Formative homework assessment strategies to promote student self-reflection and improve time management: a pilot study

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At the University of Maine's small Brunswick Engineering Program we have launched a pilot assessment of two different homework-grading schemes aimed at increasing student's timely reflection on any mistakes made. Homework solution access-patterns and student self-reported reflection and learning are discussed for, first, homework submissions followed by the students taking a quiz consisting of one of the homework questions during the next class day and, second, homework submissions followed by a self-grade of the submission also due the next class day. In both cases the homework results are published immediately following the due date, and student access patterns to the solutions are recorded. Results indicate increased interaction with the homework solutions for both strategies, with self-grading access patterns displaying the highest frequency and least concentration before the test, as well as a student-perceived higher effectiveness in supporting their learning effort.

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Introduction

The Brunswick Engineering Program (BEP) was started in 2012 to implement modern engineering pedagogy in an off-campus startup setting. The BEP delivers the first two years of the Mechanical, Electrical, Computer and Civil Engineering Bachelor Degree programs using an integrated curriculum that teaches the mathematical and science content within an engineering context, with a strong emphasis on experiential and project- and problem-based learning, flipped classroom pedagogy, and overall a highly student-centered learning environment. The objectives of the program are to provide an additional entry point into Engineering Education at the regional area of interest, while at the same time increasing student persistence through the application of the student-centered pedagogy.

The framework of the program constitutes an ideal environment to introduce pedagogical innovations, as its small size allows a high level of curricular flexibility directly supported by extensive interaction between the faculty and the students. The program has been used to pilot a number of interventions, such as an evolutionary integrated curriculum (Wilhelm A. Friess 2013a), a series of cornerstone integrated PBL experiences (Wilhelm Alexander Friess and Davis 2013), just in time learning in Engineering Design (Wilhelm A. Friess 2013b).

Many of the pedagogic activities at the BEP are supported by traditional homework assignments, carried out by the students outside of class hours. As such, homework constitutes a core learning element for all courses, and represents an important formative assessment tool for the instructor.

However, homework often only represents a small portion of the overall course grade, and students who couple their effort to the weight of the deliverables may not consider it as important as other higher-weighted course assessments, and accordingly reduce their effort and time commitment. These students often do not recognize the importance of the homework in acquiring the skills that will be needed to succeed in the exams, resulting in time management schemes that rely on extreme (and often ineffective) study efforts concentrated immediately before the exams, rather than an ongoing study including the review of the homework and self-assessment of mistakes made. Observations show

that for these students the focus is not on inquiry, but on maximizing the grade, with the implication that once the task that will be assessed for a grade is completed, little to no reflection on the experience is conducted. Reflection on the student's own performance in the homework is thus typically only conducted sporadically before the exams, where homework solutions are reviewed during just in time 'cram sessions'.

In addition, the typical student perception that homework is a 'hurdle to a good grade' triggers a primary focus on delivering correctly solved problems, which can lead to shortcutting the process altogether by using the increasingly available solution manuals, thus negating not only reflection on their work, but also the initial self-regulated attempt at a solution.

In the manner homework is typically used, learning becomes a byproduct of the student's effort in attaining the highest grade, and not the focus of the exercise. The work presented here, and in the context of the BEP's pedagogical research activities, aims to relate student's post-submission critical review of their homework efforts by analyzing access patterns to the published solutions for two specific homework strategies aimed at increasing this interaction: a homework based quiz, and a self grading activity.

Prior work

Homework is a core component of the pedagogical methods used at all grade levels, and a wide range of research-based evidence supports the effectiveness of homework in learning (Trautwein and Köller 2003). Cooper et al. (2006) presents a comprehensive review of research on the effectiveness of homework, and Kitsnatas and Zimmerman (2008) analyze the role homework plays in academic achievement and reinforcing self-belief. They identify a weakness in the homework research:

'The impact of homework experiences on college students' acquisition of self-regulated learning skill has received very little study to date. In fact, most of the research on homework has focused on its positive impact on achievement' (Kitsantas and Zimmerman 2008)

The authors argue that self-regulatory skills such as goal-setting, time management, and self-reflection and evaluation, are highly indicative of academic achievement, and current homework practices do not explicitly support the development of these skills.

Self-reflection, defined as 'the action of turning (back) or fixing the thoughts on some subject, in order to learn' (Higgins 2011), contributes to the development of student self-regulation (Ramdass and Zimmerman 2011), which in turn has been widely recognized as a primary building block of learning:

- Self-reflection supports knowledge retention (Shacham 2005).
- Self-reflection, through the critical observation of the students own work, and through the identification of mastery experiences, is conducive to building self-efficacy (Hutchison et al. 2006).

Effective learning in such a setting encompasses not only cognitive aspects, but also metacognitive and behavioral dimensions (Li, Swaminathan, and Tang 2009), and as such has triggered the development and application of a wide range of pedagogical techniques. Approaches such as experiential learning and peer instruction and concept based learning (Crouch and Mazur 2001; Watkins and Mazur 2013) are creating student-centric learning environments that stimulate the student to actively participate in his learning. A key element in this student-centric learning process is teaching the student to reflect on the learning experience (Lawanto 2010), and may be triggered through increased faculty interaction and formative assessment strategies (Bjorklund, Parente, and Sathianathan 2004) such as the one discussed here.

The work presented here explores and pilots strategies to decrease the perceived worth of homework correctness towards attaining the grade, and to increase the students reflection on their effort in order to maximize the learning contribution of homework.

Methodology

This pilot study applies two different strategies to motivate the students to revisit their submitted homework and reflect on their mistakes made:

- Normal homework submission followed by a quiz the next class day
- Normal homework submission followed by a submission of a self-grade based on a given rubric

The study is carried out at the BEP over two years (4 courses, both at freshman and sophomore level), with total participation of 22 students. Due to the low student numbers, no assessment of the learning benefit of self-reflection is conducted, but only an analysis of student access patterns to homework solutions and survey based student self-reporting on effectiveness on time management and in the learning process.

The quantitative analysis of student access is carried out by leveraging the reporting capabilities of Blackboard course management system utilized at the BEP. Homework solutions are distributed to the students via this system, and access logs show data and time of student first access, as well as number of times accessed. A limitation of this approach is that students can download the solution files, and use them offline without the system recording any access beyond the first access. However, as the analysis presented here shows the relation of first access (time and date) with the time and date of the quizzes and exams in the courses, reporting the first access represents the maximum time they have spent on the homework solutions, and thus can be considered a conservative estimate.

Analysis of homework solution access-patterns of regular submitted and graded homework shows that students do not look at the solutions and reflect on what they did right or wrong, but rather –if at all – only download the solutions the day before the major tests (Figure 1). At this time the specific difficulties that they underwent to solve the problems when they were assigned are long forgotten, and thus a disconnect exists between the mistake and the reflection on how to solve it correctly.

The goal of this work is to trigger self-reflection immediately after the submission. This is accomplished in 2 ways:

1 – Formative quiz. The homework grade is divided into a quiz grade and a submission grade, and thus the 'grade-worth' of correctly solved homework is reduced (this has the desireable side effect of reducing the pressure on the student to submit the correct solution, which in turn reduces instances of academic dishonesty and copying). As the students prepare their homework solutions, they prepare them in duplicate form, only submitting one of their copies for grading, keeping the other one to compare with the solutions that are published immediately after the submission. Given the technology available to students, it has not been a difficulty for the students to prepare this twofold homework; the more technologically savvy use tablets and submit pdf's, while the more traditional students take pictures with their smartphone or even use paper notebooks that automatically generate a second blueprint copy. Immediately after the submission deadline the solutions are published on the Blackboard course management system, and the students know that during the next class session one of the homework problems that they just submitted will be given to them as a quiz. Thus, if they review the solutions and contrast them to the copy of their solutions, and identify and learn where the mistakes have been made, they should be able to solve the problems correctly and receive full credit on the quiz. This approach has been implemented in a first-year integrated course (IEN110), and a second year Strength of Materials course (MEE251).

2 – Self-grade. While the submission process remains the same as in the reflective quiz method, now instead of a quiz, the students are asked to self-grade their homework by the next class session. Detailed self-grade rubrics are given to the students, and the expectation for the self-grade is a written reflection on the student's performance and difficulties in each problem, including how they approached it, and where the mistakes (if any) were made.

Reason for deduction	**Max Deduction**
Wrong or lacking units	-0.5
Solution correct but not clearly laid out	-1
Solution correct but steps missing	-1
Solution incorrect due to minor math error	-1
Solution incorrect due to minor concept error	-2
Solution incorrect due to major concept error	-5
Solution not attempted	-6
Missing diagrams (FBD and Kinetic – if applicable)	-2

Table 1. Example of self-grade rubric for MEE270 (Engineering Dynamics). Each problem can receive a maximum of 6 points.

In addition to assigning themselves a numerical deduction based on the rubric of Table 1, students were also required to critically reflect on their mistakes in the form of a narrative (excerpts of student self-grade submissions):

'… when I went to find the second half of the problem, I had forgotten to include the angle when I found V …'

'…the pulling force of the rope was supposed to be treated as one force, not twice the tension force. This caused all subsequent equations to be half their expected value'.

From the narrative of the self-grading, the level of the student's self reflection on the mistakes made can be seen. The self-grade report (quantitative deduction and self-reflective narrative) is then graded for completeness, depth of analysis, and overall levels of reflection and understanding. This grade provides the remaining 50% of the homework grade (the first 50% is based on a traditionally graded initial submission). This strategy effectively reduces the value attributed to homework correctness, and introduces a grade for the student's efforts in understanding their own mistakes.

Results

Results were collected in 3 classes; IEN110 (Integrated Engineering 1, 11 students, twice), MEE251 (Strength of Materials, 5 students), and MEE270 (Dynamics, 5 students).

Baseline: Student Access Patterns for Courses with Traditionally Graded Homework

Starting with the initial BEP cohort for the fall 2012 edition of IEN110 and continuing each semester, specific direction was provided to the students as to the proper way of presenting solutions to homework problems. Sample solutions to representative problems were provided primarily as a guide for correct homework formatting.

Almost immediately, IEN110 students began requesting that solutions to homework assignments be provided. The justification was two-fold: for reflection on mistakes made on their work and for additional examples on correct solution presentation. The requested solutions for homework problem sets were subsequently provided for the students in the fall 2012 IEN110 course as well as the companion spring 2013 course, IEN130. However, at this time, solutions were provided as hard copies, distributed in class, making it difficult to track how the students were using the information.

Starting with the fall 2013 offering of IEN110, homework solutions were scanned and made available through the course management website. By offering the solutions electronically, access patterns could be monitored using the tools available on Blackboard.

Figure 1 shows the access patterns to the homework solutions for the 2013 edition of the IEN110 course (11 students). While this cohort had not specifically requested homework solutions, they were directed to use them as study aids. This iteration did not include any kind of specific homework self-reflection activity. The students accessed the solutions sporadically, and primarily only before the course examinations.

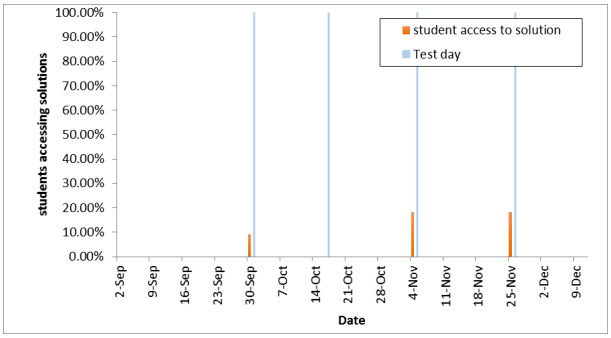

Figure 1. Homework solution access pattern for IEN110 (given without reflective homework components)

Not only is the access infrequent, but the total number of instances of access is quite low; over the course of a full semester with 11 graded homework assignments, solutions were downloaded a total of 13 times. This represents only 10% of the number of downloads expected if each student had downloaded each solution once. Further investigation of the data revealed that 10 out of the 13 downloads (77%) could be attributed to a single student. Even with the few instances where students downloaded solutions, it was often weeks after assignments had been returned and would have had little value in closing the loop on understanding what mistakes were made and why. The indication here is that students do not value

homework as an effective study tool (a large majority of the students never looked at the solutions at all), but rather, as previously hypothesized, merely as a part of the grade that needs to be maximized.

Self-reflection by Quiz

Upon introducing the quizzes, the access patterns change: now students do access the homework solutions, however the trend is that they access them only on the day of the quiz (Figure 2), and only briefly review them in the hour preceding the test (Figure 3).

This strategy was implemented in two courses: IEN 110, and MEE 251, with similar results:

MEE251: Strength of Materials

The MEE 251 course was conducted using the homework quiz approach during the Fall 2014 semester (5 students). Figure 2 reflects homework access patterns as related to test days:

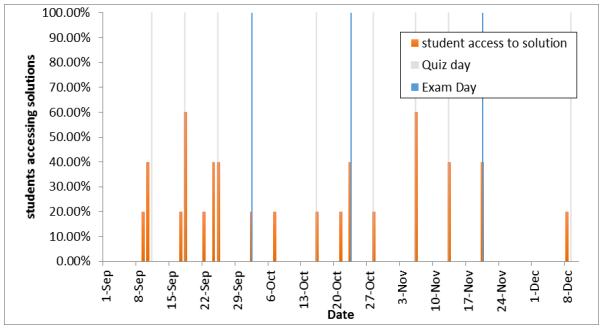

Figure 2. Homework access patterns for MEE251 course.

Access patterns depicted in Figure 2 show that access to the published results happens primarily (64%) on the day of the quiz or test. While early in the semester students show that they revise the homework solutions a day or two before the test, after about the third homework the access only happens on the day of the quiz or test (with a single exception during the last week of the semester).

In addition, and as shown in Figure 3, over 40% of the access occurs the hour before the quiz/test. Thus students briefly look over the solutions shortly before the quiz, and do not spend any significant time reflecting on the details of how they did in their submission. The exercise contains little self-reflection, but only an attempt to memorize the solution or solution path of the individual problems for the quiz.

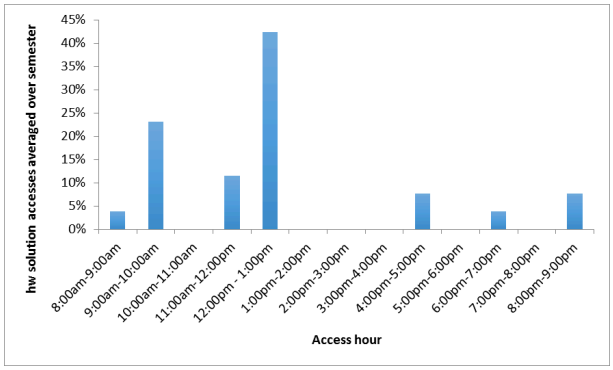

Figure 3. Access hour (averaged over all accesses throughout the semester) for MEE251. The exam or quiz took place during class hour, from 1:00pm to 2:15pm.

IEN110 Integrated Engineering 1

The same approach was also applied in the IEN110 course (freshman course with 11 students), where homework was collected on Friday and solutions were released immediately. The homework quiz was then given the following Wednesday. The data shows that students downloaded 88 % of the homework solutions for the first time on the day of the homework quiz or exam.

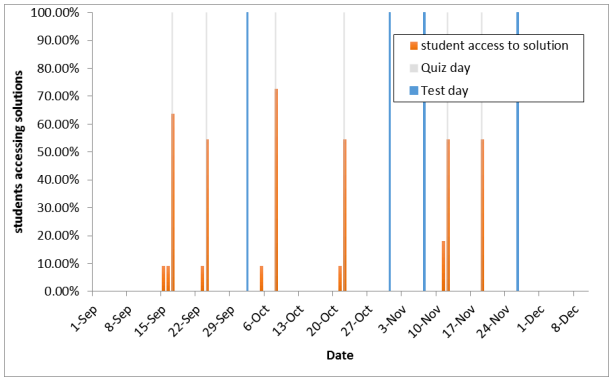

Figure 4. Access day (averaged over all accesses throughout the semester) for IEN 110.

Observing the time-of-day distribution (Figure 5) of these access points reinforces the interpretation that the students simply glance over the solutions just before the quiz (the quiz is given on Wednesday at 8am).

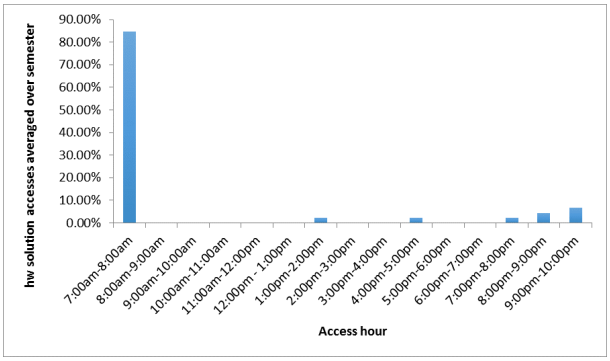

Figure 5. Time-of-day access to the homework solutions as a percentage of total access points (semester average) for IEN110.

This pattern again shows that students spend very little time with the solutions, and merely glance them over to remember how to solve the problems (more than reflect on any misconception or mistake that they made in their original submission). This short-term approach does not fulfill the self-reflection goal, and the quizzes are not liked by the students.

The data from MEE251 and IEN110 indicate that giving a quiz consisting of one of the homework problems does move students to download and review the solution, however the time-on-task is typically short, as students skim the solutions just before the quiz. Qualitative student surveys administered reflect this attitude:

- *'[The quiz] still made me look at solutions'*

- *'[The quiz] I was never prepared for because of my own fault cause I'd skim the solutions'*

- *'[The quiz] was good in a way that if you didn't study the solutions, then you did poorly'*

Thus while providing an improvement over the regularly administered homework, a quiz does not have the desired effect of triggering a critical self-reflection on the submitted work. In order to directly address this, a homework strategy with a self-grading deliverable was implemented in MEE270 (Engineering Mechanics: Dynamics).

Self-reflection by Self-grading, MEE270 Engineering Mechanics: Dynamics

The homework submission is again split into two components: first the students submit their attempt at solving them and retain a copy of their submission. On the following class students are then required to submit the quantitative self-grade rubric (Table 1) accompanied by a narrative describing the shortcomings of their solution and relating them to the deductions applied in the rubric.

Figure 6 shows the weekly access patterns for MEE270 (Engineering Dynamics), a course that utilizes self-grading as its reflective activity. It is clear that the patterns show a much larger spread than those reported for the quiz-based method (Figure 2), as access points do not concentrate exclusively in a short period of time before the submission is due.

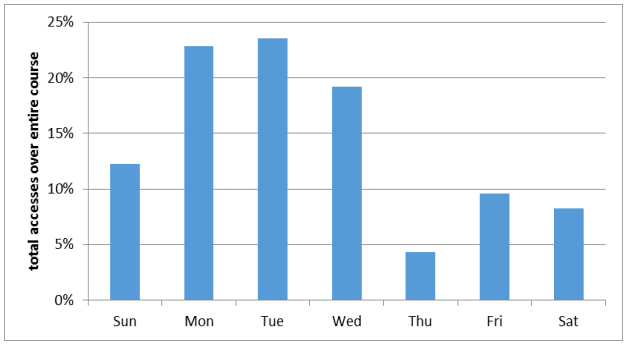

Figure 6. Weekly access distribution MEE270.

While it is impossible to assess how much time the student's spend with the solutions (as the system only indicates access, and not time-on-task), at least the time of access suggests that they require more lead time to analyze their submission and contrast it with the solutions. The much more distributed access times reinforce this conclusion, as access does not happen immediately before class (class during this semester was Mondays and Wednesdays from 13:00-14:15 hrs.)

But most important, the task of self-grading now requires them to critically reflect on their initial submission; in order to prepare for the quiz it is sufficient to have a quick glance at the results, which does not require the same level of reflective effort than the self-grading. Students prefer this method to the quiz as, even though it is more time consuming for them, it is perceived as being easier to attain a better score (the self-grade is graded, it however does eliminate the uncertainty of the quiz).

Incorporating reflective homework practices has a beneficial effect on overall student motivation to

access the solutions: total access of the homework solutions for the IEN110 course without reflective activities to quiz reflection rises from 13 to 46 (this represents 1.3 to a 4.6 accesses per student, which is less than the number of homework assignments – so not all students review the solution before the quiz). Upon implementing a reflective self-grade in MEE270, the per capita student access rises 6.4, which represents an almost full equivalency to the number of self-grade activities required (9 homework assignments were given, however only 7 required a self-grade as the other two coincided with exam weeks):

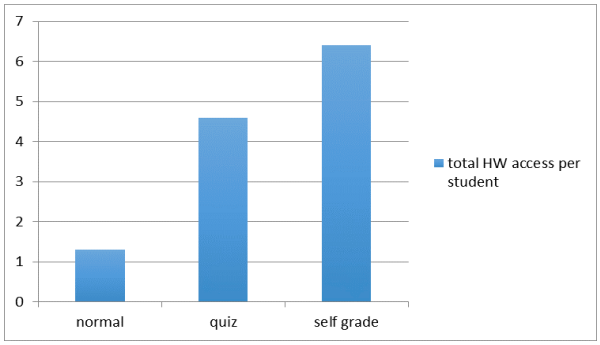

Figure 7. Comparison of total number of homework downloads (throughout the course) per student for the different homework methods.

Survey results indicate that the students like the self-grading format and appreciate the learning effect:

-"I learned a lot when I had to go back and identify my own mistakes"

-"…we were getting a grade for going through and actually understanding the problems, instead of a possible bad grade because of a mistake on a quiz"

-"for some reason you look at solutions and get interested in where you went wrong"

In the survey administered at the end of MEE270 (these are the same students who also had taken MEE251 in the previous semester), all students supported the self grading and preferred it over the quiz.

Conclusion

Results of both formative quizzes and self-grade exercise methods indicate that students' access patterns to the homework solutions change by becoming more frequent when compared to traditional homework submissions. The numbers change from the students accessing 1.3 homework solutions during the semester (out of 11), to 4.6 out of 11 if they are quizzed on one of the problems, to 6.4 out of 9 if they are required to self grade their effort. Results also indicate that in the case of formative quizzes, these access patterns show that students devote little time to reviewing the solutions, which is indicative of little to no reflection on their mistakes, but rather only try to familiarize themselves with the correct solution (this is decoupled in time from their initial submission). In contrast, the self-grading exercises (in lieu of the quiz) show a longer access time window, and introduce significant self-reflection on the mistakes made. In addition, student preference is that of self-grading, as that eliminates the uncertainty of the quiz.

Further work is necessary to study the link between reflection time and outcome assessment. But these results demonstrate that how homework assignments are administered influences both the quantity and quality of self-reflection the student engages in once provided with the solutions.

Future work

The work presented here has been carried out as a pilot study in the context of the small classes of the BEP. As such, no conclusions on any improvements in academic performance attributable to the application of the reflective strategies presented can be made. Future work will aim at scaling the strategy to courses with a large number of students, and studying the changes in student academic performance arising from the reflective methods.

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