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Understanding the impacts of extra credit modules on students' learning experience in a 100-level electrical and computer engineering course

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Understanding the impacts of extra credit modules on student learning experience in a 100-level Electrical and Computer Engineering Course

Abstract

This Complete Evidence-based practice paper investigates students' perceptions regarding the presence of two extra credit (EC) modules on parallel computing topics in an introductory electrical and computer engineering course. Prior work investigating these EC modules showed a high participation rate (48-60%) across and high performance (80-88%) on the end-of-module EC quiz across three semesters [1]. The presence of extra credit has long been a topic of discussion in education, gaining strong arguments both for and against its inclusion in curriculum. Those opposed to extra credit cite ethical concerns related to grade inflation and question the utility of providing students with extra work that is not distributed as a traditional assignment. However, prior work has suggested that EC, when carefully designed, can have affordance such as motivating additional learning. This paper seeks to extend the previous, quantitative findings relating to these parallel computing EC modules by investigating students' motivations for completing or not completing the modules, as well as impacts on anxiety, effort, and learning. In doing so we seek to understand the affordances and drawbacks of extra credit in an effort to provide further insight into how to effectively design and deploy EC in introductory engineering courses.

A survey, consisting of a mix of five-point Likert items and short answer questions, was distributed to a large introductory electrical and computer engineering course across two semesters gaining 105 responses. The Likert questions related to: 1) students' motivations for completing the extra credit, 2) perceived learning gains from extra credit opportunities, 3) interest generated in the topics EC assignments covered, and 4) the relationship between anxiety and the presence of EC in the course. Survey responses for a set of short answer questions were analyzed with multiple rounds of inductive coding. In cases where a large number of related codes emerged, axial coding methods were used to extract thematic groups.

The following are results from the Likert questions and analysis of the corresponding short response questions. For those respondents who did complete the EC modules, the primary motivations they identified were: 1) maximizing their grade either by supplementing their current grade or protecting it from potential deductions in the future, 2) exploring new concepts, and 3) the approachability of the assessments due to their perceived low difficulty level and time requirements. Similarly, among those respondents who did not complete the EC modules, they stated a lack of time and no need for the extra points as the primary reasons.

Students overwhelmingly indicated through their Likert responses that they were willing to put large amounts of effort into extra credit assignments even in cases where they were only worth a few points. When asked about the factors that influence that effort, responses expanded upon the notion of 'grade protection' with some responses indicating that, if the time and points were sufficient, they were willing to dedicate large amounts of effort to the assignment. In particular, to protect against falling below particular grade boundaries (e.g., B+ vs A-). Related to this, when students were asked about the relationship between anxiety and the presence of extra credit, though the majority indicated through Likert responses that it had no negative impact, several suggested that the increase or protection in grade that the EC provides reduced their anxiety. With that said, a few did indicate that they either felt stress while completing the EC quiz or some stress immediately prior to beginning the quiz.

In terms of the impact of parallel computing EC modules on students' interest in those concepts, responses were evenly split between no impact and some degree of positive impact, with no participants reporting a negative impact. Those who felt it had a positive impact mentioned enjoying the opportunity to engage with a new concept and that opportunity increased their interest in that topic. When asked to reflect on what aspects of the assignments they found interesting and why, students' responses contained themes such as gaining further insight into and extending their knowledge of more fundamental concepts they had learned previously. Furthermore, several mentioned enjoying the authentic, "real-world" feel of the tasks with which they were presented.

Introduction

The inclusion of extra credit (EC) in a course has been used in an effort to address a variety of pedagogical goals, including to improve student learning [2, 3], reduce procrastination [4], promote additional work [5], and increase attendance [6]. However, the presence of extra credit in courses has long been a subject of debate, typically advocated by students excited by the opportunity to earn extra points but treated with skepticism by instructors [7] who question their pedagogical utility. Norcross et al. [8] surveyed students and faculty in Psychology department to identify attitudes surrounding its usage. They found a relatively wide disagreement between the two groups best illustrated by the 3% of students who felt extra credit should never be offered versus 21% of the faculty surveyed who felt the same. When queried on the potential advantages, students viewed it as a second chance to make up points whereas faculty reported using it as a way to motivate students to do given tasks and an opportunity to allow students to explore topics in greater depth. Of particular note was the hostility with which many faculty responded to this section typically citing issues such as causing students to take the required coursework less seriously or lowering standards. A follow up study by Hill IV et al. [9] had similar findings in addition to finding that many instructors stated if the instructors thought the extra-credit assignments were useful for students then they should simply be required.

With these perspectives considered, it is clear that many instructors have concerns regarding how extra credit assignments should be integrated into a curriculum, if at all. Zare [10] suggests that some of these concerns can be mitigated by making the work commensurate with the extra points, clearly communicating the special nature of those assignments, and setting clear limits on how

much will be offered in the syllabus. Similarly, Burke [11] implemented a semester-long extra-credit assignment to mitigate his concerns that extra credit would be used as an easy out rather than reflect ideals of commitment and knowledge as extended beyond the expectation of the standard curriculum. Such approaches may help instructors overcome their concerns that students may use extra credit as an easy way to improve their grades. However, it should be noted that increasing the workload associated with extra credit substantially might reduce the number of students who are able to complete it. In particular, some researchers have raised concerns that extra credit may contribute to inequity in the classroom by offering additional advantages only to students who have the ability to complete it [8, 12]. By increasing the difficulty substantially, it is possible that this potential inequity might be increased. These illustrate some of the design considerations that should be taken into account in the process of designing extra credit.

Though some instructors may hold the perspective that extra credit assignments offer lower-performing students the ability to make up those points [8], this is not always the reality of how they are utilized. Several studies have indicated that only the top-performing students tend to complete extra credit [2, 13, 14, 15]. This has led some to question the utility of these assignments as a mechanism by which lower-performing students can redeem themselves [14]. Similarly, Allevato and Edwards [4] attempted to mitigate procrastination by offering students 10% bonuses for turning in programming assignments three days early but found no impact, concluding that this only benefited students who were already managing their time well. However, these results have not been universal with Henley and Savage [16] finding no significant difference between the number of extra credit students at different levels of test performance earned - suggesting that students of all performance levels took advantage of the assignments. This discrepancy may indicate that the degree to which students utilize extra credit is not universal and the underlying design of the assignment and the student body to which it is being given should be considered when the goal is to maximize the number of students utilizing it. However, the factors that may influence participation rates have not been investigated to such a degree that clear recommendations on how to do this can be made.

Despite claims by some that extra credit could be used to reduce student anxiety [8, 17], relatively few studies have sought to verify this. The intuition underlying this argument is that given the strong relationship between anxiety and performance [18] and that by giving students the opportunity to raise their grades, their anxiety related to performance in the course should be reduced. However, findings related to this are few and contradictory. Stark et al. [19] found perceived academic stress was higher for students offered extra credit especially amount high performers. Conversely, Rice [20] found that by offering quizzes as extra credit they were able to reduce the anxiety associated with the quizzes but retain the learning benefits of more frequent, formative testing with marginal grade inflation ($\sim$2.5%). Given the variety of forms extra credit can take, this leaves a variety of open questions. These might include, under what circumstances does extra credit influence anxiety, what influences the magnitude and direction of this change, and in what contexts do those relationships emerge?

In summary, we identify the following gaps in the literature. First, it appears that high-performing students are among those most likely to complete the extra credit. However, both why some students engage in extra credit assignments and why others do not have undergone little investigation. Additionally, the relationship between the presence of extra credit assignments and

students' stress and anxiety in the course has undergone very limited investigations with only two studies, to the best of our knowledge, investigating the topic. Finally, multiple surveys suggest that instructors believe extra credit should demonstrate a deeper understanding of the curriculum or the ability to go beyond the base curriculum. However, few studies have investigated students' perceptions of assignments that follow this and assessed its utility. As such, we seek to investigate the following:

- The reasons why students choose not to complete extra credit and what might motivate them to do so.
- The motivations of students who do choose to do the extra credit.
- The relationship between extra credit assignments in the curriculum and anxiety.
- The impact of extra credit assignments that cover advanced topics, specifically parallel computing, on students' perceived learning and interest in those topics.

In doing so our findings contribute not only to filling these gaps in the literature but also to provide guidance on how assignments of this ilk can be integrated into a curriculum and the affordances they provide.

Methods

We conduct an exploratory, qualitative study aimed at evaluating students' general perceptions on the presence of extra credit in a 100-level Electrical and Computer Engineering course. Additionally, we investigate how those perceptions are related to the topic of parallel computing. In the first subsection we cover the development of these extra credit modules and their learning objectives. The second subsection discusses the survey design, data collection, and analysis process.

Course Context and Extra Credit Modules

Students in the course were given the opportunity to complete two extra credit modules: a parallel adder [21] and a parallel counter [22]. These are extensions to full-adders, carry-ripple adders, and ripple counters, which are topics covered in the base curriculum of the course. Each module contains a set of animated slides and a recorded 10-minute video lecture. Students are expected to self study and then complete a quiz with multiple-choice and fill-in-the-blank questions in order to earn extra credits. These quizzes were graded for correctness, and previous analysis shows that students performed well on these quizzes (80-88% correct) indicating that they get the majority of the available extra credit [1]. Points from the first extra credit quiz were applied to the homework category of the course grade, which is worth 15% of the total grade; points from the second extra credit quiz were applied to the labs category (15% of the course grade). The remaining 70% of the students' grade is made up of discussions (10%) and exams (60%)

Data Collection and Analysis

A digital survey was developed to investigate these research questions, which included questions both for students who did not complete the extra credit and for those who completed one or both.

The set for students who did not complete the assignments included questions on their reasoning for not completing either of the assignments as well as what would have potentially motivated them to do so. As for students who did complete the extra credit, questions were divided into four categories: 1) learning, 2) motivation, 3) interest in computing and parallel computing, and 4) anxiety. Each of these sections contained a mix of five-point Likert items and short response questions.

The survey was administered across two semesters. In the first semester (N=400) students were contacted via email in groups throughout the end of the semester. In the second semester (N=374), the survey was posted alongside the extra credit quizzes. In both semesters students were compensated with a free drink redeemable at the department's cafe.

Collected responses were divided into two groups based on whether or not students completed the assignments. For each, plots were constructed to represent the responses to Likert items. Short responses were subject to multiple rounds of inductive coding. Axial coding was then utilized to group related codes into thematic groups where appropriate. A researcher experienced with qualitative analysis but external to the project was given the resulting codebook and a random subset of student responses. Interrater reliability was calculated using Krippendorff's Alpha and found to be 0.84, well exceeding the accepted minimum threshold of 0.68 [23, 24].

Results

The results of the study are divided into four categories. We begin by reviewing the reasons students who did not complete the extra credit had for not completing it and what motivators might have compelled them to do so, finding that a lack of time or need to improve their grade was responsible primarily. Similarly, we review the motivations of those students who did complete the extra credit, finding that those students wished to make up for past losses or prevent future ones in addition to using it to expand their knowledge. Next, we discuss the relationship between students' anxiety and the presence of extra credit along with the relationship to the prevention of future points losses and the ability to make up for past ones. Finally, we review students' perception of the assignments as a learning opportunity, finding that roughly half the students self report an increased interest in parallel computing. Of those students, many referenced enjoying the opportunity to extend and improve on patterns they had learned in class.

Students' Reasons for not Completing Extra Credit

In total, we received responses from 29 students who did not complete the extra credit. When asked about their reasons for not completing the extra credit two themes emerged:

- *Prioritize Course Work:* Students in this category indicated that they did not complete the assignments since they were primarily focusing on the course's required assignments.
- *Extra Credit Not Needed:* Students with responses relating to this category indicated they did not feel they needed the extra points to succeed.

These students were given a follow-up question on what factors might have motivated them to complete the extra credit.

Sufficient Grade: Within this category students primarily mentioned having a lower grade in the course or category the EC was being applied to as factoring impacting their motivation.

- "*If my grade was worse I would have been motivated to focus on it.*"
- "*If my other homework assignment were graded poorly I may have decided to do the extra credit.*"
- "*If I needed it to get an A.*"

Some students further specified that poor performance that fell below a certain threshold would have motivated them to attempt the extra credit.

> "*Significantly lower scores, i.e. I would have homework and labs that could not be dropped that I would have 50% grades on.*

These factors are of course beyond the control of the instructor, but they do provide a basis for understanding the core motivations behind why students in this sample did not complete the extra credit.

Changing Category: Other factors students mentioned that are more within the control of an instructor included changing the category to which the extra credit was being applied:

- "*If the extra credit had been applied to a different category in the grade book, I would have completed it.*"
- "*Potentially adding credit in a category like exams instead.*"
- "*If it applied to the test category.*"

Students did not offer explanations as to why a category change would impact their motivation. However, given the findings in the previous category relating to sufficient grades, it might be the case that students would be more likely to complete extra credit in a category where they had lost points or anticipated losing points. As such, if concerns such as grade inflation are not a concern then allowing students to select the category it applies to or applying it to high value categories could be a way of increasing participation in these assignments.

Increasing Extra Credit and Removing Caps: As might be expected, increasing the number of points the extra credit is worth was also stated as being a potential motivator. This may be difficult given the balance that must be struck between having a sufficient number of points available to motivate students but low enough to moderate any concerns related to grade inflation. However, there are other considerations related to increasing extra credit point value that may act as a motivator as well. Several students mentioned that removing the cap on points applied to a specific grade category as being a potential motivator:

- "*If the extra credit could allow the grade to go beyond their percentage caps.*"
- "*If there was an ability to exceed the overall 15% [of the final grade] that homework gives.*"

To add context, students in this course had extra credit applied to the homework grade and lab grade categories, but they were not able to exceed 100% of the points available in that category.

Removing that cap offers a potentially interesting way in which to increase the number of students engaging with the extra credit without increasing the extra credit. Students for which the issue of a cap would be a relevant issue are likely already top performers in the class thus rendering the issue of inflating grades largely moot.

Motivations for Completing Extra Credit

We received 76 responses from students who completed at least one extra credit module. Compared to those who did not complete the extra credit, students were much more diverse in their reasons for completing extra credit:

- *Maximizing Course or Category Grade:* Codes within this category are related to supplementing an existing grade, protecting against future deficiencies, or recovering from previous poor performance.
- *Personal Edification:* Responses mapped to codes within this category related to students finding the exercises to be a good learning opportunity or having a general curiosity for the topics at hand.
- *Extra Credit Approachability:* Responses falling under this category related to the perception that the extra credit wouldn't take much time and weren't overly difficult.

Each of these categories are explored in greater depth below.

Maximizing Course of Category Grade: As might be expected, a significant portion of the participants listed the accumulation of extra points as their primary reason for completing the extra credit. Within this category, students appeared not only to care about increasing their overall grade, but also recovering their grade from points lost on previous assignments and protecting against the potential of future points losses.

- "*I wanted to make up points because I missed the deadline for a previous homework assignment.*"
- "*I completed the extra credit assignment to make up for losses that I had and could have had in other assignments*"
- "*I had extra time and I'm missing just about 1.5% of my homework grade so I did it. I did the lab one because I felt like I understood it well enough. Also in case I did worse on the labs I could use the buffer*"

One student expanded upon this indicating that the recovery aspect of points offered through extra credit was particularly useful as it gave students the opportunity to remediate those deficiencies.

> "*Extra-credit assignments are a great way of improving grades for students who might've fallen behind. Each course should have a substantiated amount of them to help struggling students succeed.*"

Though a substantial number of extra-credit assignments may be both unfeasible and at odds with course design goals, they may be used in moderation to allow students to recover from minor

lapses in performance. Additionally, topics underlying the assignments used in this study were tightly coupled with past coursework. This allowed students to reflect on things they had learned previously while extending them into new areas.

Personal Edification: A substantial number of respondents also indicated they completed the assignment due to their perceived learning benefits or due to a general curiosity concerning the topics.

- "*I thought that it would've been a good opportunity to learn more about the topics I've learned during the class*"
- "*The extra credit provided additional points for learning additional material related to the course so it was a good opportunity to improve my grade as well as gain more insight into course topics.*"
- "*I just wanted to learn something new, so I did it*"

These responses indicate that students are not only motivated by points but also by the content of the assignments and their interest in that content or learning new things in general. As such, in designing extra credit assignments ensuring that the content it covers is current and relevant to the student's interests may play an important role in motivating students to complete it.

Extra Credit Approachability: Finally, several participants also made note that they perceived the assignment(s) were sufficiently low in terms of their time requirements and difficulty that they could attempt it. Some examples of this include:

- "*The extra credit did not seem like it would take too much time and it seemed simple.*"
- "*It was a short assignment and I found it interesting so I did it*"

The degree to which this motivation is a concern for those designing extra credit will largely depend on what the goals of those assignments are. If one of the subgoals are to maximize the number of students who are able to do it, the size and scope of the assignments should be carefully considered so as to strike the balance between the assignments being useful learning exercises and ensuring the majority of their class would have the time and ability to complete them.

Relationship Between Extra Credit Opportunities and Anxiety

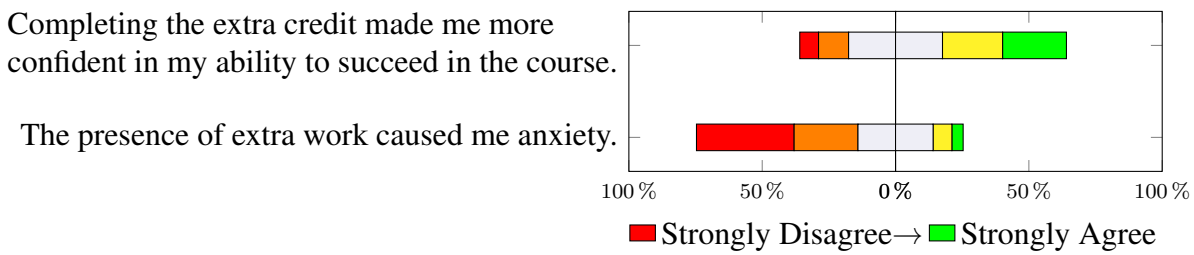

Figure 1: 5-point Likert questions concerning the presence of extra credit in the course and its impact on students' confidence and anxiety.

When asked about the impact of the presence of extra credit opportunities on their anxiety, students' responses overall indicated that it has little impact on anxiety but generally increased their confidence in their own success (Figure 1). Analysis of the short answer responses related to these Likert questions uncovered three categories:

- *No Impact on Anxiety:* Student indicated that the presence of extra credit had no impact on their overall anxiety in the course or that they felt no pressure to complete it.
- *Anxiety Reduction:* Student states that the presence of extra credit reduces their anxiety
- *Anxiety Increases:* Students whos responses fit into this category indicated that the medium of the extra credit and a sense of pressure to complete the assessment were contributing factors.

The short answer responses, like the Likert responses, were fairly evenly split between no impact on anxiety and anxiety reduction. However, the avenues by which extra credit might still be associated with anxiety may still represent important considerations that should be taken when these assessments are designed.

Extra Credit Doesn't Impact Anxiety: Of the responses, a significant portion indicated that the presence of extra credit had no impact on their anxiety in the course.

- "*Extra work was minimal and thus did not cause me any anxiety.*"
- "*I didn't have to do it. It was completely optional.*"
- "*It didn't need to be done so no, it was a nice break from all of the required work.*"

Related to the quotes above it appears that the lack of anxiety primarily hinged on students not feeling the pressure to complete the assignments. As one student put it:

> "*As it was not required, I was not stressed about completing it and would have been fine without doing it.*"

Though there is an argument that one would want to maximize the number of students who are making use of extra credit assignments, these responses suggest that the lack of pressure is what differentiates them from ordinary coursework and thus removes associated anxiety. As such, instructors incorporating extra credit into their curriculum should likely be careful when finding ways to motivate students to complete the assignments so as not to cause undue pressure and subsequent anxiety.

Extra Credit Reduces Anxiety: A significant number of students indicated that the presence of extra credit reduced their overall anxiety in the course primarily due to the added points.

- "*It's nice to have extra points as a cushion for my grade.*"
- "*Extra work actually reassures me. If I don't do well in future assignments, I can use the extra credit to boost my grade.*"

- "*Since it was only an extra credit opportunity, the assignment did not give me anxiety. Rather it made me feel better as I could cover up on some of the marks that I had lost during the semester.*"

When examining the quotes listed above, there is a clear relationship between the ways in which extra credit remediate these students' anxiety and their motivations for completing the extra credit. For example, one student's mention of extra credit reducing anxiety as a "cushion" is similar to the previously mentioned category of extra credit as a method of grade protection. When examining the impact of extra credit on students grades, we found that for the semesters where the extra credit was offer, 23-35% of students who completed the extra credit had their grade pushed up to the next grade category (e.g., B $\rightarrow$B+). Though students' motivations for completing the extra credit are likely primarily due to those categories discussed in the previous section, it appears that the improvement or protection of grades reduces anxiety often associated with maintaining good grades.

Causes of Anxiety Relating to Extra Credit: A significantly smaller number of students indicated that the extra credit were a source of anxiety. Within this category, students mentioned pressure to complete the assignment and anxiety associated with quiz element of the extra credit as being factors as well:

- "*I felt obligated to do the extra work even though it was optional.*"
- "*The only time I get anxiety is a few minutes before tests.*"
- "*Even though it's optional, I feel I have to make time to study and complete the quiz.*"

Related to this, a few students offered insight into a potential intersection between extra credit as a source of anxiety and a source of anxiety relief.

> "*It seemed as though this work is mandatory in order to protect my grade in the case of emergencies from unexpected typos, merge errors and technical errors that are unrelated to the effort I've put in a lot of my work.*"

As seen previously, many students found extra credit as method of reducing anxiety and protecting their grades However, it is worth considering that in courses with an already heavy workload the balance can shift towards the presence of extra work being a source of anxiety in the event students feel the pressure to complete them. As such, moderating the scope and quantity of these assignments may be necessary to ensure the positive benefits are maximized in addition to ensuring as many students as possible are able to make use of them.

Extra Credit as a Learning Opportunity

Students had a general positive perception of the extra-credit assignments in terms of its impact on their interest in computing topics and their value as a learning opportunity (Figure 2). Of particular interest is the impact of these assignments on students' interests in parallel computing topics where the Likert responses indicate approximately one-third of students were neutral and the remaining two-thirds were positive. In investigating the short-response answers related to this question, we uncovered the following attributes that underlaid both of those groups:

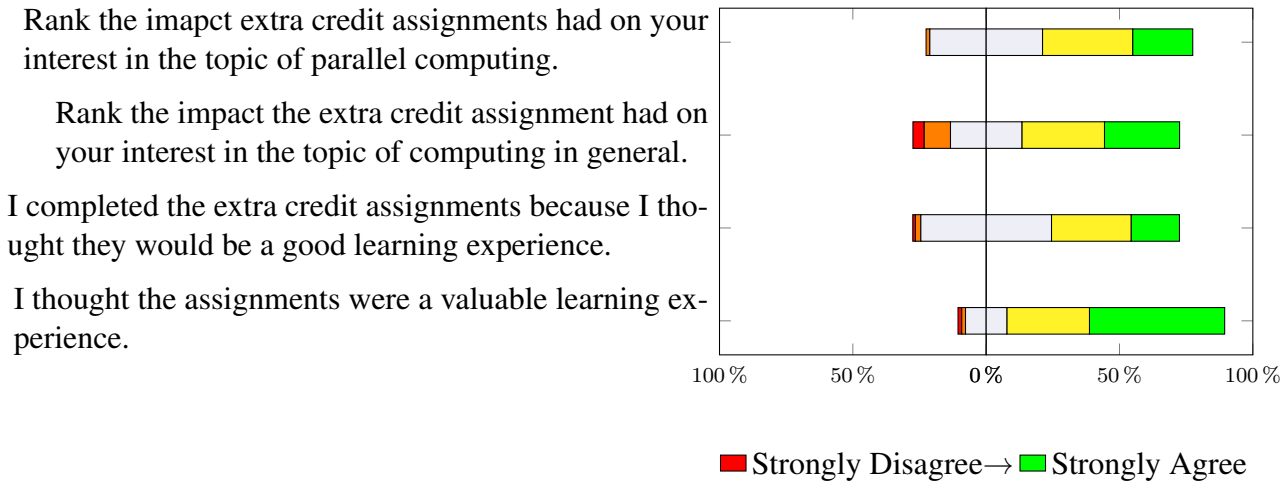

Figure 2: Responses to 5-point Likert questions regarding the impact of extra credit on interest and their value for learning

- *No Impact on Interest in Parallel Computing*: Students in this category typically gave terse responses indicating the assignments neither increased nor decreased their interest in the topic(s). A subset of those responses also indicated this was due to the student in question either already having other primary interests or only having done the EC assignment for the extra points.
- *Increased Interest in Parallel Computing*: Students who responded in the affirmative indicate that it increased their interest as the assignment introduced them to a new topic and showed them how the fundamental they had learned in their other assignments could be applied to more advanced topics.

No Impact on Interest in Parallel Computing Multiple students, when asked to expand on their ranking for the impact of the extra credit assignments on their interest in parallel computing indicated that the assignment had little or no impact.

1. "*It did not really change my interest in the parallel computing topic.*"
2. "*I am already interested in power electronics and electric propulsion, so doing these extra credit quizzes isn't enough for me to change my area of interest.*"

Of these, some students indicated this was primarily due to their core motivation being the extra points rather than the topics which the assignments covered.

1. "*I only did the assignments for extra credit so it had no affect on my learning*"
2. "*I wasn't too interested in the topic to begin with, so I just did the assignment for the points*"

With that said, it is worth noting that the free-response answers reflected the Likert responses in that no participants indicated the assignments caused them to become disinterested or damaged preexisting interest.

Increased Interest in Parallel Computing A variety of students also indicated that the extra credit assignments increased their general interest in the topic of parallel computing. Beyond this, some students indicated that it introduced a new topic and motivated continued learning in the topic.

- "*I did some research on parallel computing after that which allowed and motivated me to learn more.*"
- "*I thought it was neat that parallel computing can run much faster than series computing, but at the cost of complexity and resources.*"
- "*I see that parallel computing has many applications and can improve the speed of computing compared to other serialized designs.*"

Additionally, several students noted how the presence of extra credit assignments allowed them to gain insight into how the topics they were learning in their introductory courses translated to more advanced course work.

- "*This expanded on the knowledge we learnt and served as a good example for what we may be learning next.*"
- "*I appreciated the carry lookahead assignment as it had me apply patterns that I recognized while designing arithmetic units to an effective projection on paper. It felt satisfying seeing how I can apply a pattern I recognized.*"

Notably, one student extended this and mentioned that given the introductory nature of the course increased their awareness and understanding of the subject as an option for future investigations.

> "*Just enough info to catch my attention, not quite enough to satisfy my curiosity. The assignments gave meaning to parallel computing courses, instead of them being just other options from the list.*"

In aggregate, these sentiments offer insight into how the presence of assignments that serve as an introduction to more advanced topics can: 1) motivate interest in those topics, 2) contextualize the fundamentals students are currently learning, and 3) give insight into future coursework that will allow students to guide their decision-making when choosing upper-division electives. By including these assignments as extra credit, access to these topics can be made available without adding to what are often already difficult and time consuming courses.

Conclusion and Future Work

Overall, it appears the extra credit parallel computing modules in a 100-level Electrical and Computer Engineering course had a positive impact on students with minimal disadvantages. Given the high participation rates of the assignments, it appears that students were generally motivated to complete the assignments. However, understanding the motivations of those who did and did not complete the extra credit assignments can offer insight into how to design effective assignments, improve students' experiences, and increase participation.

With regard to students' motivations for completing or not completing the extra credit assignments, we uncovered that factors relating to grades were the primary motivators. For students who did not complete the assignments, the majority mentioned they felt they had a sufficient grade. Similarly, for those students who did complete the assignments most mentioned they were recovering points or protecting against future point loss. If the goal is to maximize the number of individuals completing the extra credit, the responses of those who completed them suggest the assignments should be kept approachable and reflect the interests of the class. For those who did not complete the assignments, some indicated that if the EC points were applied to another category (e.g., exams) or there was no points cap they might have completed them. This is likely due to the fact that students are more likely to lose points in that category. If the course's design allows, applying points to a category where students are more likely to lose points may be a way of increasing both the utility of the extra credit and the number of students who will be motivated to complete it.

Related to students' motivations for extra credit, we found that in some cases the presence of extra credit reduced some students' anxiety. They cited the ability to regain points they had previously lost or protection against future points as reasons for this anxiety reduction. Those who reported no impact on their anxiety mentioned the optional nature of the assignments as being the primary reason. A very small number of students mentioned an increase in anxiety due to the pressure to complete the assignments. From these findings, it appears that extra credit may be an effective way by which to reduce students' anxiety overall. However, careful consideration should be given with respect to the design and delivery of the assignments such that students don't feel pressured to complete them. If they do, it is likely that the group of students who feel the work is mandatory and a sense of pressure to do it will grow and the anxiety-reducing benefits will be undermined.

Many students appeared to enjoy the parallel computing EC modules and find them interesting, commonly referencing it as a way to improve the performance of serial solutions previously covered in class and add context to future courses in which they may enroll. For students who showed no interest, there are two possibilities: 1) they are motivated purely by points, and changing the topic would have a minimal impact on interest and motivation, or 2) another advanced topic would have interested them more. For the latter group, it may be a worthy investment to introduce other extra credit assignments modeled on more advanced topics. This would retain the benefits of allowing students to see the road ahead in addition to extending and applying what they are currently learning. However, this should be done while bearing in mind that some students felt anxiety due to a sense of obligation to complete the assignments. As such, it may be best to create more assignments but limit students to completing a small number of them so as to mitigate the risk of these students overloading themselves and becoming anxious.

There is currently a dearth of prior work on how the design of extra credit can influence things such as the factors that motivate students to complete the assignments, students' anxiety, and the interest they can generate in the topics they cover. The results of this study uncovered how students judge these factors and provide avenues for future investigations which can be used to inform the design and expected outcomes of extra credit. In particular, our findings that extra credit, in this context, caused some reduction in anxiety related to performance in the class are particularly noteworthy and worthy of future investigations. If including extra credit activities

gives students the ability to remediate deficiencies in knowledge and points while reducing the anxiety this would provide a strong argument in their favor. In this way, they could be considered similar to second-chance testing which allows students a second opportunity to take their tests for some form of grade replacement and has similarly been associated with reductions in anxiety due to factors such as the ability to recoup points lost [25]. Extra credit if designed and deployed properly could provide a similar role for instructors who want to achieve similar benefits without increasing the number of tests they give in the course.

References

[1] Zeran Zhu, Ujjal K Bhowmik, Yue Wang, Zuofu Cheng, and Yuting W Chen. Having it all: Infusing parallel computational thinking in the lower-level computer engineering curriculum using extended learning modules. In *2021 ASEE Virtual Annual Conference Content Access*, 2021.

[2] Laura M Padilla-Walker. The impact of daily extra credit quizzes on exam performance. *Teaching of Psychology*, 33(4):236–239, 2006.

[3] Mohammad Muztaba Fuad and Elva J Jones. Using extra credit to facilitate extra learning in students. *International Journal of Modern Education and Computer Science*, 4(6):35, 2012.

[4] Anthony Allevato and Stephen H Edwards. The effects of extra credit opportunities on student procrastination. In *2013 IEEE Frontiers in Education Conference (FIE)*, pages 1831–1836. IEEE, 2013.

[5] BR Bate. Extra credit: A token reinforcement system for increasing interest, motivation, and outside reading. *Directory of teaching innovations in psychology*, pages 64–65, 1976.

[6] David A Wilder, William A Flood, and Wibecke Stromsnes. The use of random extra credit quizzes to increase student attendance. *Journal of Instructional Psychology*, 28(2):117–117, 2001.

[7] James L Groves. Students' perceptions of extra credit. *Journal of Hospitality & Tourism Education*, 12(1):27–62, 2000.

[8] John C Norcross, Linda J Horrocks, and John F Stevenson. Of barfights and gadflies: Attitudes and practices concerning extra credit in college courses. *Teaching of Psychology*, 16(4):199–204, 1989.

[9] G William Hill IV, Joseph J Palladino IV, and James A Eison IV. Blood, sweat, and trivia: Faculty ratings of extra-credit opportunities. *Teaching of Psychology*, 20(4):209–213, 1993.

[10] Mortaza Zare. The formation and management of academic entitlement: The case of extra credit assignments. *College Teaching*, 70(4):405–412, 2022.

[11] John Francis Burke. The extra credit project: Turning a bane into a blessing. *PS: Political Science & Politics*, 24(2):220–222, 1991.

[12] Christopher A Pynes. Seven arguments against extra credit. *Teaching Philosophy*, 37(2): 191–214, 2014.

[13] Marissa A Harrison, Denise G Meister, and Amy J LeFevre. Which students complete extra-credit work. *College Student Journal*, 45(3):550–555, 2011.

[14] Marjorie S Hardy. Extra credit: Gifts for the gifted? *Teaching of Psychology*, 29(3): 233–233, 2002.

[15] Laura M Padilla-Walker, Byron L Zamboanga, Ross A Thompson, and Larissa A Schmersal. Extra credit as incentive for voluntary research participation. *Teaching of Psychology*, 32(3):150–153, 2005.

[16] Tracy B Henley and Indy L Savage. Who earns extra credit these days? *The Journal of psychology*, 128(3):311–314, 1994.

[17] Anya Goldina, Peter Licona, and Patricia Likos Ricci. Creating extra credit assignments that challenge, inspire, and empower students. *HAPS Educator*, 2020.

[18] Jennifer Barrows, Samantha Dunn, and Carrie A Lloyd. Anxiety, self-efficacy, and college exam grades. *Universal Journal of Educational Research*, 1(3):204–208, 2013.

[19] Gary Stark, Stacy Boyer-Davis, and Melissa J Knott. Extra credit and perceived student academic stress. *Journal of Business and Educational Leadership*, 10(1):88–108, 2020.

[20] Brian Scott Rice. How extra credit quizzes and test corrections improve student learning while reducing stress. In *2020 ASEE Virtual Annual Conference Content Access*, 2020.

[21] Charles H Roth Jr, Larry L Kinney, and Eugene B John. *Fundamentals of logic design*. Cengage Learning, 2020.

[22] Ramachandran Vaidyanathan, Jerry L Trahan, and Suresh Rai. Introducing parallel and distributed computing concepts in digital logic. In *Topics in Parallel and Distributed Computing*, pages 83–116. Elsevier, 2015.

[23] Klaus Krippendorff. *Content analysis: An introduction to its methodology*. Sage publications, 2018.

[24] Antonia Zapf, Stefanie Castell, Lars Morawietz, and André Karch. Measuring inter-rater reliability for nominal data–which coefficients and confidence intervals are appropriate? *BMC medical research methodology*, 16:1–10, 2016.

[25] Chinedu Emeka, Timothy Bretl, Geoffrey Herman, Matthew West, and Craig Zilles. Students' perceptions and behavior related to second-chance testing. In *2021 IEEE Frontiers in Education Conference (FIE)*, pages 1–8. IEEE, 2021.