Students' Self-Efficacy Beliefs and Performance in the Programming Course

معتقدات الكفاءة الذاتية لدى الطلاب وأدائهم في صف البرمجة

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Abstract: This article targets first-year engineering students' self-efficacy beliefs and their relationship with performance in the first half of the semester and the final grade of the programming course. Self-efficacy is the belief in one's capabilities to reach a desired goal or outcome by setting and implementing the required courses of action. In education, self-efficacy is crucial to academic growth, for it helps students take charge of their own learning, develop their skills, set goals, and regulate their motivation in order to accomplish these goals. Considering the difficulty of the programming course, self-efficacy plays a vital role in the challenges the students face in the programming course, their magnitude, and the skills the students use to overcome them. Self-efficacy beliefs were measured through a survey administered twice to 118 engineering students in the first half of the semester and correlated with the first quiz of the semester and the midterm grade, then with the final grade. The results showed that there is in fact a relationship between students' self-efficacy beliefs and performance in the programming course. However, the relationship was shown to be inverse in the first half of the semester but positive with the final grade. These findings highlight the importance of student efficacy beliefs especially in the first half of the semester.

Keywords: Self-efficacy, Programming course, Engineering students.

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طالبة دراسات عليا في مجال العلوم التربوية في جامعة القديس يوسف، بيروت. و هي عضو في مختبر البحوث التربوية في جامعة القديس يوسف بيروت.

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دكتور محاضر في جامعة القديس يوسف بيروت، و رئيس اللجنة العلمية في مختبر البحوث التربوية في كلية العلوم التربوية في جامعة القديس يوسف بيروت

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ريتا نصرالله دكتورة محاضرة في كلية العلوم التربوية في جامعة القديس يوسف بيروت.

الملخص

يستهدف هذا المقال معتقدات الفعاليّة الذاتّية عند طلاب السنة الأولى في الهندسة، وعلاقتها بالأداء في النّصف الأول من الفصل الدراسي والعلامة النّهائيّة في صف البرمجة. الفعاليّة الذّاتيّة هي الاعتقاد بقدرة الشّخص على تحقيق هدف مرغوب أو نتيجة معينة من خلال وضع الإجراءات اللازمة وتنفيذها. في مجال التعليم، تعدُّ الفعالية الذاتية أمرًا حاسمًا للنمو الأكاديمي؛ إذ تساعد الطلاب على تولّي مسؤولية تعلمهم الخاص، وتطوير مهاراتهم، وتحديد الأهداف، وضبط دوافعهم من أجل تحقيق هذه الأهداف. ونظرًا لصعوبة مقرر البرمجة، تؤدي الفعالية الذاتية دورًا حيويًا في التّحديات التي يواجهها الطلاب في هذا المجال، وفي درجة الصعوبة التي تواجههم، والمهارات التي يستخدمونها للتغلب عليها. قِيسَت معتقدات الفعاليّة الذاتيّة من خلال استطلاع أُجري مرتين على 118 طالبًا في الهندسة في النصف الأول من الفصل الدراسي ورُبطت بالاختبار الأول للفصل والعلامة الوسطى، ثم بالعلامة النهائية. أظهرت النتائج أن هناك علاقة فعلية بين معتقدات الفعاليّة الذّاتيّة للطلاب وأدائهم في صف البرمجة. ومع ذلك، كشفت الدّراسة أن العلاقة كانت عكسيّة في النصف الأول من الفصل وإيجابيّة في العلامة النهائّية. تسلط هذه النتائج الضوء على أهمية معتقدات فعاليّة الطلاب خاصة في النصف الأول من الفصل.

الكلمات المفتاحيّة: **الكفاءة الذاتية، مقرر البرمجة، طلاب الهندسة**.

I. INTRODUCTION

Programming is a course that has been gaining more and more value for engineering schools as a response to 21st century market needs. Students in programming do not merely learn academic concepts but acquire reasoning, sequential reasoning, critical thinking, and problem-solving skills. In addition to being vital, programming has also the reputation of being a very difficult course initially because first-year students are unfamiliar with university experiences, and more importantly, most of them have never been exposed to programming material [1], [2]reliability test, mean, standard deviation, and rotated component matrix were utilized to analyze the resulting data. Results indicated that there is not much difference between males (45%. Kanaparan et al., [3] argued that the high failure rates in the programming course are caused by two factors: difficulty of the cognitive requirements of the course, and the behavior of the students in terms of engagement and self-efficacy. Though the difficulty

of the programming course content and its cognitive requirements are not within the control of the students, self-efficacy beliefs are. Self-efficacy plays a vital role in the challenges the students face in the programming course, their magnitude, and the skills the students use to overcome them [4] Information Systems (IS. Self-efficacy is a person's belief in their ability to accomplish a certain task and thus is crucial to academic growth for it helps students take charge of their own learning, develop their skills, set goals, and regulate their motivation in order to accomplish these goals [5]. In fact, student self-efficacy beliefs and their academic performances are directly related; improving the first, will automatically improve the second [6].

Considering the need to further explore the challenges of the programming course from the perspective of students in terms of their beliefs in their abilities to overcome challenges, failures, stressful situations, and remain motivated, the current study focuses on self-efficacy beliefs in terms of cognitive, motivational, and affective processes [5] and their relationship with performance of first-year engineering students in the programming course.

Previous research on self-efficacy in the programming mainly focused on factors affecting self-efficacy or considered self-efficacy as part of a construct or as a mediating factor to performance [7]–[11]. However, the current study considers self-efficacy beliefs as being the starting point and the origin of the internal processes that play a role in performance in the programming course.

Hence, the purpose of the current study is to explore the relationship between first-year engineering students' self-efficacy beliefs and their performance in the programming course

II. LITERATURE REVIEW

Self-efficacy is the belief in one's capabilities to reach a desired goal or outcome by setting and implementing the required courses of action; it is the belief that people have control over events that influence their lives. People are motivated to accomplish certain goals only when they believe that they are able to implement the right courses of action to reach them [5]. Self-efficacy beliefs affect people's thoughts as cognitive processes in terms of cognitive constructions and inferential thinking, motivation as motivational processes in terms of attribution theory, and emotional states as affective processes, as well as forethought, the perception of ability, and goal setting

all of which affect their actions and subsequently performance [5].

Perceived academic self-efficacy is a judgement of one's capabilities to organize and execute courses of action to reach desired educational performance [5], [12], [13]. In education self-efficacy is manifested through cognitive involvement in academic activities which influence motivation and achievements [13]. In order for students to appraise their self-efficacy, they evaluate the learning required, the skills and knowledge they need to possess, their existing knowledge, their previous experiences in learning, and the extent to which they can regulate their acquisition of new information [12]. Therefore, self-efficacy beliefs are to be measured and assessed before students take on new academic activities [13] especially because these beliefs are bound to change during and after academic performances [12].

On the other end of the spectrum, many situations cause discrepancies between self-efficacy beliefs and performance. The most frequent false judgement or optimistic judgment of self-efficacy stems from the person's misunderstanding or underestimation of demands embedded in a certain task rather than their exaggerated appraisals of their capabilities. In some situations, self-appraisals of abilities are correct, but task demands are misjudged, while in other situations abilities are inflated but task demands are clear, and at times, both personal abilities are overestimated, and task demands are underestimated. Furthermore, faulty appraisals of efficacy occur when tasks require high cognitive skills [5]. Complex tasks that require complex cognitive performance are not always easily discerned by students especially because they are hidden in what appears to be simple tasks [14] self-percepts of efficacy, and intrinsic interest. 40 children (7.3–10.1 yrs of age. Even if tasks are deemed simple, when they demand more than one skill that may not be equally acquired, students are prone to base their efficacy appraisal on the skill they have mastered while neglecting the skill they have not entirely acquired and thus overestimate their abilities, or focus on the skill not yet mastered and underestimate their abilities [15]128 undergraduates focused on factors that could enhance or impair their performance. Ss then indicated their perceived self-efficacy (SE. Another reason for faulty self-appraisals of efficacy stems from ambiguities either of task demands or performance requirements rather from actual misjudgment of self-efficacy [5].

In the search for self-efficacy beliefs in first-year engineering students, programming was found to be one of the most challenging courses [2], [16]as most industries require engineers to own this skill. Prior studies discuss programming self-efficacy (PSE while also being a vital course for all engineering students. In the fast growing market and demand of today, programming has become an essential skill sought by the industry and thus focused on by all universities offering engineering programs[2], [3]as most industries require engineers to own this skill. Prior studies discuss programming self-efficacy (PSE. Most programming students struggle in completing the course and find that the skills required are too difficult to be mastered [2], [16] as most industries require engineers to own this skill. Prior studies discuss programming self-efficacy (PSE. Programming courses have the highest dropout rates in the discipline and are deemed extremely difficult by students and instructors alike which results in unsatisfactory outcomes ranging from repeating the course or even a change in majors[7].

A. Abbreviations and Acronyms

COE: Computer Engineering. ELE: Electrical Engineering. MCE: Mechatronics Engineering. MEE: Mechanical Engineering. INE: Industrial Engineering.

[1] B. Hypotheses

Based on the theory and concepts of self-efficacy [5], [12], [13] as well as the literature relevant to the purpose of the current study [1]–[3], [7]–[10], [17]–[19]reliability test, mean, standard deviation, and rotated component matrix were utilized to analyze the resulting data. Results indicated that there is not much difference between males (45%, the following hypotheses are considered:

1) There is a positive correlation between students' self-efficacy beliefs and their successes and failures in assessment tasks in the first half of the semester.
2) There is a positive correlation between students' self-efficacy beliefs in the first half of the semester and their final grade in the programming course.

III. Methodology

[2] A. Sample

The current study targets undergraduate students at a high-ranking Lebanese higher education institution. The sample is comprised of 118 first-year engineering students in the programming course given in the first semester of the

academic years 2020 and 2021. Student distribution across majors is as follows: 36.4% in Computer Engineering (COE), 18.6% in Industrial Engineering (INE), 17.8% in Mechatronics Engineering (MCE), 16.9% in Mechanical Engineering (MEE), and 10.2% in Electrical Engineering (ELE).

[3] B. Measures

In order to measure self-efficacy beliefs, a tool was constructed based on Bandura's theory of self-efficacy and the concepts it entails under three processes; cognitive, motivational, and affective [5]. The formulation of the questions was inspired [20] [21] in terms of sentence structure such as "I am confident that I can achieve good exam results if I really put my mind to it" [21, p. 32], and verb use such as "I'm confident I can understand the most complex materials presented in the graduate courses" [20, p. 915]. After the factor structure and items were finalized, reliability coefficients alpha with 95% bootstrap bias-corrected confidence intervals were calculated. Then, a normality test was conducted using Shapiro Wilk which showed a p-value bigger than 0.05 indicating that the variable is normally distributed. The content validity of the survey tool used in the current study was measured by submitting it to a committee of experts who examined the content.

The tool constructed and used in the current study focuses solely on self-efficacy as the core theory to be linked to performance and not under the umbrella of any other concept through ten survey items to which students were asked to rate their level of agreement using a 4-point Likert-type scale ranging from 1 (strongly disagree) to 4 (strongly agree).

Table I displays the self-efficacy survey constructed for the current study.

Successes and failures in assessments tasks in the first half of the semester were measured using Quiz 1 and the Midterm grades, while performance in the programming course were measured through the final course grade consisting of in-class evaluation 5%, quizzes 40%, midterm examination 25%, and final Examination 30%.

IV. data collection procedure

Prior to implementation, the researchers obtained a certification as a Social-Behavioral-Educational Researcher from the Collaborative Institutional Training Initiative (CITI) and presented it along with the survey questions and data collection procedure to the Institutional Review Board (IRB) office at the targeted university.

Table I. Self-efficacy Survey

	Item	Strongly Disagree	Disagree	Agree	Strongly Agree
1	I can perform well in the programming course if I try hard enough				
2	I don't give up when I face a difficult task in the programming course				
3	I can overcome stressful situations in the programming course				
4	I can see myself succeeding in this course				
5	If my exam results do not match my expectations, it is because I wasn't prepared enough				
6	Failing in the exams makes me doubt my abilities in the programming course				
7	I adapt my studying strategies based on my exam results				
8	Failures in this course motivate me to work harder				
9	I am confident that if I persist, I can overcome failures and succeed in this course				
10	The more exams I fail, the more discouraged I am				

The survey was first sent at the beginning of the semester before any graded assessments had taken place. The survey was sent second before the second graded assessment had taken place, and the third time the survey was sent before the midterm. However, the responses collected for the second survey were extremely low and thus were not taken into consideration. The main aim was to have the same students answer surveys in stages one and three so that the results would in fact track their self-efficacy beliefs at different stages of the first half of the semester and study the relationship with academic attainments Hence, the survey sent the first time is considered Survey 1 and the survey sent the third time is Survey 3. The total number of students who answered both surveys was 118 and thus formed the final sample of the current study.

The data collection took place during the Fall semester of 2020 for Mechanical and Industrial Engineering students, and the Spring semester of 2021 for Electrical, Computer, and Mechatronics Engineering students in the programming course.A. Exploratory Factor Analysis

Exploratory factorial analysis (EFA), precisely principal axis factoring was conducted.

For the survey sent out the first time, results of the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity showed that Exploratory Factor Analysis (EFA) was appropriate for use with the proposed scale items.

Two factors were set and the results are the following. Factor 1 (Q1,2,3,4,5,8,9) Factor 2 (Q6, 7 and 10). The two factors explain 38.703% of the total variance. The results of reliability analysis show very good Cronbach Alpha for the first factor with $\alpha 1 = 0.761$; However, reliability analysis of the second factor suggests removing question 7 to obtain an acceptable level of $\alpha 2 = 0.58$. KMO of scale after removing question 7 is

0.795. Consequently, the exploratory analysis, in the method of principle axis factoring gives 2 factors: Factor 1 combining Q1,2,3,4,5,8,9 and Factor 2 combing Q6,10 that explain 41.148% of the total variance. Principal axis factoring, oblique rotation direct oblimin of the new scale after removing question 7 gives us a KMO of 0.795, Chi-square = 407.774; df = 36, p = 0.00; the correlation between the two factors is 0.462; Cronbach alpha of scale = 0.758 for a number of items = 9.

For the survey dispatched the third time, results of the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity showed that Exploratory Factor Analysis (EFA) was appropriate for use with the proposed scale items. Two factors were set, and the results are the following. Factor 1 (Q1,2,3,4,5,8,9) Factor 2 (Q6, 7 and 10). The two factors explain 43.179% of the total variance. The results of reliability analysis show very good Cronbach Alpha for the first factor with $\alpha_1 = 0.839$; reliability analysis of the second factor suggests removing question 7 to obtain an acceptable level of $\alpha_2 = 0.621$. So, the exploratory analysis, in the method of principle axis factoring for the third survey after removing question 7 gives 2 factors: Factor 1 combining Q1,2,3,4,5,8,9 and Factor 2 combing Q6,10 that explain 47.726% of the total variance. Principal axis factoring, oblique rotation direct oblimin of the new scale (excluding Q7) gives us a KMO=0.838, Chi-square = 440.498; df = 36, p = 0.00; the correlation between the two factors is 0.449; Cronbach alpha of scale = 0.830 Number of items = 9.

V. Results

After conducting factorial analysis, factor 1, referred to as *dF1*, corresponds to the cognitive processes of self-efficacy and factor 2, referred to as *dF2*, corresponds to its motivational processes, and item 7 ("I adapt my studying strategies based on my exam results") was removed from the tool.

For questions 6 ("Failing in the exams makes me doubt my abilities in the programming course") and 10 ("The more exams I fail, the more discouraged I am") in the survey, a reverse scoring system was used, where the responses were assigned values in the opposite direction of a typical Likert scale. In this case 1 corresponds to "strongly disagree" and 5 corresponds to "strongly agree." The interpretation of the average score of student self-efficacy beliefs was in accordance with the 4 levels of the Likert scale ranging from Strongly Disagree to

Strongly Agree considering 2.5 to be the average mean.

[4] A. Hypothesis 1

Spearman's test of correlation shows (p=0.092, r= -0.156) which indicates that there is no correlation between engineering students' self-efficacy beliefs and quiz 1 and midterm grades. Yet there is a weak inverse relationship between these variables though statistically insignificant.

Regarding factor 1 i.e., cognitive processes, Spearman's test of correlation (p=0.033, r= -0.196). This indicates that in the sample of the current study, there is a weak inverse correlation between students' cognitive processes of self-efficacy beliefs and their quiz and midterm grades.

Regarding factor 2 i.e., motivational processes, Spearman' test of correlation shows (p=0.628, r= -0.045). This indicates that in the sample of the current study, there is no correlation between students' self-efficacy beliefs in terms of motivational processes and their quiz 1 and midterm grades. Yet, there is a weak inverse relationship between these variables though statistically insignificant.

[5] B. Hypothesis 2

Pearson's test of correlation between engineering students' self-efficacy beliefs and their final course grade shows the following results: (p=0.025, r=0.206). Hence, there is a weak positive correlation between students' self-efficacy beliefs and their final grade. In regard to correlations between each factor separately and final course grade, results showed no correlations (p=0.063, r=0.172) for factor 1, and (p=0.114, r=0.146) for factor 2.

VI. DISCUSSION

The inverse correlation between cognitive processes of self-efficacy beliefs and all engineering students' successes and failures in assessment tasks in the first half of the semester [p=0.033 and r= -0.196] can be explained by self-regulatory mechanisms that students need to employ in terms of perceived self-efficacy or self-efficacy appraisal, and long and short-term goal setting in order to guide and motivate their efforts.

Students in the current study had faulty efficacy appraisals that resulted in incompatibilities with their successes and failures because they might have had incorrect estimations of their capabilities and/or task demands underestimated or misjudged task demands of the programming course, or overestimated their abilities, or both. They might have also faced difficulties with the complex cognitive demands

of the programming course rendering them unable to correctly appraise their efficacy, or the point in time when these beliefs were measured did not work for the benefit of the students since self-efficacy beliefs at the beginning of a task can be inaccurate because students have no previous experience with the context presented to them i.e., first-year students with no prior experience in undergraduate studies and more particularly the programming course demands.

Programming is a difficult course which encompasses high cognitive demands and complex skills acquisition. Therefore, students in the current study might have faced faulty appraisals of their efficacy due to the fact that they were faced with complex demands in the assessment tasks. Since quiz 1 and the midterm examination targeted identifying errors in programming language as well as writing codes, the complexities lied in writing codes [7], [22]–[24] rather than identifying errors. Hence students might have found it easy to identify errors in codes already written and thus have appraised their efficacy based on this knowledge while neglecting the fact that they had yet to master the knowledge to write full and efficient codes. Or, they might have focused on their inability to write full codes which overshadowed their ability to identify errors in codes and thus undermining their efficacy beliefs. In both scenarios, students had faulty appraisals of efficacy in relation to their performance abilities on assessment tasks in the programming course in the first half of the semester.

Finally, Bandura's short and long-term goals theory [5] did not apply to the sample of the current study for short-term goals did not guide students' performances maybe because they had faulty efficacy appraisals to begin with, mixed with the novelty of the programming course especially in the first half of the semester, or because, as he also stated, self-efficacy beliefs are formed through a vast range of tasks rather than judged directly before each performance.

These overall discrepancies between efficacy beliefs and academic performance highlight the lack of awareness that the students in the current study displayed regarding their efficacy appraisals as well as the appraisal of the cognitive and skill demands of the programming course.

The data presented for hypothesis 2 showed a positive correlation between all engineering students' self-efficacy beliefs in the first half of the semester and their final grade in the programming course [p=0.025

and r= 0.206]. This finding reveals that students who exhibited high self-efficacy beliefs in the first half of the semester, up until the midterm examination, scored a higher final grade, and those who exhibited low self-efficacy beliefs scored a lower final grade in the programming course.

This result coincides with Bandura's theory stating that self-efficacy plays a highly important role in performance [5] as well as numerous previous studies confirming that student's self-efficacy beliefs play a role in their academic performance [8]–[10], [17] while also adding to the body of literature the new finding that highlights that self-efficacy beliefs at the beginning of the experience display a relationship with achievements at the end of the experience.

VII. CONCLUSION

Measuring self-efficacy beliefs of first-year engineering students in the first half of the semester of the programming course has added to the theories of self-efficacy in education [5], [12]–[14]Albert Bandura, and the ever-widening circle of related research that has emerged from Bandura's original work. Intended for advanced undergraduate or graduate courses, or for professional use, the book is based on Bandura's theory that those with high self-efficacy expectancies—the belief that one can achieve what one sets out to do—are healthier, more effective, and generally more successful than those with low self-efficacy expectancies. (PsycINFO Database Record (c as well as the literature regarding efficacy beliefs in the programming course [7]–[10], [17]. The results confirmed that, in fact, there is a relationship between student self-efficacy beliefs and academic performance. The results of the current study highlighted the inverse relationship between engineering students' self-efficacy beliefs and their successes and failures in the first half of the semester of the programming course calling attention to the lack of awareness that the students displayed regarding the appraisals of their abilities as well as the appraisal of the cognitive and skills demands of the programming course.

Furthermore, the current study revealed that students who exhibited high self-efficacy beliefs in the first half of the semester, reached higher attainments at the end of the programming course. This finding shows that self-efficacy beliefs that are formed at the beginning of the experience are carried all throughout and thus, play a role in student performance which emphasizes the

importance of self-efficacy beliefs and the need to build these beliefs in order to better face the challenges of the programming course.

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