,

Success, **I**nterest, and **C**aring, which forms the acronym MUSIC. Supporting students' efforts to develop positive perceptions toward these components is expected to support and further engage them in the learning process (Gardner & Jones, 2016; Jones, 2009). The literature includes several studies that validate the MUSIC model of academic motivation inventory and the relationships between perceptions and learning (Chittum et al., 2019; Jones & Wilkins, 2022; Jones et al., 2020, 2021, 2022; Li et al., 2022; Munz & Jones, 2021). By understanding students' motivation-related perceptions, the MUSIC model can be used to help educational researchers re-design their courses, and select the most effective teaching strategies and tools to support student learning and motivation within an educational subject (Jones et al., 2019).

2.4.1 Empowerment

The first component of the MUSIC model is empowerment, which addresses student perceptions of the amount of control that they have over their learning (Williams, 2013). This component is strongly linked with student autonomy (Jones & Skaggs, 2016), as defined by Ryan and Deci (2000). What distinguishes empowered students from others is the perception that they have the ability to practice educational agency, or to make decisions and choices about their learning and the interactions in their learning environment (Gardner & Jones, 2016). Any suggested solution to enhance students' programming skills, within this model, needs to be well considered and flexible, allowing students to control the direction and pace of their learning. There are several factors that play a critical role in the process of developing perceptions of empowerment, including task difficulty, ability, and prior knowledge and experiences (Jones, 2009). It is important to clarify, however, that empowerment needs to be felt and perceived by the students themselves— not by the instructors. It does not matter if instructors think that they allow their students to have control over their learning if students themselves do not perceive that or believe that they are able to make decisions.

2.4.2 Usefulness

Computer programming pedagogy needs to connect the field with real-world applications. Students need to feel that what they are learning is useful for their future and connected to the real world around them (Jones, 2009). In computer programming, students need to see the results of their learning applied in real world cases (Voštinár, 2020). This requires attention to learning through action, where students develop products that address and create solutions to real world problems and situations (Vahldick et al., 2020). In some courses, students do not see the value of taking the course and are not sure if it will be useful to their interests and applicable to the real world (Gardner & Jones, 2016). A student might wonder, for example, why a computer science student would need to study calculus. Establishing relevancy and applicability in student perceptions will address this issue. The second component of the MUSIC model refers to the common perception among students that the instructional materials that they are learning, and instructional activities that they are performing, are relevant to their short- and long-term goals (Williams, 2013). It is important to mention that students are more engaged when they see the usefulness of learning to their long-term goals rather than simply to their short-term goals (Simons et al., 2004). One effective way to accomplish that is to connect learning content and activities to their future careers (Jones & Skaggs, 2016). In motivation, usefulness is related to utility value and instrumentality.

2.4.3 Success

Enhancing students' learning of computer programming requires finding an approach that supports their beliefs in their self-efficacy and success; they need to believe that they are not less than others and that they can succeed if they put in the effort required. Success is an important component in the MUSIC model that is strongly linked with expectancy for success, self-efficacy, and competence (Jones & Skaggs, 2016). It refers to the belief that people can succeed if they put in the effort required. Having this belief is assumed to encourage students to engage and perform well in future activities. Female students in computer science underestimate their skills, and sometimes they believe that, no matter how hard they work, they cannot perform better than men. Success requires that students need to believe that they will be able to complete a task successfully if they acquire the required knowledge and skills (Jones, 2009). Such an approach needs to make expectations from students clear, encourage students to work together on team-based projects, and provide students with feedback regularly, instead of post-project feedback (Gardner & Jones, 2016). Moreover, this approach needs to create balance in the level of difficulty of learning so that content and activities are neither boring nor overly challenging (Williams, 2013).

2.4.4 Interest

Students need to be interested in their learning environment, including the instructional activities and materials. Interest is defined as "liking and willful engagement in a cognitive activity" (Schraw & Lehman, 2001, p. 23). This component is linked to situational interest, intrinsic motivation, intrinsic interest value, and flow (Jones & Skaggs, 2016). Effective motivational strategies can support the two major types of interest: situational and individual (Johns, 2009). Situational interest is context-specific and environmentally activated, which can be fostered by making the learning environment attractive to students. This type of interest is helpful in motivating students to engage in a specific activity. The second type of interest, which is the focus of this study, is individual interest, or a context-specific and "relatively stable affective-evaluative orientation toward certain subject areas or objects" (Schiefele, 2009, p.198).

Individuals typically have a list of activities in a domain or subject area that they are most interested in performing. For example, in educational settings, "even those students who generally are highly motivated to achieve would have interests only for a discrete set of the specific content area" (Schunk & Zimmerman, 2012, p.86). Situational interest can increase or develop individual interest (Williams, 2013). As such, there is a need for an immersive learning environment that stimulates students' situational and individual interests by relating the instructional content to students' backgrounds and providing them with hands-on activities related to those backgrounds and interests.

2.4.5 Caring

The final component of the MUSIC model addresses the importance of creating a caring environment in which students feel that the instructor and other individuals involved in the learning process care about them and their learning (Gardner & Jones, 2016). Although it is very important, caring does not necessarily mean that the instructor needs to be friendly. Instead, it refers to the importance of showing students that the instructor cares about their learning experience (Jones, 2009). This component is strongly linked with belongingness, relatedness, and attachment (Jones & Skaggs, 2016). Caring plays an important role in supporting students' intrinsic motivation and self-determination, which increases the likelihood that they will participate in more activities in a particular domain or subject area (Deci & Ryan, 2000). This is evident in all-female computer science courses, where women feel more comfortable and welcomed.

3. Research Questions

RQ1: Do students' perceptions of the MUSIC model's components significantly predict students' programming learning outcomes?

RQ2: Are there any statistically significant differences between males and females in their perceptions of the MUSIC components?

4. Methods

This study aimed to understand the relationships among factors assumed to influence student motivation and achievement. Since students' perceptions of the MUSIC model are expected to influence their motivation, this paper aims to show which of the motivation-related components of the MUSIC model are predictive of students' learning of computer programming. The study also analyses those gender-based differences in students' perceptions of the MUSIC model that were shown to be significant. The study followed a pre-post-test design in which participants took the MUSIC inventory and the coding test at the beginning and at the end of the three workshops.

4.1 Participants

The participant body in this study was comprised primarily of 97 freshmen male and female computer science majors and non-majors from a public university in the United States. The participants included 49 females and 48 males, and they were gathered from three project-based programming workshops that were taught at the same time for the same length. All the three 8-week long workshops were taught by the same instructor and covered the same fundamental aspects of programming. The workshops consisted of three main components: learning, application, and reflection. The workshops were project-based and designed to teach computer programming in a contextually relevant approach and to connect the activities to real world uses. Participants were randomly selected and assigned to one of the three project-based programming workshops. All participants took a coding test and filled out the MUSIC inventory before and after the programming workshops. A pre- and post-test design was used to compare participants' perceptions of the MUSIC model components at the beginning and end of each workshop. The purpose of the post-test was to assess any changes in the students' perceptions that were related to their academic performance.

4.2 Data Collection

4.2.1 The MUSIC Inventory

The MUSIC inventory is a scale that assesses learners' empowerment, usefulness, success, interests, and caring. The inventory comes in different versions to assess student perceptions of the five components of the MUSIC model, in different educational settings. The college students' version, the one that was used in this study, has been tested in different studies, and the results show high reliability. Jones and Skaggs (2016) used different statistical tests to prove the validity and reliability of this inventory. The study showed high validity and reliability with Cronbach's alpha values of 0.91 for empowerment, 0.96 for usefulness, 0.93 for success, 0.95 for interest, and 0.93 for caring.

4.2.2 Coding Skills Test

To assess students' coding skills, a coding test was developed to appraise the essential skills in programming, including input/output, operations, arrays, condition statements, loop statements, and functions. The test was reviewed by multiple computer science instructors. The reliability of the instrument was tested, and it returned $\alpha = .785$.

5. Data Analysis and Results

The analysis of the research questions went through two phases: 1) checking the assumptions of all statistical tests and 2) analysis of the statistical relationships between the variables of each research question.

5.1 Phase #1: Checking Assumptions

The male-female ratio was relatively balanced across CS majors and non-CS majors (Figure 1). Confirming this, a Chi-square test was performed and showed no statistically significant differences between the groups (X-squared = 0.11721, df = 1, p-value = 0.7321). Based on these results, the null hypothesis, that there were no significant gender differences between CS majors and non-CS majors, was accepted.

The assumptions of the multiple linear regression were checked, including outliers, normality of residuals, homoscedasticity, collinearity, and auto-correlated errors. An assessment of the linear model assumptions, using the global test on 4 degrees of freedom, produced a level of significance $p< 0.05$. The plots (Figure 2) showed no violations of any of the assumptions. The Shapiro-Wilk test was performed to check the normality assumption. The null hypothesis was that the data came from a normally distributed population. The Shapiro-Wilk test (Table 1) returned W = 0.99015, p-value = 0.7029. Based on this, it is reasonable to assume the data came from a normal distribution.

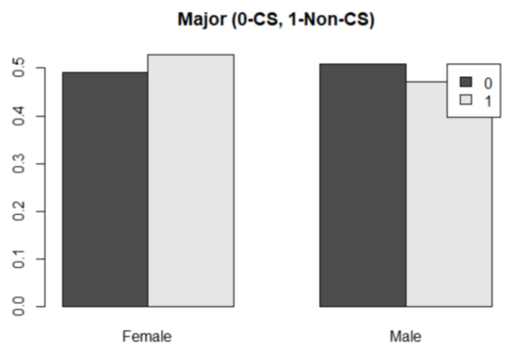

Figure 1: Bar Plot of Gender for CS Majors and Non-Majors

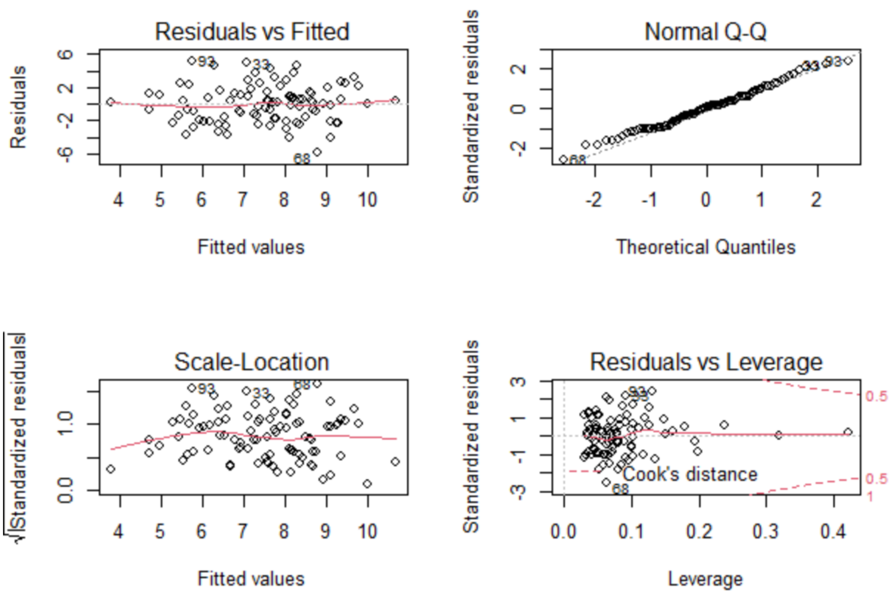

Figure 2: Q-Q Plots of Multiple Linear Regression

Table 1. Shapiro-Wilk Normality Test for the Multiple Linear Regression

Shapiro-Wilk normality test		
Normality test	W	0.98844
	p-value	0.5632

5.2 Phase #2: Answering the Research Questions

The first research question investigated the importance of students' perceptions of the MUSIC model in predicting their success at learning computer programming. In response to this question, a multiple linear regression was conducted to test the following statistical model:

Learning Programming=β0 + β1Major + β2Gender+ β3eMpowerment + β4Usefulness+ β5Success + β6Interest + β7Caring+ε

At the beginning of the study, the analysis showed that only two components of the MUSIC model were significant predictors of student learning: interest (p-value=0.012935) and caring (p-value =0.015530). The other components, empowerment (p-value=0.513828), usefulness (p-value=0.441571), and success (p-value=0.841961), were not statistically significant. In addition to the components from the MUSIC model, gender (p-value= 0.005386) and major (p-value=0.000673) were found to be significant predictors of student learning of computer programming.

Table 2. Multiple Linear Regression of Pre-Test

Residuals:				
Min	**1Q**	**Median**	**3Q**	**Max**
-5.8079	-1.7777	0.1794	1.2797	5.2477
Coefficients:				
	Estimate	**Std. Error**	**t value**	**P value**
(Intercept)	6.91943	2.10902	3.281	0.001479 **
Pre-Major	-1.75506	0.49799	-3.524	0.000673 ***
Pre-Gender_Male	1.47480	0.51694	2.853	0.005386 **
Pre-eMpowerment	-0.31472	0.48012	-0.656	0.513828
Pre-Usefulness	-0.38624	0.49966	-0.773	0.441571
Pre-Success	0.09927	0.49641	0.200	0.841961
Pre-Interest	1.75355	0.69129	2.537	0.012935 *
Pre-Caring	-1.03057	0.41770	-2.467	0.015530 *
Residual standard error: 2.321 on 89 degrees of freedom Multiple R-squared: 0.2738, Adjusted R-squared: 0.2167, F-statistic: 4.795 on 7 and 89 DF, p-value: 0.0001302				

Table 3. Multiple Linear Regression of Post-Test

Residuals:				
Min	**1Q**	**Median**	**3Q**	**Max**
-6.3372	-1.3256	0.3932	1.6128	4.3496
Coefficients:				
	Estimate	**Std. Error**	**t value**	**P value**
(Intercept)	10.03342	1.39917	7.171	2.10e-10 ***
Post-Major	-2.13631	0.49531	-4.313	4.15e-05 ***
Post-Gender_Male	0.10726	0.47112	0.228	0.82042
Post-eMpowerment	-0.09756	0.57120	-0.171	0.86477
Post-Usefulness	-0.81195	0.38489	-2.110	0.03770 *
Post-Success	0.15489	0.40254	0.385	0.70131
Post-Interest	1.39778	0.49721	2.811	0.00607 **
Post-Caring	-0.40509	0.50452	-0.803	0.42416
Residual standard error: 2.257 on 89 degrees of freedom, Multiple R-squared: 0.2372, Adjusted R-squared: 0.1772, F-statistic: 3.954 on 7 and 89 DF, p-value: 0.0008382				

When testing the same students at the end of the study, the post-test (Table 3) showed that interest (p-value=0.00607) was still a significant component. Unlike the pre-test, students' perceptions of usefulness (p-value=0.03770) became a significant predictor by the end of the study, while their perceptions of caring (p-value=0.42416) became insignificant. Students' perceptions of success (p-value=0.70131) and empowerment (p-value=0.86477) were insignificant in both the pre-test and post-test. While the differences between CS majors and non-majors were statistically significant in both the pre-test and post-test ($p<0.05$), it is important to also mention that gender (p-value=0.82042), which was a significant predictor in the pre-test, became insignificant in the post-test.

To answer the second research question, a MANOVA test was used. For the pre-test, the MANOVA test (p-value=0.004606) showed statistically significant differences between males and females (Table 4), while in the post-test (Table 5), the results were insignificant (p-value=0.4069) at level a=0.05. To investigate the relationships more deeply, each one of the MUSIC components was analyzed (Table 6 and Table 7).

Table 4. A MANOVA Test for the Gender Differences in Pre-Perceptions of the MUSIC Components

	Df	Pillai	approx F	num Df	den Df	Pr(>F)
Gender	1	0.16744	3.6603	5	91	0.004606 **
Residuals	95					
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

Table 5. A MANOVA Test for the Gender Differences in Post-Perceptions of the MUSIC Components

	Df	Pillai	approx F	num Df	den Df	Pr(>F)
Gender	1	0.053386	1.0264	5	91	0.4069
Residuals	95					
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1						

At the beginning of the study, the across-gender comparison showed that there were statistically significant differences between males and females in students' perceptions of caring (p-value= 0.04155) and success (p-value=0.005499), while there were no statistically significant differences between males and females in their perceptions of interest (p-value=0.8134), empowerment (p-value=0.2229), and usefulness (p-value=0.4557).

When testing the same students at the end of the study, the across-gender comparison showed that there were no statistically significant differences between males and females in students' perceptions of any of the MUSIC components.

Table 6. Cross-Gender Comparison Between Pre-perceptions of MUSIC Components

Response Pre-eMpowerment	**Df**	**Sum Sq**	**Mean Sq**	**F value**	**Pr(>F)**
Gender	1	0.737	0.73682	1.5052	0.2229
Residuals	95	46.504	0.48952		
Response Pre-Usefulness					
Gender	1	0.269	0.26915	0.5611	0.4557
Residuals	95	45.573	0.47971		
Response Pre-Success					
Gender	1	4.320	4.3199	8.0726	0.005499 **
Residuals	95	50.837	0.5351		
Response Pre-Interest					
Gender	1	0.026	0.02588	0.056	0.8134
Residuals	95	43.870	0.46179		
Response Pre-Caring					
Gender	1	2.497	2.49743	4.2685	0.04155 *
Residuals	95	55.583	0.58508		
Signif. codes: 0 '*' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1**					

Table 7. Cross-Gender Comparison Between Post-Perceptions of MUSIC Components

Response Post-eMpowerment	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Gender	1	0.057	0.05716	0.0666	0.7969
Residuals	95	81.503	0.85793		
Response Post-Usefulness					
Gender	1	0.483	0.48255	0.4857	0.4876
Residuals	95	94.393	0.99361		
Response Post-Success					
Gender	1	2.249	2.24864	2.4027	0.1244
Residuals	95	88.907	0.93587		
Response Post-Interest					
Gender	1	0.005	0.00542	0.0048	0.9447
Residuals	95	106.497	1.12102		
Response Post-Caring					
Gender	1	0.044	0.04404	0.0425	0.8372
Residuals	95	98.487	1.03671		
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1					

6. Discussion

In addition to the high-level thinking skills that learners need to develop to be successful in the field, maximizing success at learning computer programming requires developing positive perceptions of all aspects of being a computer programmer. This study aimed to investigate the relationships between students' academic motivation and their performance in learning computer programming, by studying the relationship between students' success at learning computer programming and their perceptions of empowerment, usefulness, success, interest, and caring in the learning process. From the results, it appears that some of students' perceptions of the MUSIC model components changed from the beginning to the end of workshops. This can be explained by different factors, such as gender and learning gain. This section will discuss the changes of students' perceptions in more detail.

6.1 Empowerment

Allowing students to take control of their learning process is strongly linked with their autonomy (Jones & Skaggs, 2016). Empowerment occurs when students design or develop solutions for real world problems (Tissenbaum et al., 2017). In computer programming teaching and learning, it is important for instructors to come up with constructivist teaching strategies to move students from engagement to empowerment. One example of such an approach is project-based learning, which was implemented in this study. This approach has the potential to help students not only perceive control over their learning, but also develop creativity, critical thinking, and collaboration skills (Frydenberg & Mentzer, 2020). In this study, students' perceptions of empowerment were not statistically significant regarding being predictive of their learning. Ultimately, the study did not find any statistically significant gender-based differences in student perceptions of empowerment.

6.2 Usefulness

Computer programming courses are usually criticized for lacking the ability to show the connection to real world applications (Lagesen, 2006,2011) and many studies have shown the importance of doing so (Brandt et al., 2013; Vahldick et al., 2020; Voštinár, 2020). Confirming this, the current study found students' perceptions of usefulness to be a significant predictor of their progress in learning computer programming at the end of the study. Previous studies have shown that females are largely unaware that computer science can be connected to the real world (Lagesen, 2011). However, this study did not show any gender differences related to students' perceptions of the usefulness of learning computer programming.

6.3 Success

Students' beliefs about success play a significant role in shaping their performance. Students need to believe that they can succeed if they put in the effort required. Several studies have shown that females have lower perceptions of success compared with males in computer science (Goh et a;., 2007; Marín-Raventós et al., 2020; Seibel & Veilleux, 2019). Despite equality in learning and performance, female students tend to underestimate their abilities, and they often see computers as tools and themselves as users, instead of as the professionals who create the technology (Vitores & Gil-Juárez, 2015).

In the current study, students' perceptions of success were not found to be a significant predictor of their performance in computer programming. However, this study supports the findings of previous studies in the literature by confirming the existing significant gender differences in student perceptions of success.

6.4 Interest

Kong et al. (2018) argued that students with an interest in programming might have a greater sense of programming empowerment. While in this study students' perceptions of empowerment were not found to be a significant predictor of student learning outcomes, their interests were a significant predictor of their success at learning to code. The literature shows that there is a gender gap in students' levels of interest in computer programming (Master et al., 2017). However, this study found that both males and females were interested in learning computer programming. This suggests that computer programming instructors need to enhance their teaching strategies in order to stimulate students' situational and individual interests.

6.5 Caring

Constructivists in computer science education believe that teachers' roles have changed from being "a sage on the stage" to being "a guide on the side" (Gaspar et al., 2016), which requires more attention to instructor-to-student relationships. The analysis of data showed that at the beginning of the study, students' perceptions of caring were significant predictors of their success at learning computer programming.

The literature shows that students' perceptions of student-teacher relationships affect their motivation and engagement in instructional activities (Lazarides et al., 2018; Quin, 2017; Roorda et al., 2011; Xerri et al., 2018; Zhou et al., 2020). Varol and Varol (2014) found that a lack of communication between students and faculty is one of the leading causes of the underrepresentation of female students in the field of computer science. This study adds to the literature by examining the impact of students' perceptions of caring on students' successes in learning computer programming. Although caring was a significant predictor of student success at learning computer programming, it turned out to be insignificant at the end of the study. It is important to mention, however, that males and females perceived teachers' caring differently. This supports the findings in the literature that females most often do not feel support from their instructors and believe that they do not belong in the field of computer programming (Master et al., 2016). Such findings indicate that students need to feel that their instructors care about their learning in order to perform well in learning computer programming.

6.6 Learning

Students' success at learning computer programming depends on several factors. From this study, it appears that their perceptions of usefulness, caring, and interest can predict their performance in learning computer programming. Lau and Yuen (2011) conducted a study on the impact of multiple learning characteristics on programming performance, and found significant gender-based differences in how students built mental models, which had a significant impact on their programming performance.

The current study found a gender gap in performance at the beginning of the study. However, at the end of the study, the gap was closed, which supports the findings in the literature that suggest there is no significant gender difference in terms of performance related to computer science topics, such as programming and robotics (McDowell et al., 2003; Nourbakhsh et al., 2004).
One explanation of the gap closure is likely related to the individual instructor's approach and use of constructivist teaching approaches, such as project-based learning. The results led to a decrease in the gap between males' and females' learning of computer programming, as is shown in the post-test.

7. Conclusion

Learning computer programming has been, and continues to be considered challenging for many CS students around the world. Researchers have been studying the key factors that play significant roles in the enhancement of student achievement in programming. Since learning computer programming requires a high level of motivation, due to abstraction in programming logic, this study investigated the relationships between students' academic motivation and their performance in computer programming. Building upon the MUSIC model of motivation, this study further examined the determining factors of influence in CS education by testing the assumption that the motivation-related components of the MUSIC model would increase student success in learning computer programming.

Although all the motivation-related components of the MUSIC model are important, this study found students' perceptions of usefulness, caring, and interest to be significantly predictive of their learning success. While there were no significant gender-based differences at the end of the study, there were significant gender gaps in students' perceptions of success and caring at the beginning of the study. Researchers and instructors need to pay more attention to such factors.

They need to design computer programming curricula in ways that connect the field with its real world applications so students can feel that what they are learning is useful for their futures. Educators within this field also need to select instructional strategies, such as project-based learning, that increase students' situational interest, intrinsic motivation, intrinsic interest value, and flow. Moreover, CS instructors need to show their students that they care about their learning, in order to increase their belongingness, relatedness, and attachment. Finally, CS researchers and instructors need be aware of the gender gap in students' perceptions of success, and use different types of motivational strategies to increase female students' sense of self-confidence in their ability to be computer programmers.

8. Limitations

The current study was limited by the scope of time, and it measured only the short-term changes in students' perceptions of the MUSIC model components. Further work to better understand the reasons behind the changes in students' perceptions of the MUSIC model components were outside this study's scope. Unfortunately, the design of the current study did not allow for qualitative data to be collected.

9. Further Research

This study tested the impact of students' perceptions of the motivation-related components of the MUSIC model on their performances in computer programming. The MUSIC model (Jones, 2009) has identified several internal and external factors that could play significant roles in shaping student motivation. A follow-up study is needed to test the relationships between these internal and external factors and students' success at learning computer programming. The MUSIC model showed a relationship between students' motivation and their engagement in a given activity, and it would be worth investigating which components of the MUSIC model are predictive of students' engagement in computer programming courses.

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