Effect of peer-review on development of students' problem-solving abilities

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Abstract. We have investigated the effect of peer-review on the development of students' problem-solving abilities in an introductory physics course. Specifically, we report the results of a multiple-group pre/post-test quasi-experiment comparing two groups receiving different treatments with respect to activities completed after cooperative group problem-solving sessions. The treatment group completed rubric-based peer-review online for three randomly selected students, whereas the control group did not. Reliability-corrected analysis of covariance showed that the treatment group demonstrated greater improvement in problem-solving process compared to the control.

1 Introduction

Many effective pedagogies designed to improve student problem-solving ability are based on the theoretical framework of cognitive apprenticeship [1]. These pedagogies focus on modeling expert-like process, coaching and scaffolding of group problem-solving, and student articulation through written solutions. However, one of the key requirements for effective cognitive apprenticeship is reflection [2]. Reflection is a metacognitive process, and therefore a difficult one to "assign." Since reflection is an action that must be done by the student, it's also an activity that is difficult to explicitly incorporate into problem-solving pedagogies [3].

In an effort to incorporate explicit instruction on reflection-on-process, we have undertaken two applied research projects: (1) the development and validation of a pedagogy-specific rubric for problem-solving process that also serves as a self-teaching tool for the student, and (2) an investigation into the efficacy of rubric-based peer-review and its potential as an assignable metacognitive task. With respect to the second project, we ask the following research question: does student peer-review result in greater reflection-on-process? As a starting point to answering this question, we have investigated the effect of peer-review on the development of students' problem-solving abilities: do students participating in peer-review become better problem-solvers?

2 Experiment Design

We have conducted a pre/post-test quasi-experiment having nonequivalent group design, where we compared two groups receiving different treatments with respect to activities completed after cooperative group problem-solving (CGPS) sessions [1]. Students self-selected into one of two CGPS discussion sessions attached to an introductory calculus-based physics course on mechanics. Assignment of which section would be the control versus treatment group was random. All students attended the same lecture with the same instructor. CGPS sessions were also taught by the same instructor. Equivalency was established using a two one-sided t-test (TOST) on the Force Concept Inventory pre-scores.

Problem-solving process ability was measured using the validated rubric described above [4]. The rubric was supplied to all students at the beginning of the semester, and both groups were encouraged to refer to the rubric when solving problems. The treatment group completed rubric-based peer-review online for three randomly selected students, whereas the control group did not.

3 Results

There were 45 total participants in this study, with 24 in the non-peer-review group (Non-PR) and 21 in the peer-review group (PR). Two and three students from the Non-PR and PR groups, respectively, did not complete either the pre- or post-test.

After CGPS, students in each group individually completed identical problems each week from the following topics: (1) 1D motion, (2) 2D motion, (3) force/acceleration, and (4) a 2D motion problem on the exam. Figure 1 shows average individual scores on all 4 problems for each group. The PR group began the experiment with lower scores and ended the experiment with higher scores compared to the Non-PR group. This could be the result of a selection-regression threat common with nonequivalent group design; however, a cross-over pattern emerged suggesting the result is likely treatment-based [5].

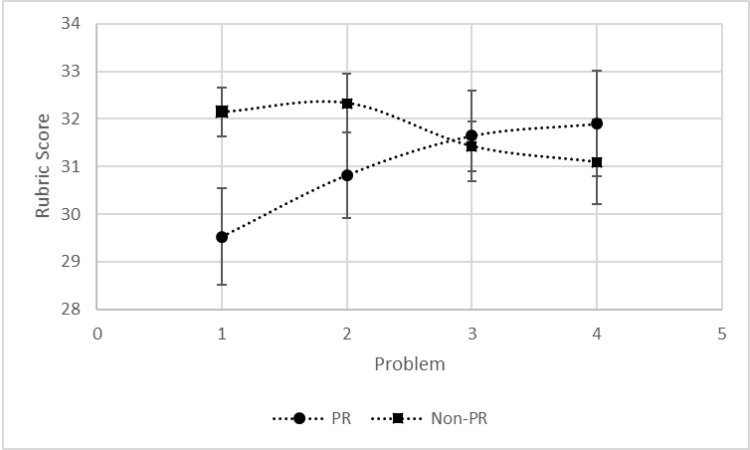

Figure 1: Rubric score on four problems over four weeks. Topics included 1D motion, 2D motion, and Force. The final problem (4) was a 2D motion problem administered on an exam and served as the post-test.

A reliability-corrected one-way ANCOVA was conducted to compare the effectiveness of peer-review with pre-score (Problem 1) as the covariate. Levene's test and normality checks were carried out and the assumptions met. There was a significant difference in mean post-test score ($F=7.94$, $p=0.008$) between the two groups. Eta-squared effect-size was found to be 0.163, which is considered a small effect.

4 Conclusion

A small positive effect on student problem-solving ability was found over four weeks for students participating in rubric-based peer-review. This result could be explained by increased reflection-on-process. Further research involving student interviews is necessary to establish if the observed effect is the result of metacognitive processes.

References

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