Impact of Extra Credit for Practice Questions on Programming Students' Participation and Performance

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Abstract

Introductory programming courses are intrinsically hard for many reasons, including problem-solving, logical reasoning, and syntax requirements. Due to these hard concepts, many students struggle, stay behind in courses, or drop out altogether, causing retention issues. One possible way that students could overcome the challenges is to increase their engagement with the course by providing ample practice options. Knowing the prevalent issues, instructors constantly introduce innovative ways to engage students and inspire them to practice more and more. Although these additional practice venues could allow the students to explore problem-solving techniques, develop critical thinking, and improve programming skills, they are not always mandatory. Often, the instructors use the practice questions to provide an opportunity to explore programming problems outside of regular class work, with students' voluntary participation. With this paper, we hypothesize that introducing credit, specifically additional or extra credit, will motivate students to solve and consider these practice questions as an added venue for learning. Specifically, we will examine the relationship between extra credits offered and their impact on students' participation in the practice questions and overall impact on students' performances in an introductory programming course. The programming course comprises 15 modules, each covering one programming construct. In this paper, we will answer the research questions 1) How does extra credit influence students' participation in programming and problem-solving practice questions? 2) How does participation in practice questions impact students' performance during exams in a programming course?

We used a quasi-experimental research design to evaluate how extra credit influences students' participation and performance. Using the data from two semesters, each comprising 49 students, we introduced the same practice questions for both students. However, in the first semester, students (control group) were provided practice questions with no extra credit. In contrast, students in the second semester (intervention group) could earn extra credit for participating in the practice questions. In both semesters, practice questions were given for 11 modules covering important programming constructs. For this study, we recorded students' successful participation in each module's practice questions. To answer research question 1, we used descriptive statistics. For the second question, we used a t-test to examine the mean difference between the control and intervention groups' exam scores. Additionally, we used regression analysis to determine the relationship between students' participation and their performance in both exams. In this full paper, we present the analysis results and explain the role of extra credit on students' performance for instructors and researchers. Also, we provide the implications and directions for future work.

Introduction

There has been an increase in students' interest in taking programming courses[1]. Most engineering students take introductory programming courses in their sophomore or junior year to build their skill set for portfolio building [2]. Although a beneficial skill, introductory programming courses can be challenging for many students, especially novice and beginner programmers [1]. Students often find these courses hard due to their lack of prior experience, the course's heavy reliance on problem-solving and critical thinking, developing an understanding of writing unambiguous instructions and understanding syntax and semantics [3-5]. Most students try to overcome these challenges using additional help [6, 7], which could involve more practice opportunities, watching YouTube or online materials, or taking guidance from the instructional team or peers. However, such additional help could easily require more effort and time. Prior studies suggest that not mitigating the challenges could result in developing a dislike for the course, dropping or withdrawing from the course, or leaving a career trajectory that involves programming or intrinsically hard concepts[8, 9].

Over the years, many efforts have been reported emphasizing the importance of creating a learning environment that helps students develop their skills in programming courses[5, 10]. Additionally, studies have reported the need of effective learning environments and pedagogical techniques to improve students' performance[11, 12]

Commonly used methods have been suggested to include environments with project-based learning, introduce pair programming, use language-independent courses, or provide practice opportunities in courses [13, 14]. However, the literature suggests that one good way to build students' ability and enhance their learning is by allowing them to practice more questions outside of the coursework [15]. However, providing more practice chances comes with its nuances. For example, mostly such options are left to students' choice and are not mandatory, which could result in fewer students even attempting them [16]. Hence, instructors need to develop innovative course shells [17] and enticing ways to add additional practice questions for students to try out. Studies have suggested using incentive systems (e.g., extra credits) for out-of-class practice opportunities [18]. Although, the literature supports the need to create practice opportunities in programming courses. There is a lack of literature to examine the impact of practice questions on students learning[19] and how adding another benefit to practicing questions (e.g., extra credit) may help students use practice options.

Considering the importance of practice questions in students' learning abilities, in this paper, we examined the relationship between students' learning and practice exercises. More specifically, we addressed the following research questions.

1) How does extra credit influence students' participation in programming and problem-solving practice questions?
2) How does participation in practice questions impact students' performance during exams in a programming course?

Literature review

Prior literature studies have examined the use of extra credit in various aspects of student learning and performance. These aspects include students' active participation in the classroom, students' performance in the course, lifelong learning, affective domains such as stress, students' motivation, and interest. However, the literature found mixed results regarding the effectiveness of extra credits and their impact on the quality of students' outcomes in respective courses.

For students' participation, most studies examined the use of extra credits in different academic disciplines[20-22]. For example, a study by Parikh and colleagues[23] underlined the usage of extra credit activities to foster students' interest and engagement in an introductory heat transfer course for undergraduate students. Apart from three regular course components, i.e., in-class activities, at-home assignments, and laboratory experiments, they included the use of extra credit assignments. They collected data on student engagement, where students self-reported the time spent completing these assignments. Results showed that doing extra credit assignments increased students' interest and engagement in the course. However, the measure of outside-class engagement was not wholly correlated with course performance. Another similar study by Ennis and colleagues [17] utilized extra credit pop quizzes to enhance participation and students' performance in an English course at an Italian university [24]. Results highlighted that extra credits increased students' interest and participation in English courses.

In an exemplary study, Shepard et al.[16] examined the use of extra credits in a mechanical engineering fluid mechanics course to measure its impact on students' performance[16]. Although the instructor did not mention the extra credits at the start of the course, they announced them in the last few weeks of the semester. The instructor assigned some challenging problems which needed multiple steps, knowledge of material learned during class, and knowledge learned in the previous math course. The experiment was conducted on 180 students and results indicated that half of the students took advantage of extra credit assignments and improved their grades.

Half of the students who did not take advantage of extra credits is another aspect requiring consideration [16]. Existing literature studies have reported various reasons for students not considering the advantage of extra credit [25, 26]. For example, Lei and colleagues [25] reviewed the opinion of college instructors who used to give extra credits in their courses and found that extra credit is generally an attraction for students with higher motivation and who have been high scorers in their previous courses. Also, the authors suggested that students not attracted to extra credit activities might have several academic or personal reasons, like the task being too challenging or its reward not improving their grades. However, another study examined the use of extra credit assignments to measure students' performance and found similar reasons behind students' motivation and enhanced performance[26]. Their results clearly indicated that students attempted more questions when they knew the assignments, they were doing were extra credits, increasing their chance of gaining a better grade.

Furthermore, Rice and colleagues[27] examined two fundamental aspects of students' performance 1) exam stress and 2) lifelong learning. They hypothesized that using Extra Credit Quizzes (ECQ) could somehow reduce students' stress when they bear in mind that solving a quiz wrong wouldn't affect their grades much compared to regular non-ECQ. Moreover, if students were allowed to correct their answers after attempting an exam, this would improve their lifelong learning. To complete the study, 38 ECQs were given in 2018 and 35 in 2019. At the end of the course, students were given a survey to measure the effectiveness of ECQ and exam corrections. Surveys included MCQs and open-ended questions. They conducted t-test to compile the results. Class sizes of 22 and 17, respectively, took part in the study. Results indicated that students learning from mistakes improved because of test corrections. The stress level was reduced due to ECQ.

Although existing studies have identified some benefits of extra credits for students, including giving students a chance to improve their performance and enhance their involvement in a particular course, growing literature identifies the associated challenges for instructors. For example, such options could overburden the course instructor to evaluate timely. To overcome the issues, Reid et al. [18] proposed introducing extra credit and administering a project to their computer technology course[18]. The author developed a mechanism that did not overburden instructors to evaluate extra credit projects. The entire process of the extra credit project included discussion outside the scheduled class time. Students took instructions from the instructor about what should be enough for a semester project, identified a customer, which can be anyone from the faculty but the one teaching that course, gathered requirements from the customer, got acceptance from the customer, and then provided results. Customers then evaluated the project per the requirements and sent the result to the course instructor.

Although these studies have promising results on the effectiveness of extra credits in terms of students' participation in the course and their improved performance, the research status of applying for extra credits, specifically in programming courses, where more practice is needed from students, is still developing. Considering the scarcity of the existing studies, in this study, we examine the use of extra credits and how they provide students a chance to perform better in their exams and improve their problem-solving skills by giving them extra opportunities to practice in complex programming courses.

Research Methods

This study uses a quasi-experimental approach to investigate the relationship between students' engagement with practice questions and its effect on performance.

Site and Participants

We collected data from two sections, a total of 98 undergraduate engineering students enrolled at the University of Florida during Fall 2021 and Fall 2022. For this two-semester long study, data was collected from students enrolled in a programming course titled 'Introduction to Computer Programming with MATLAB'. The students were given the practice question in the first semester, but no extra credit option was given (Control group). In the subsequent year, the students got the option for extra credit (intervention). This introductory programming is taught using a flipped classroom model. The coursework is split into 15 modules, where practice options were provided for 11 modules. Each week students get exposed to a new programming concept in MATLAB, such as variables, selection, loops, vectors, strings, functions, and image processing. Table 1 presents the numbers of control and intervention groups and total participants.

Table1: Students in the control group vs. intervention group

	Total number students	Male	Female
Control	44	28	15
Intervention	48	32	16

Measures and Data collection

In this two-semester-long study, we collected the data on two aspects 1) students' participation in practice questions and 2) students' performance.

For students' participation, we calculated various measures for control and intervention groups, including 1) no. of students who participated, 2) how many modules the students participated in, 3) within each module, how many questions were attempted, 4) within each module how many questions were correctly responded, and 5) measure of successful participation, which was based on scoring 40% score in the module.

For students' performance, we used the student's scores in the two exams during the semester. Each exam is comprised of two parts. In part 1, students completed questions based on their reasoning and debugging skills, while in part 2, they used problem-solving and their coding ability to provide a solution for given questions.

The students were provided practice questions for 11 modules across both semesters. For each module, students had to at least score 40% to be considered successful in the practice question sets and receive 1. If they did not score 40%, they were assigned 0.

Procedure and analysis

We used SPSS v29.0 to analyze the data for students' exam performance. Each exam consisted of two parts. We also calculated the total score of two exams in the course. For students' participation in practice questions, we used two measures. For the first measure of whether students successfully participated in the practice questions, we collected information on students' participation in practice questions of each module. We assigned 1 for successful participation, indicating that students attempted 40% of the practice questions correctly, and zero was assigned if students were unsuccessful in participation. We computed how many modules students successfully participated in. For the second measure, we considered students' scores obtained in each module. Each module score was calculated the percentage score as follows:

Module score = Number of correct questions/No of attempted questions *100

We calculated each student's total participation score (out of 100%) by combining the module scores of all 11 modules and calculating the percentage.

We used descriptive statistics to analyze the data for the first research question and examine the influence of extra credit on students' participation in programming and problem-solving questions. We reported the change in students' participation in two semesters (Control vs. Intervention groups). We used a multimethod approach for the second question and to examine the relationship between students' participation and exam scores. We examined the mean difference using a t-test between the exam scores of the control group and the intervention groups' exam scores. Also, we examined the relationship between students' participation in the practice questions and their exam scores using regression analysis between students' total scores in practice questions and their scores in both exams. We tested the assumptions for t-test and regression analysis and found no issues.

Results

1) Influence of extra credit on students' participation in practice questions

We used descriptive statistics to examine the variation between students' participation in control (when no extra credit was awarded) vs. intervention (when students were given extra credit for their successful participation in modules' practice questions) groups. Table 2. presents the results of the descriptive statistics.

Table 2. Descriptive statistics of students' participation in control vs. intervention groups

	No of the students participated	Participation Score (Mean ± SD)	Exam1 Score (Mean ± SD)	Exam2 Score (Mean ± SD)
Control	3	11.045 ± 17.118	71.000 ± 8.889	61.667 ± 18.930
Intervention	30	38.533 ± 24.801	82.379 ±19.197	72.793 ± 21.594

It was evident that only 6% of students attempted the practice questions without extra credit. However, with the extra credit option, more students (61%) participated in the extra credit questions. Also, Table 2 indicates the mean and standard deviation of the participating students. The results indicate that among participating students, the intervention group's students (with extra credit), on average, had higher participation scores, higher exam1 scores, and higher exam2 scores.

We also examined the number of successful participants for the intervention group for each module (see Figure 1). However, the same comparison was not warranted for the control group, as only 3 students participated in practice questions.

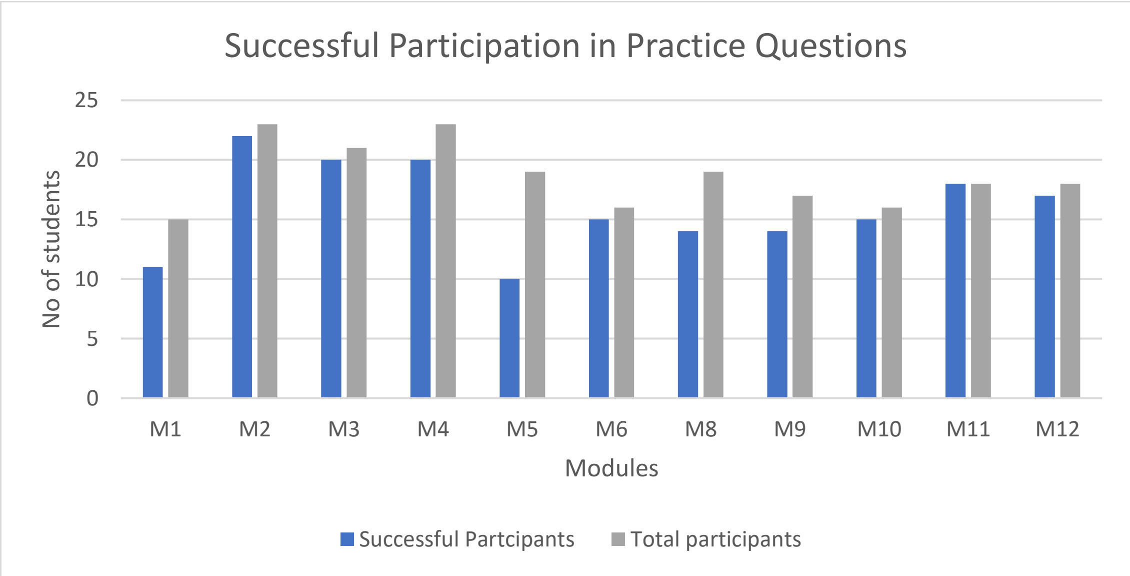

Figure 1. Comparison of successful vs. total participants in the intervention group

Figure 1 indicates that more students participated in the practice questions for module 2 and module 4. Also, Figure 1 indicates that the most successful participation can be observed for Module 11 with 100%, Module 2 with 95.6%, and Module 3 with a 95.2% success rate. Also, the lowest success rate was observed for Module 5, with a 53.6% success rate.

2) Role of participation in practice questions on students' performance in exams

To answer the research question about the role or impact of extra credit-based participation on students' performance in exam scores, we first compared the two exam scores for the control vs. intervention group. We hypothesize that students in the intervention groups performed better than students in the control group. We used a one-tailed interdependent sample t-test between the two groups. The results are presented in Table 3

Table 3. Mean comparison of exam scores between control and intervention groups

	Control (N = 44) Mean ± SD	Intervention (N = 48) Mean ± SD	*t*	*p*
Exam1 Part 1	38.18 ± 10.63	38.52 ± 9.72	-.160	.437
Exam1 Part 2	41.23 ± 8.80	44.52 ± 8.75	-1.799	.038*
Exam2 Part 1	30.11 ± 10.76	37.36 ± 12.53	-2.951	.002**
Exam2 Part 2	49.50 ± 12.82	37.66 ± 9.60	5.008	<.001**

* indicated <0.05; ** indicates <.01

The results indicate that although the students in the control group performed better than those in the intervention group for exam2 part2, students in the intervention group outperformed them on exam1 part2 and exam2 part1. As students in the control group rarely participated in practice questions, these results indicate the successful role of students' participation in practice questions on their exam performance.

In addition, we examined the relationship between students' participation in practice questions measured through their total percentage score and their performance in exams using simple linear regression analysis. We treated the total percentage score as the independent variable and exam scores in both parts of the two exams as the dependent variable. The results are presented in Table 4. As the control group didn't participate much, we ran the regression analysis for the intervention group only.

Table 4 Regression analysis between students' participation score and performance in exams

	B (Score)	SE	*F (1, 27)*	*p*
Exam1 Part 1	.151	.145	1.083	.307
Exam1 Part 2	.089	.150	.347	.561
Exam2 Part 1	.279	.146	3.643	.067*
Exam2 Part 2	.109	.147	.548	.466

* indicated <0.05; ** indicates <.01

The results indicate no relationship between students' participation scores in practice questions and exam performance. Although the regression analysis is significant for exam2 part1, the same cannot be observed for any other exam.

Discussion and Conclusion

This study examines the role of students' participation in practice questions and their performance. To design the experiment, we used literature evidence supporting that extra credit options could enhance students' participation in practice questions, which could impact their performance. We designed a quasi-experimental study to examine: 1) the influence of extra credits on students' participation in a programming course and 2) the impact of participation in practice questions on students' learning.

We used descriptive statistics to compare the participation measures in control (without extra credit) and intervention (with extra credit) groups. The results indicated a considerable increase in both groups' student participation (from 6% to 61%). Also, students who participated in practice questions were mostly successful, with the lowest success rate being 53.6% for module 5. This suggests that extra credit could motivate students to try the practice questions, which agrees with existing literature evidence on motivation[24, 28] and learning. Furthermore, These results align with existing literature that suggests that students attempted more questions when they were made aware of the extra credit possibility with additional work[26]. Besides the influence of the extra credits on students' participation, these results highlighted exciting insights from the course design perspective. We observed that Module 5 resulted in 19 students' participation and the lowest success rate (10 students being successful). This result is interesting because module 5 covers "for loops", a relatively harder concept for beginner and novice programmers [29]. This result is further interesting as the higher student success rate with Module 2 and Module 3 introduced students to sequential programming aspects (input/output, selection using if-else). Literature suggests that students could find loops more challenging for many reasons, including the schema of loops in program design, complexities in syntax [30], and the first addition of layers into an otherwise sequential program [29, 30]. Although our study design didn't warrant the evidence from the control group, such result is worthy of further exploration. Instructors could decide whether students need more practice options on the syntax and semantics of the loops before using them in the actual program. Also, we noticed a higher success rate in Module 11, which focused on matrix concatenation and debugging. One possible explanation of this result could be rooted in that Module 11 was conducted right before Exam2. Due to exam pressures and motivation to get higher grade in exam, students may have spent extra effort to participate and be successful in practice questions [16].

For the second research question, we used the mean comparison between the two exam scores for the control vs. intervention group to answer the role of extra credit-based participation on students' performance in exam scores. The results of the one-tailed interdependent sample t-test between the two groups indicate that for exam1 part 2 and exam2 part 1, students in the intervention group performed significantly better than students in the intervention group. Our findings confirm the existing literature where authors reported increased student performance by using extra credit [26]. Although these results indicate the impact of the students' participation on exam scores, it also raises questions about what the practice questions is in the nature of, which although they improved students' skills in part1 over time (from exam1 to exam2), didn't impact students' abilities for part2. This is interesting as most practice questions were designed around the skill of reasoning and debugging. However, the regression results indicated no significant relationship between students' participation scores in practice questions and exam performance.

Limitations

The results of this paper may be interpreted with several limitations. First, this study only investigated the impact of one variable- the effect of practice questions on exam scores. Other variables, such as the mode of delivery of practice questions and emphasis provided by the instructor weekly, may also have a significant impact. Future studies can be designed with more confounding variables. Secondly, Future studies can consist of a larger sample size of programming students exposed to practice questions. Thirdly this study only included two semesters of students, hence a small sample size. Future studies can mitigate the above limitation and have a larger sample size which will help investigate further. Also, this study was not designed with a randomized control sample and had a very small control group, which could impact the generalizability of the study. Future studies could collect sample data using randomized control sampling techniques with equivalent control groups. Also, using multi-modal investigations [31], studies may consider including process data to understand students' feedback, motivation, and experience on practice questions. Similarly, instructors' perceptions may be helpful in students' growth and participation. Also, classroom observations could help in understanding students' participation[32]. Future studies could consider the use of integrating extra practice questions as part of the learning environment and with different modes of instruction.

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