Article Summary – Meeting Students Halfway

Snapshot of this article:

- √ Higher education setting (4 institutions; 5 courses/instructors; 692 students)
- √ Mixed methods (surveys of 692 students; semi-structured interviews of 5 instructors)
- √ Examines links between conceptual change (i.e., student outcome), student interest, and self-efficacy

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Research Question(s)

Conceptual change research involves the investigation of change processes, the factors that influence the degree to which change occurs, and the instructional methods and environments that facilitate change. For example, conceptual change researchers might examine the process of moving from a perspective that global warming is a hoax to a perspective that embraces it as a real phenomenon, as well as the factors and instructional methods that support that change. The authors of this article use a specific conceptual change model (the CRKM) that combines elements from cognitive psychology, science education and social psychology. In particular they focus on one aspect of the CRKM model that claims motivational characteristics, such as *self-efficacy* and *interest*, influence the degree to which a learner experiences conceptual change.

The authors draw on: (a) Hidi and Renninger's (2006) model of interest development, which states that interest is domain specific and refers to "a learner's predisposition to reengage particular disciplinary content…over time and the psychological state that accompanies this engagement," and (b) Bandura's (1997, 2001) social cognitive theory which identifies four main sources of self-efficacy: mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states. Bandura considered mastery experiences—the actual successful completion of tasks—the most important factor affecting self-efficacy, "because they provide the most authentic evidence of whether one can muster whatever it takes to succeed."

Through quantitative surveys of students and qualitative interviews of instructors, the authors address the questions:

(1) How does post-instruction self-efficacy for learning astronomy relate to changes in understanding of star properties, a topic common to many introductory undergraduate astronomy courses?

(2) (a) How do understanding of star properties, self-efficacy for learning about star properties, and interest for learning about star properties change after semester-long instruction and (b) how are they affected by instructional design and implementation?

Methodology

This study surveyed college students (final N=692) from 5 different astronomy courses at 4 different institutions (see Table 1 for details). Students answered pre- and post-instruction surveys with four-questions about subject interest on course related topics (star properties, stellar evolution, the Sun, and the solar system), six questions about self-efficacy on tasks typical of general education courses (e.g. Understand the readings for the class.), and 22 questions about concepts taught in a typical astronomy course.

- The questions about interest were scored on a 5-point Likert scale with 1 representing "not at all interested" and 5 being "very interested."
- The questions about self-efficacy for course tasks used a 5-point Likert scale with 1 labeled "I cannot do this at all" and 5 labeled "highly certain that I can do this."

- The questions on the concept inventory were asked in a multiple-choice format on the topics relating to star properties such as mass, temperature, and lifetime, star formation, and the nuclear fusion process that powers stars. Answers were scored 1 if correct and 0 if incorrect.

A retrospective, semi-structured interview protocol to elicit information about potential sources of self-efficacy was created. Questions related to the nature of the course, such as the structure of the "lecture" period, assignments, and grading policies, presence and role of teaching assistants, and students' use of office hours were asked of each instructor.

TABLE I. Participating instructor, course, and school characteristics.

Instructor name[a]	Approximate course enrollment	N[b]	Percent female	Percent prior astronomy coursework	Unique course characteristics	School type[c]
Olga	5 sections of 25 each	71	70.4%	49.3%	Online; "stars and galaxies"	Public, Associate's suburban-serving multi-campus
Nick	1 section of 100	60	26.7%	21.7%	Second-tier (300-level); "stars and galaxies"	Public, Masters-large
Seth	1 section of 800	375	52.0%	7.5%	Concert hall setting; whole universe	Public, research university/very high[d]
Jeff	2 sections of 150 each plus 1 section of 60	100	58.0%	6.0%	Planetarium setting	Public, Masters-large
Shawn	1 section of 600	417	54.4%	40.0%	Concert hall setting; second-tier (200-level); "stars"	Public, research university/very high[d]

[a]Pseudonyms.
[b]N here represents the number of students who consented for their responses to be used in the study.
[c]From Carnegie Foundation for the Advancement of Teaching, Institutional Classifications (2010 edition, retrieved 11/2/2012 from http://classifications.carnegiefoundation.org/lookup_listings/institution.php).
[d]Seth and Shawn teach at the same institution.

Results

Sequential multiple regression revealed that 27.6% of the variance in post-instruction conceptual understanding scores was explained by the predictor variables (pre- conceptual understanding, pre- self-efficacy, pre-interest, post-self-efficacy, and post-interest). Pre-conceptual knowledge, pre-self-efficacy, and pre-interest together accounted for 8.6% of the variance ($p < 0.001$), as demonstrated by the first step. Post-self-efficacy accounted for an additional 19.0% of the variance above and beyond the pretest measures ($p < 0.001$). Post-interest did not account for any additional significant variance ($p = 0.22$).

A repeated measures MANOVA revealed a significant interaction between time and instructor for the combined scores of self-efficacy and conceptual understanding ($p < 0.001$). Follow-up repeated measures univariate analyses of variance (ANOVAs) indicated that the interaction between time and instructor was statistically significant for both conceptual understanding ($p < 0.001$) and self-efficacy ($p<0.001$). In other words, student self-efficacy for course tasks significantly increased over the course of instruction under two of the five instructors and was correspondingly related to larger gains in knowledge (figures 1 and 2).

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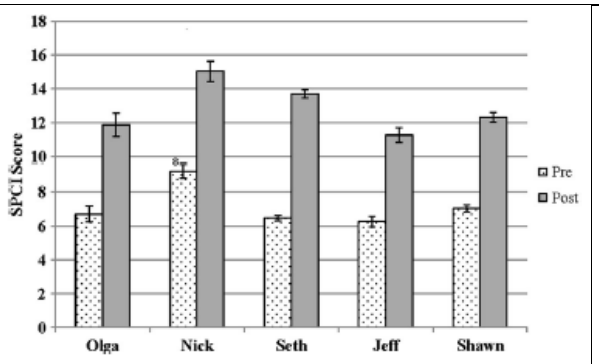

FIG. 1. Mean SPCI scores by instructor. All postscores are significantly greater than prescores ($p < 0.001$). *Nick's mean prescore was significantly greater than all other instructors' scores ($p < 0.01$). Bars show standard errors.

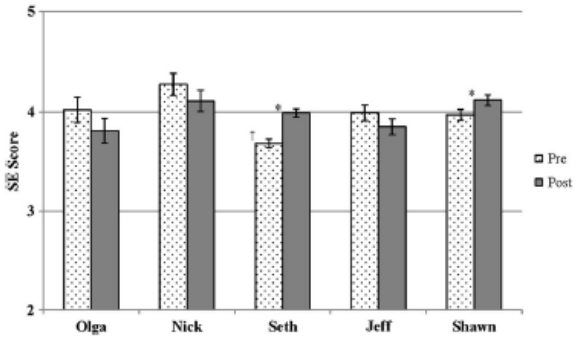

FIG. 2. Mean SE scores by instructor. *Seth's and Shawn's posttest scores were significantly higher than their pretest scores ($p \leq 0.001$). †Seth's pretest score was significant lower than all other instructors' (all $p < 0.01$), except Olga's ($p = 0.13$). Bars show standard errors.

SPCI = conceptual understanding, SE = self-efficacy

Instructor Interviews

With the exception of Olga's class which was taught online and asynchronously, all instructors relied heavily on lecture, in-class collaborative lecture tutorials, and conceptual questions in a think-pair-share or peer instruction model, which are designed to facilitate student discussion and reflection on course content. All five instructors discussed attempts to create a positive class environment and most discussed their attempts to increase student interaction and motivation, as well as student responsibility for their own learning. However, there were some notable differences between the two instructors (Seth, Shawn) who saw significant increases in student self-efficacy and the others. These two instructors consistently apply the following strategies:

- They purposely scaffold[1] activities. For example, starting with easier think-pair-share questions to build confidence and eventually moving to harder ones that then lead into a lecture tutorial.
- They give more specific direction regarding the actions students need to perform to master the content and do well in the course, as well as provide more purposefully planned opportunities for students to practice/perform those actions.
- They provide detailed feedback that takes the form of large-scale, class-based discussion of the in-class activities and think-pair-share questions (because large class size precluded individual feedback). This feedback includes performance related feedback (i.e., mastery experience) and verbal encouragement (i.e., social persuasion).
- They give students opportunities to reason through problems in both writing and orally through homework assignments (i.e., meta-cognitive opportunities). These opportunities were closely aligned with weekly quizzes (used in lieu of less frequent, high-stakes exams).
- One instructor (Shawn) also provides comprehensive individual feedback on the first draft of a large written assignment.

These two instructors did not mention student failure experiences while the other three instructors mentioned student failure as a common theme with respect to the first exam or quiz. For instance, Olga mentioned that students often get discouraged after the first quiz because their scores are lower than they are used to getting in other classes; Jeff said that students find the first exam "very shocking" and that "the normal mode for the average student is they tend to do poorly on the first exam".

Implications

[1] Here, scaffolding is defined as "instructor-controlled aspects of the task that are initially beyond students' capabilities and facilitate students' successful task completion" (p. 12).

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Scaffolded classroom and homework activities with extensive feedback enabled mastery experiences, which in turn supported the development of self-efficacy for course tasks. Instructors who gave exams or quizzes only, or exams or quizzes in conjunction with homework assignments that included little or no performance-related feedback did not see the same gains in self-efficacy and conceptual understanding.

Continual opportunities to perform the necessary actions for success while receiving relevant, ongoing, elaborated feedback may have helped students become more metacognitively aware of discrepancies between their perceived level of knowledge and actual level of knowledge, while simultaneously continuing to practice the skills and improve their performance. It is likely that with ongoing practice and feedback, students were better able to gauge their actual knowledge or performance level and adjust learning strategies accordingly, as well as increase their prospects for mastery experiences throughout the course. These findings suggest that experiences such as those outlined above have a positive impact on self-efficacy for course tasks and subsequently deeper learning of content knowledge.

Additional Citations

Bandura, A. (1997). *Self-efficacy: The exercise of control* (pp. 3-604). New York: WH Freeman.

Bandura, A. (2001). Social cognitive theory: An agentic perspective. *Annual Review of Psychology*, *52*(1), 1-26.

Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, *41*(2), 111-127.