Homework Corrections: Improving Learning by Encouraging Students to Reflect on Their Own Mistakes

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Abstract. In spite of using active-engagement techniques in our classes, big percentage of students can not answer straightforward questions of the type we have covered in class and assigned as homework. We believe that students lack one of the essential components of meaningful learning: self-reflection. How do we engage students in a meaningful self-reflection and measure its implications? We hypothesize that we can achieve that by having students reflect on their homework solutions and doing self-corrections. Incorporation of a state-of-the-art software platform such as ePortfolio can greatly facilitate the task, as well as create new lifelong learning skills. We have conducted an experimental-control group design study in a conceptual physics course at Queensborough Community College (QCC) to measure the impact of such reflective activities on students. We present the results of the study and discuss its implications.

BACKGROUND & MOTIVATION

QCC Conceptual Physics course is a general education introductory physics course focusing on concepts with minimum math requirements for non-science majors. Every semester it impacts about 180 QCC students. The overwhelming majority of students in this course intend to become licensed teachers. Schoolteachers play a critical role in inspiring and training the next generation of students to join the STEM disciplines. Improving the scientific knowledge, attitude toward science and teaching skills of prospective teachers must be critical goals for Conceptual Physics course.

In spite of using active-engagement pedagogical techniques in our classes, we still find a big percentage of students who can not answer straightforward questions of the type you have covered in class and assigned as homework. We believe that one of the missing components of the learning process is the lack of student reflection. How much do students reflect in our courses? Although we cannot directly measure students' reflection on strategies and self-regulation, we do have a way to check whether students reflect over their homework problem solutions. After grading and returning students' homework, we post homework solutions on the Blackboard and ask students to compare their answers with the posted solutions. However, very few students actually do this (you can use Blackboard to track the number of students who have opened the solution file), although we know that majority of them had difficulties with homework problems. Other researchers have found similar results [1].

Educational literature in various disciplines such as physics and mathematics has shown the importance of self-reflective activities in science courses [e. g., 2-3]. One way of engaging in reflective activities is through self-corrections of homework and exams [4-5].

In [4], Henderson and Harper described a few physics classroom experiments where self-corrections have been used. The results are more than encouraging.

We would like to explore further the impact of using reflective self-corrections of physics homework on students' content knowledge and scientific attitudes. Our study is the first attempt to explore the issue as a control-group design experiment (comparison of experimental and control groups). We also propose incorporation of additional facilitating resources, namely, ePortfolios and spreadsheets.

	A	B	C	D	E	F
1	Homework1	What I did or thought wrong		New solution	Points recovered	Instructor's comments
2	Question 2	I forgot to take into account that air-resistence increases with speed.		As the car increases its speed, the air-resistence force increases as well. Once the air-resistence force becomes big enough to balanc the road-tire fiction force, the car will not accelerate.	2	Excellent
3	Question 4	No clue.		Kinetic energy will be twice as much.	0	Unproductive self-reflection. New solution should have explanation. How do you know it's twice as much?

FIGURE 1. Sample Excel spreadsheet for reflective self-corrections of homework activity

REFLECTIVE SELF-CORRECTIONS OF HOMEWORK

Students in our experimental groups were required to do reflective self-corrections of their homework. Reflective self-correction consisted of the following steps:

a) Students should compare their graded homework with homework solutions provided by the instructor. Note that homework was graded without any comments by the instructor.

b) Students should reflect on what they did or thought wrong in their original solution. They should write an explanation on what was wrong in their original answer and why it was wrong. Without this step students were not allowed to recover lost points.

c) Students should write down new solutions. They can recover points only if they provide correct new solution that is not a copy-paste of the solution provided by the instructor.

Excel spreadsheets as a facilitating tool

Spreadsheet applications can serve as a facilitating tool for reflective activities. They also provide a handy way of storing and getting feedback on self-corrections and other reflective activities [6].

In order to facilitate the process of doing self-corrections as well as grading it, we provided students with an Excel template (Figure 1). The second column of the template asks students to report reflections on their mistakes, and the third column asks them to provide new solutions. The remaining two columns are filled-in by instructors. Column E shows students how many points they have recovered, and column F contains instructor's feedback.

After grading homework, we returned them to students along with our solutions. Then we asked them to do reflective self-corrections and submit it within a week along with their original graded homework. Once both students' homework and self-corrections were submitted to us, we filled in the last two columns of the spreadsheet. Note that no points were recovered if the student left the second column empty (no self-reflections). Finally we returned their homework and self-correction spreadsheets back to students. Please note that self-corrections were made mandatory and students' homework grade was changed to zero if they hadn't done so.

ePortfolio as a facilitating tool

Epsilen is a centrally hosted eLearning environment offering a wide range of course delivery, assessment and collaboration products and services. In particular, it allows students to create ePortfolios (electronic portfolios). The primary purpose of having student ePortfolios is to engage students throughout his or her academic career. By having an electronic space where a student can store and present academic achievements, the student gains a better sense of progress toward his or her academic goals [7].

For instructors, it allows them to create a course hub, where they can post assignments and other course materials, as well as monitor and control students' activities and postings.

We provided homework assignments and solutions through ePortfolio. Students submitted reflective self-corrections in a special folder in the ePortfolio course webpage. They could see only their own submissions in that folder, however all submissions were visible to the instructor.

Students were encouraged to keep all their self-correction sheets in their own accounts for the preparation of exams and future use as well. We also hope that this experience will encourage students to use ePortfolios as personal learning portfolios. For instance, they can keep record of their misunderstandings and difficulties in different classes in an ePortfolio and use that information for self-improvement as well as class remediation.

DESCRIPTION OF THE STUDY

***Course Description*:** The Conceptual Physics course at QCC has three 50-minute lectures and one 1 hr 50 minute long laboratory per week. It is a one semester-long introductory physics course focusing on concepts with minimum math requirements for non-science majors. We offer 6 sections with about 30 students in each section. The overwhelming majority of students in this course intend to become licensed teachers.

Each of us taught two sections; for each of us one section served as a control group and the other one as an experimental group.

The official textbook for the course was Paul Hewitt's "Conceptual Physics". Weekly homework assignments consisted of ten problems from the textbook. The course had two written midterm exams and one final exam. Midterm exams were composed of 20 multiple-choice and 4 open-ended questions.

We graded all homework problems using the following 4-point scoring rubrics:

- 1-point -> it appears the student read the question but could not go further;
- 2-points -> it appears the student made a reasonable attempt;
- 3-points -> the student provided partially correct solution;
- 4-points -> the student provided correct solution.

After collecting each homework, we posted its solution in the ePortfolio course web-page. Students of both experimental and control groups had access to the posted solutions.

***Intervention*:** Only the experimental group students were required to do reflective self-corrections of their graded homework (for the first 7 homework assignments).

Other than that, there were no significant differences in our treatment of control and experimental groups (same content, same teaching method, same homework assignments, exams and labs).

We combined our experimental groups (same with control groups) to have bigger number of students available for the statistical analysis purpose. The comparison of our experimental and control groups showed that they were statistically indistinguishable. Hence, our results are instructor-independent and combined analysis is not likely to be a validity threat.

Data collection: We considered as pretests students' combined grades on the first two homework assignments. The self-correction submissions started only after students have submitted the second homework. The results of the first midterm exam served as our post-test. It was conducted after students have submitted self-corrections for 7 homework assignments (sample midterm exam questions are provided in Appendix A).

Few of the reasons why we used the midterm exams rather than FCI scores for the analysis are the following: a) we have covered a wider range of topics and concepts in mechanics than FCI does; b) the number of students who took post-test FCI was low, and out of those, who took it, many of them left it unfinished. We believe this was due to the fact that we didn't count FCI scores as part of a course grade, and thus, students were not motivated to take it seriously.

DATA ANALYSIS

The result of the comparison of the pre-test and post-test data is shown in Table 1. The number of students in the experimental and control groups was 47 and 52, respectively. We have excluded those students who failed to submit more than three self-corrections from the data pool. We have performed two-tail unequal variance t-test on both pre-treatment and post-treatment data (confidence level = 0.05). The analysis shows that the two groups were initially statistically indistinguishable ($p = 0.24$). After the treatment the two groups were statistically distinguishable ($p = 0.05$). The effect size is $\Delta = 0.4$ (medium impact) [8].

DISCUSSION

The analysis of the experimental pretest-posttest control group design study showed that the reflective self-corrections of homework activity has a positive impact on students' physics content knowledge in c community college setting (effect size = 0.4). Nonetheless, we were expecting bigger differences between the two groups. The following limitations of the study might have prevented seeing bigger differences.

TABLE 1. Pre-post treatment analysis

	Pre-test Data	**Post-test Data**
Experimental group	58.5 (out of 80)	39.9 (out of 60)
Control group	54.3 (out of 80)	35.9 (out of 60)
Statistical analysis	t-test p-value = 0.24	t-test p-value = 0.05

Limitations: One of the limitations is the duration of the intervention. In order to guarantee fair treatment between experimental and control groups, we were able to extend the intervention up to the first 7 homework. After that control groups started to do self-corrections, and the experimental group stopped doing it due to fair treatment. Bigger differences could have been expected if the duration of the intervention were longer.

Another limitation was the assumption that the control group students did not engage in reflective self-corrections themselves since they were provided with homework solutions as well.

Student Feedback: Overall, students liked the opportunity of recovering homework grades. Appendix B has some sample feedbacks from students. They appreciated self-corrections' positive impact. Students were motivated to continue this activity.

Future Research: We are planning to conduct a finer-grained analysis of students' responses to investigate the impact of the intervention on specific physical concepts. The analysis of the intervention impact on students' scientific attitude is in progress as well.

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APPENDIX A

Sample midterm exam questions:

1. As an object freely falls downward, its
   a) velocity increases.
   b) acceleration increases.
   c) both of these.
   d) none of these.

2. Which contains more apples, a 2-pound bag of apples on Earth or a 2-pound bag of apples on the Moon? Which contains more apples, a 2-kg bag of apples on Earth or a 2-kg bag of apples on the Moon?
   a) same, same.
   b) Moon, Moon.
   c) Earth, earth.
   d) Moon, same.
   e) Earth, Moon.

3. Two people each pull with 300 N on a rope in a tug of war. What is the net force on the rope? How much force is exerted on each person by the rope?

APPENDIX B

Student feedback samples:

1. "The self-corrections guided me and provided me with more understanding to the chapters I read. I was able to go back and review the questions I misunderstood and by being provided the answers I was able to understand what the question was really asking."

2. "I made errors in many of the areas covered but the self-corrections helped me focus on the areas that I needed more work and needed to review."

3. "With self-corrections I feel that it actually helped a whole lot in improving my understanding on material that was unclear to me in the homework and sometimes even in class."

4. "The self-corrections helped me realize what I did wrong. This can prevent me from making the same mistake twice, so I can use the homework to help me prepare for my physics exam."

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