Using Reflection with Peers to help Students Learn Effective Problem Solving Strategies

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Background

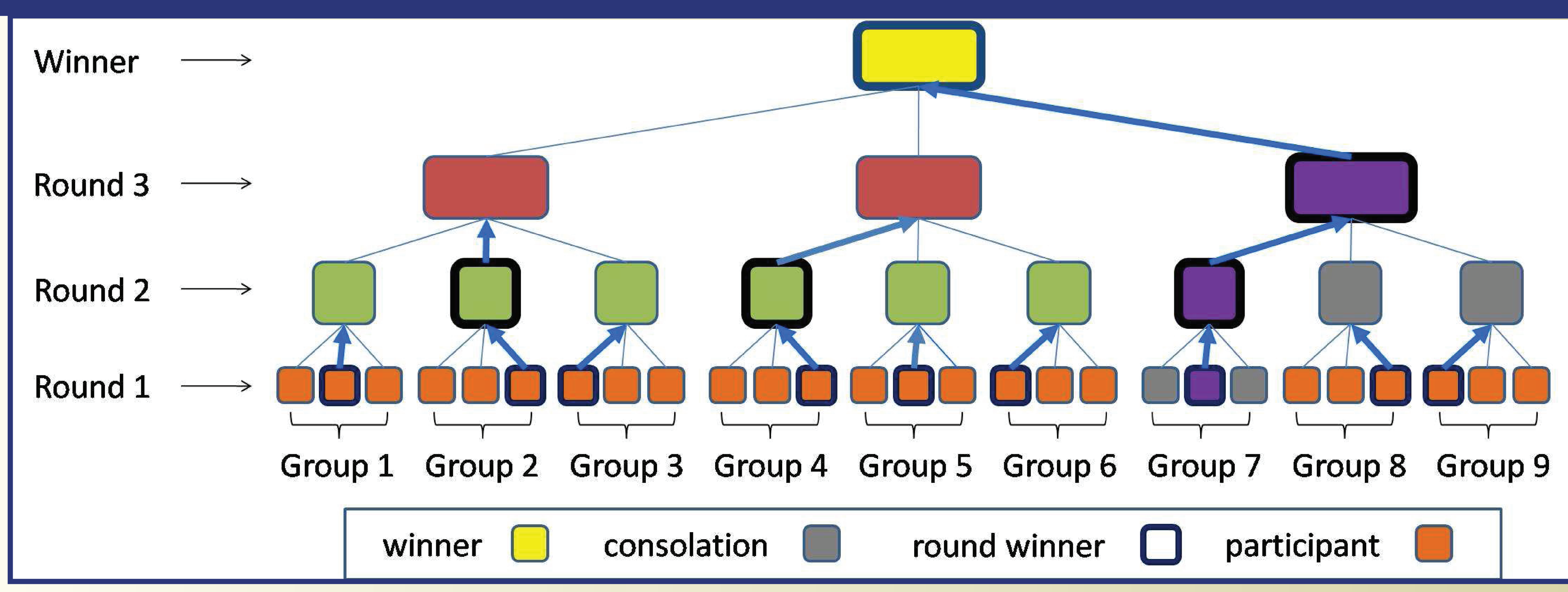
Students must learn effective problem solving strategies to excel in physics, e.g., converting a problem from initial representation to other suitable representations such as diagrammatic, tabular etc. However, many traditional courses do not explicitly emphasize effective problem solving heuristics, and many students need explicit guidance in learning these skills.

One effective strategy may be reflection with peers about problem solving heuristics. Prior work (e.g. group problem solving in Peer Instruction (Mazur 1997)) shows the effectiveness of peer collaboration.

Introduction

Our prior research (source?) shows that even with no guidance from instructors, students could co-construct knowledge in 29% of cases. Neither student alone was able to solve problems related to electricity and magnetism, but two students in a group were able to do it. Here, we investigate the effect of peer reflection about problem solving strategies in recitations for an algebra-based introductory physics course (~200 students). There were two types of recitations: traditional recitations and the peer reflection (PR) recitations. Each week in recitation, small teams in the PR group reflected on problem solving strategies within selected problems from homework with guidance from the TAs. In the traditional group, the TAs answered questions about the homework before giving a quiz each week.

PR Team Structure



Above is an illustration of the team structure for three stages of the PR activities. For each team in each round, the student in the dark border is the winner for the round and advances to the next stage. All students who participated in selecting the overall winner will get a consolation prize in the form of bonus points, providing an incentive to participate.

Model and Goals

The PR group intervention is based on the field-tested cognitive apprenticeship model of learning (Collins et al. 1989). Three main components of this model are modeling, coaching, and fading. The TAs demonstrate and exemplify effective problem solving skills and thus provide modeling. The students get an opportunity to practice these skills with guidance, i.e. coaching, from the TAs and their peers, who decrease support gradually (i.e. fading) with a focus on helping students develop self-reliance at the task. Students solved HW problems, discussed their solutions with peers to determine top three solutions, and were given feedback from the UTAs and TAs about why those solutions are better.

We hypothesized that PR intervention in a recitation may be beneficial in helping students learn effective problem solving strategies. We examined intergroup & group-independent effects with the following questions in mind:
- Is there a statistical intergroup difference in the average number of problems for which students drew diagrams and wrote scratch work?
- Do students who draw more diagrams, despite knowing that there was no partial credit for it, perform better on the final exam (regardless of group)?

Results

First, we look at the means and p-value comparisons of daytime and evening sections with and without PR intervention in the evening section. Although no pretest was given, the evening section was somewhat weaker than the daytimesection. One reason may be that the evening students commonly work full-time and take courses simultaneously, which tends to not be as common for daytime students.

Daytime vs. Evening Classes	Daytime means (%)	Evening means (%)	p-value
2006: midterm exams	72.0	65.8	0.101
2006: final exams	55.7	52.7	0.112
2007: midterm exams	78.8	74.3*	0.004
2007: final exams	58.1	57.7*	0.875

The same professor taught both sections both years. In 2006, both class sections and their respective recitations were taught the same way (NO PR intervention). The table shows that on the same midterm and final exams, the daytime section performed better than the evening section, but the result is not statistically significant. In 2007, both sections had the same midterm and exams, but the evening section had PR intervention. The final exam scores of both sections were not statistically significant.

We then examined the average number of problems with diagrams for both groups. The PR group has more problems with diagrams than the traditional group, both overall and respectively for quantitative and conceptual problems. The students drew more diagrams in multiple-choice questions when there was no reward for doing it. The number of occurences of scratchwork for the PR group and the traditional group was not significantly different.

	Question type	Traditional group per student	PR group per student	p-value between groups
Number of problems with diagrams	All questions (40 total)	7.00	8.57	0.003
	Quantitative (20 total)	4.31	5.09	0.006
	Conceptual (20 total)	2.69	3.48	0.016
Number of problems with scratch work	All questions (40 total)	20.21	19.60	0.496
	Quantitative (20 total)	16.03	15.57	0.401
	Conceptual (20 total)	4.18	4.03	0.751

Correlations

This table shows a positive correlation between final exam score and the number of problems with diagrams or scratchworks for each group. We are unaware of any previous studies showing a positive correlation between the final exam score and the number of diagrams drawn when answering multiple-choice questions when there is no partial credit for it. The correlation between number of diagrams drawn and the final exam score is identical for quantitative and conceptual questions. The correlation between number of diagram and amount of scratchworks drawn and the final exam score is stronger for the PR group than for the traditional group.

	Traditional: Final		PR: Final	
	R	p-value	R	p-value
Diagram	0.24	0.014	0.40	0.000
Diagram(Q)	0.19	0.046	0.36	0.000
Diagram(C)	0.20	0.042	0.36	0.000
Scratch work	0.39	0.000	0.53	0.000
Scratch work (Q)	0.42	0.000	0.59	0.000
Scratch work (C)	0.28	0.004	0.32	0.002

Summary and Discussion

Intergroup effects: On multiple-choice questions where there was no partial credit, the PR group drew more diagrams. The diagrams drawn by the PR group explain more of the final exam performance (higher correlation).
Group independent effect: There is a positive correlation between how often students wrote scratchworks or drew diagrams & students' final exam scores. Students in both groups were also more likely to draw diagrams or write scratchworks for quantitative problems than for conceptual problems.

Chi et al. (2000) suggest that students are likely to improve their approach to problem solving and learn effectively from an intervention if two criteria are met: first, if the students compare artifacts, e.g., an expert solution and their own solution, and realize that there are omissions in their mental model; second, if the students receive guidance to understand why the expert solution is better and how they can improve on their approaches.