

Offering Partial Credits in Exams Created Using Blackboard Quiz Pools in Mechanical Engineering Courses

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Abstract

Instructors give homework and exams to help students apply what they are learning in class. Grading them is time-consuming for the instructor or teaching assistant (TA), and the feedback to the students comes at a time when they are no longer thinking of the problems. In addition, many students obtain access to textbook solutions. Some book publishers (e.g., Pearson's Mastering Engineering and McGraw Hill's Connect) provide automated grading for homework and exam problems. However, using a publisher's grading site is an additional student expense.

To keep the benefits of automated grading without the cost to the students, question pools in Blackboard were created for textbook problems but using different numbers. The same method was also used for exams, allowing each student to have a different exam than other students in the class. All exams were graded by Blackboard's automated grading system as either correct or incorrect, regardless of whether the student never understood the concept or made a minor calculation error, an issue complained about by the students at the initial implementation of the automated grading system.

To address this shortfall, students were offered a chance to upload their detailed work after the exam for potential partial credit. Sometimes, students fully understood the concept and the problem-solving process but made minor calculation errors. In those cases, the instructor can review their detailed work and decide if the student's effort is worth partial credit. This partial credit mechanism was added to the Blackboard-based automated grading system during the second year of implementation.

At the end of the semester, students completed a survey about their experiences with the automated grading system. They found the computerized grading system helpful and appreciated not having the extra expense of a textbook grading system. Students particularly liked the opportunity to receive partial credit. This paper will focus primarily on the partial credit mechanism and its impact on student learning and performance. It was found that students were more motivated to learn and to prepare for the exams when partial credit was offered, as illustrated by the semester-end survey.

At present, the detailed work students submit for partial credit is reviewed manually by the instructor. In the long run, the authors would like to seek a semi-automated process of gathering and grading the detailed work to support the partial credit mechanism.

Introduction

Manual grading is one of many tasks a faculty member encounters daily in the academic environment. It is probably not most professors' favorite part of a teaching job. They could spend

their time and effort on more productive work, such as searching for new applications and developing new lecture topics. In addition, manual grading does not provide instant feedback to the students on their performance and understanding. With the ever-evolving technology, more and more homework has moved online in recent years, and many online homework problems come with automated grading.

Research on auto-grading has shown mixed results ranging from being helpful to students to having no significant effect. Arora *et al.* show that online homework significantly improved students' grades in a statics course [1]. Multiple attempts at homework problems have been shown to improve the performance scores in an economics class [2]. Magalhães *et al.* [3] provide a literature review of the benefits and pitfalls of online homework. They noted that others found that the ability for students to try again may encourage students to practice to achieve mastery [4] and that randomization of exercises is likely to reduce cheating [5]. One drawback of their reported online homework is that it emphasizes the final answer rather than the process [6]. Cooke and Al Faruque saw mixed results in implementing Mastering Engineering in a Strength of Materials course [7]. O'Neill *et al.* [8] saw a slight improvement in using Mastering Engineering on students' test scores. Overall online grading reduces the faculty workload and could benefit the students as well.

This paper continues our previous work in implementing a Blackboard-based automated grading system in mechanical engineering courses [9]. The Blackboard help page provided the question upload formatting [10], and the Excel guide helped in developing the questions [11]. While it initially took a considerable effort to set up the system, it reduced the overall time and effort in grading the student assignments and exams. The process also provided instant feedback to the students on their performance. It enhanced their understanding of the topic concept and its applications.

Automated grading is not new. Major publishing companies have provided such services to the higher education community for years. Examples include Pearson's Mastering Engineering and McGraw Hills's Connect. One of the drawbacks of using such services is the cost to the students on top of already expensive textbooks.

The implemented system we presented previously used Blackboard quiz pools and Excel, so there was no additional cost to students. It also saved university costs by eliminating the need for teaching assistants (TA). In addition, its implementation had some side benefits, such as minimizing cheating and having greater flexibility in offering exams.

On the other hand, the Blackboard-based automated grading had its drawbacks. The issue that stood out among the student surveys was the complaint of not having a chance to obtain partial credit in the exams. Using Blackboard's automated grading system, students either get full credit for submitting a correct numerical answer or no credit if the submitted numerical answer was incorrect. Sometimes, students understood the concept and made a calculation error. They were treated the same as the students who never understood the concept.

Offering partial credit for an exam is an interesting topic by itself among the educational community. Some faculty members do not give it, while many others do. The methods for

determining partial credit include reviewing exam papers manually [12], asking and reviewing post-exam reflections from the students [13], and conducting in-person interviews [14]. Some faculty members went in the other direction of eliminating partial credit and supplementing it with extra credit problems [15].

After reviewing student requests, we decided to offer partial credit for the exams. The students were allowed to upload their detailed calculations to Blackboard for partial credit within ten minutes after completing the exam. The teaching faculty will review their detailed calculations and make partial credit decisions for each problem. Partial credit could be added to their exam score if the mistakes resulted from a minor calculation error.

We also decided that uploading documents for partial credit is optional. If the students are happy with the results, they do not need to submit detailed work to support their answers. Over the last two semesters, about half of the students chose to submit their detailed work, and about half of the submitted work received partial credit. Naturally, offering partial credit increases the faculty workload. Based on the experience from the last two semesters, the added manual grading work was not significant since only half of the students chose to submit documents for partial credit. The instructors were able to accomplish this without the help of a TA. Furthermore, the manual grading allowed instructors to sample the detailed student work and identify the specific issues reflected in the exam.

The work in this paper is to address the implementation of partial credit in exams and its impact on student learning and performance. Based on the semester-end survey, we found that students benefited from it and were motivated to spend more time preparing for the exams. We plan to continue and make it an integral part of the exams in the future.

Methods

Three courses taught by the instructors were selected for adding partial credit during exams in the Blackboard-based automated grading system. The courses were Thermodynamics (four sections), Engineering Statistics (one section), and Dynamics (one section). These are courses taken in the student's Junior year. Engineering Statistics is a required course for all engineering majors. Thermodynamics is required for Mechanical and Chemical engineering. Only Mechanical and Civil engineering students are required to take Dynamics. In Thermodynamics and Engineering Statistics, students did their homework assignments on Blackboard, while students used Mastering Engineering for their Dynamics homework. Students were allowed unlimited attempts for homework, so partial credit is not needed. However, they needed to solve the exam problems on their laptops in the classroom within the specified time. Partial credit was offered for the exams of all three courses.

The university uses Blackboard as its learning management system. Blackboard has the option to upload questions to be used in online tests [10]. The detailed process of using it as an automated grading system for homework and exams was documented in our previous work [9]. Based on the feedback from our initial implementation, we decided to add partial credit in exams if the students submit on Blackboard the supporting documents at the end of the exams. Students can submit their detailed work in any form accepted by Blackboard, such as a pdf document or a

picture taken by cell phone. The work must be submitted within ten minutes after the exam to prevent cheating. The instructor reviews the submission in conjunction with the grading done by Blackboard.

Offering partial credit was implemented in the fall of 2022 with the following observations:

- (1) Since the participation was optional, about half of the students submitted the documents for partial credit.
- (2) Among the students who submitted the documents, about half received partial credit based on their detailed work. Others did not because the work did not demonstrate a good understanding of the subject or the calculation was inconsistent with the answer submitted.
- (3) The instructor recorded the decision (granting partial credit or not) on Blackboard. This note was helpful when the students challenged the decision (why they did not receive any partial credit or got less than they expected).
- (4) The instructor added the partial credit to the Blackboard grade book for later final grade calculations.

Results

The partial credit mechanism was implemented in three Junior year engineering courses in the fall of 2022. The students could receive partial credit for both mid-term and final exams. Students needed to submit the supporting document at the end of the exam to receive partial credit. Since participation was optional, not all students uploaded their detailed work. If they are happy with their grades (Blackboard grades the exam instantly upon submission), they can choose not to participate. The data in Table 1 below illustrates the participation rate.

Table 1, Partial Credit Document Submission Rate

	class enrollment	mid-term exam	final exam
Thermodynamics	59	49.2%	55.9%
Engineering Statistics	24	41.7%	50.0%
Dynamics	18	47.4%	63.2%
	Average	46.1%	56.4%

About half of the students chose to submit documents for possible partial credit. The submission rate is a little higher for the final exam than the mid-term, about 10% more on average. Based on conversations with the students after the exams, it appears that they were trying to figure out the new system during mid-term exams and became more comfortable using it during the final exams. Some students also revealed that they became more serious about their grades toward the end of the semester and more submitted documents for partial credit in the final exams. This observation is consistent with the submission rate illustrated in Table 1.

In addition, the authors noticed that the amount of work in grading the submitted documents by hand was manageable, and the partial credit system could be expanded to other engineering courses.

Table 2 shows the average exam grade between students who submitted documents for partial credit, and those who did not. As we expected, the average grades were higher among students who chose not to submit documents for partial credit. The average grade for the students who submitted documents for partial credit is lower, particularly in mid-term exams. This difference (submitted vs. not submitted) shrunk for the final exams.

Table 2, Grade Comparison between Students who Participated vs. those who did not Participate

average exam grades	mid-term exam		final exam	
	submit	not submit	submit	not submit
Thermodynamics	71.0%	90.9%	72.9%	83.8%
Engineering Statistics	81.3%	92.1%	85.3%	87.7%
Dynamics	74.1%	91.0%	79.2%	83.3%
Average of 3 courses	75.5%	91.3%	79.1%	84.9%
Difference (mid-term vs final exams)		15.9%		5.8%

The grade difference was more prominent for the mid-term than the final exam. This difference could be attributed to the different exam problems between the two. It could also be attributed to the fact that the student performance during the mid-term exam had a much wider range. Towards the end of the semester, the students with poorer performance improved, and the final exam grades had a smaller range with less variation.

Table 3 shows the exam grade improvement after adding partial credit. We learned from Table 2 that more students participated during the final exam than in the mid-term exam (about 10% more on average). This table shows that not only did more students participate during the final exam, but they also received more partial credit on average (about 2% more), a reflection of more study, better documentation, and a better understanding of the concept.

Table 3, Percentage Added by Partial Credit to the Exam Grades

	mid-term exam	final exam
Thermodynamics	5.8%	7.6%
Engineering Statistics	4.3%	6.0%
Dynamics	5.4%	8.1%
average	5.2%	7.2%

Since the exams are part of the grading rubric, it is worth looking at the impact of partial credit to the overall final course grade. In our institution, the final student course performance is assessed

by the letter grades ranging from not passing (D+ or below), C-, C, C+, B-, B, B+, and A. Table 4 shows the percentage improvement of the letter grade for these three courses as the result of partial credit. When the grade improved from C to C+, it is noted in the table as half grade improvement. Two half grade improvements are noted as a whole grade improvement. The table also shows the percentage of students who improved from not passing to passing the course due to adding partial credit.

Table 4, Course letter grade improvement after adding Partial Credit

	No improvement	half grade improvement	whole grade improvement	Improved from not passing to passing the course
Thermodynamics	47.1%	47.1%	5.9%	0.0%
Engineering Statistics	40.0%	60.0%	0.0%	0.0%
Dynamics	50.0%	50.0%	0.0%	7.1%
Average of 3 courses	45.7%	52.4%	2.0%	2.4%

The percentage is calculated among students who received partial credit, either in mid-term or final exams.

The table shows among the students who received partial credits on average, a little over half of them improved their course grade by half of a letter grade, and less than half of them received no improvement on their course letter grade. A few students (Two in Thermodynamics only) saw a whole letter grade improvement. Only one student (in Dynamics) improved the course grade from not passing to passing.

With IRB approval, students were asked to complete a survey at the end of the semester, ranking their experience with the Blackboard grading on a Likert scale.

Figure 1 shows the breakdown of the tabulated responses. In the figure, the number in the box is the number of participants with that answer. Due to class size and response differences, the figure displays answers on a percent scale. Bars in green represent positive responses (Strongly agree, somewhat agree), while red represent negative responses (Somewhat disagree, strongly disagree). The percentage of positive answers is listed in parentheses next to the question summary. Overall, students were generally positive concerning the automated grading system. The responses to some of the questions in Dynamics were statistically questionable since only four students responded.

The participation rate of this survey is something we are planning to improve in our future study. The ways of encouraging more participation could include offering extra credit or making it a special homework assignment.



Figure 1, Survey responses were positive in the different classes.

To encourage more participation in this survey, we included the minimum number of questions in the survey. This approach had its drawback. We did not include the questions about whether the students submitted the document for partial credit or not. We also did not include information related to whether if they received the partial credit or not after submitting the supporting documents. These are the areas we would like to improve in our future study.

The last two questions were explicitly included to gauge student reaction to partial credit offered for the exams. Students were asked to rate the following two questions on a Likert scale:

1. I found offering partial credits in the exam beneficial and would like to see it continue.
2. I found offering partial credits in the exam motivated me to spend more time and effort to prepare for exams.

The above figure shows that 95% ~ 100% of Thermodynamics students strongly agree with both statements. This percentage for Engineering Statistics was 80% ~ 100%. In Dynamics, 75% of the students Strongly agree with the two statements. The second question addresses the motivation issue in student learning. Student learning motivation in itself is a vast topic. Research and publications were devoted to its theory and practice for a long time. For example, Gopalan *et al.* provided a review of commonly used theories and practices of motivation in learning [16]. Park [17] further reviewed the motivation theories and their impact on instruction design. Souders [18] discussed the motivation theories and their practices in a public high school setting in San Francisco area and reported improved learning as well as teacher-student relationship.

This work focuses on adding partial credit to exams in a Blackboard-based automated grading system and its related impact. The response from the semester-end survey surfaced the interesting topic of student learning motivation, which is a very good topic for our future research. At present, both authors are continuously refining the Blackboard-based automated grading system in their ongoing teaching. To further study the motivation aspect of student learning, the survey questions need to be refined based on further study of motivation theory and the related common practices. We will address this in our future research work.

Discussions and Conclusions

With the use of an automated grading system, the grading workload was reduced, and the need for TA was eliminated, saving some operating costs for the university. The system also provided timely feedback to the students on their performances. With the option of multiple attempts to do their homework assignments, students had the chance to go back to the lecture slides for further concept review and calculation verification, enhancing their learning. By adding partial credit in exams, students had more chances to demonstrate their understanding of the concept and receive recognition for their mastery of the contents. The student feedback indicated an overall positive view of the system, and they seemed more motivated to spend more time and effort in exam preparation, enhancing their learning.

Overall, the automated grading was well received by the students, and it will definitely reduce the faculty's effort in teaching the same course in the future. At present, the detailed work students presented for partial credit are reviewed manually by the instructors. In the long run, the authors would like to seek a semi-automated process of gathering and grading the detailed work to support the partial credit mechanism in exams.

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