

## Work in Progress: How Do Students Respond to Active Learning? A Coding Guide for a Systematic Review of the Literature

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### **Ms. Sneha Tharayil, University of Texas, Austin**

Sneha Tharayil is currently in pursuit of her PhD in STEM Education at the University of Texas at Austin. Having formerly been a middle school science teacher in Southern California, Sneha developed an interest in precollege engineering education, seeing it as a rich context for integrated STEM learning. She is particularly interested in social justice pedagogies for teaching engineering to precollege students, especially those pedagogical motifs of project-based service-learning and the like.

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Dr. Cynthia Finelli is Associate Professor of Electrical Engineering and Computer Science, Associate Professor of Education, and Director and Graduate Chair for Engineering Education Research Programs at University of Michigan (U-M). Dr. Finelli is a fellow in the American Society of Engineering Education, a Deputy Editor of the Journal for Engineering Education, an Associate Editor of the IEEE Transactions on Education, and past chair of the Educational Research and Methods Division of ASEE. She founded the Center for Research on Learning and Teaching in Engineering at U-M in 2003 and served as its Director for 12 years. Prior to joining U-M, Dr. Finelli was the Richard L. Terrell Professor of Excellence in Teaching, founding director of the Center for Excellence in Teaching and Learning, and associate professor of electrical engineering at Kettering University.

Dr. Finelli's current research interests include student resistance to active learning, faculty adoption of evidence-based teaching practices, the use of technology and innovative pedagogies on student learning and success, and the impact of a flexible classroom space on faculty teaching and student learning. She also led a project to develop a taxonomy for the field of engineering education research, and she was part of a team that studied ethical decision-making in engineering students.

# **How Do Students Respond to Active Learning?**

## **A Coding Guide for a Systematic Review of the Literature**

### **Abstract**

This work in progress paper presents an example of conducting a systematic literature review (SLR) to understand students' affective response to active learning practices, and it focuses on the development and testing of a coding form for analyzing the literature. Specifically, the full paper seeks to answer: (1) what affective responses do instructors measure, (2) what evidence is used to study those responses, and (3) how are course features connected with student response.

We conducted database searches with carefully-defined search queries which resulted in 2,365 abstracts from 1990 to 2015. Each abstract was screened by two researchers based on meeting inclusion criteria, with an adjudication round in the case of disagreement. We used RefWorks, an online citation management program, to track abstracts during this process. We identified over 480 abstracts which satisfied our criteria.

Following abstract screening, we developed and tested a manuscript coding guide to capture the salient characteristics of each paper. We created an initial coding form by determining what paper topics would address our research questions and reviewing the literature to determine the most frequent response categories. We then piloted and tested the reliability of the form over three rounds of independent pair-coding, with each round resulting in clarifications to the form and mutual agreement on terms' meanings. This process of developing a manuscript coding guide demonstrates how to use free online tools, such as Google Forms and Google Sheets, to inexpensively manage a large SLR team with significant turnover.

Currently, we are in the process of applying the coding guide to the full texts. When complete, the resulting data will be synthesized by creating and testing relationships between variables, using each primary source as a case study to support or refute the hypothesized relationship.

### **Introduction**

While the corpus of active learning research continues to provide evidence that these instructional strategies positively influence a wide range of educational outcomes such as increased student learning and higher retention in science, technology, engineering and math (STEM) programs [1], undergraduate STEM instructors are still reluctant to adopt these innovative practices, partly due to perceived student resistance [2]-[4].

There are over 480 studies published over the past 20 years presenting empirical evidence of student affective reactions to active learning in STEM courses. We use affective reactions to refer to the range of possible positive and negative student reactions to active learning, including resistance. Yet these findings are often overshadowed by a focus on cognitive reactions, or whether students learn from the interventions. Synthesizing the literature on students' affective responses across a variety of settings, by employing a Systematic Literature Review (SLR) methodology, can deepen our understanding of student resistance to active learning. SLRs are procedures for interpreting a large amount of information and are "designed to identify existing gaps in a field of research and to make recommendations for closing these gaps" [5]. The benefit

of SLRs is that they follow methodical and transparent procedures to synthesize substantial amounts of information [5].

We herein describe our undertaking of a SLR of the affective responses of undergraduate STEM students to active learning instructional practices. More specifically, our full study aims to answer the following research questions:

- What affective responses are used to evaluate the effectiveness of active learning?
- What evidence is used to measure these student affective responses to active learning? What are the relative strengths and weaknesses of each type of evidence?
- How are contextual features of a course (e.g., course level, class size, required vs. elective) connected with positive or negative student affective responses?

The ensuing paragraphs detail our methods based on the SLR methodology for: searching for relevant research, developing our inclusion criteria, screening abstracts accordingly, and coding the full texts [6]. We also briefly comment on our use of free digital platforms to coordinate and execute our research efforts with a particularly large team with evolving membership.

### Gathering and screening abstracts

We began our SLR by deciding on the inclusion criteria for papers: studies must (1) involve an active learning intervention, (2) be in an undergraduate STEM class, (3) measure affective response, and (4) be published as a journal article or conference paper in English from 1990-2015. We defined affective response to include attendance, satisfaction, enjoyment, self-reports of helpful to learning, efficacy, intent to continue in course/major, and engagement. The definition excludes direct measures of learning gains (cognitive response) or learning styles. Every full text coded was required to satisfy all inclusion criteria. We worked with a university librarian to create appropriate keywords, synonyms, and search strategies for each criterion (see Table 1) and then searched five different databases, including ERIC, Compendex, and Inspec.

Table 1: Inclusion criteria

Category	Inclusion criteria	Example search terms
Active learning	Describes an active learning intervention during lecture class time. Not homework, online, nor labs	Active learning, project based learning, peer instruction, inquiry learning, just in time teaching, or think-pair-share
In-class	The active learning must be in an undergraduate STEM course, with STEM being determined by the course content rather than the student majors. The study must include course-level (not program-level) data.	Engineering education, STEM education, or mechanical engineering. AND Undergraduate, university, or higher education. NOT k-12, high school, or primary education.
Affective response	Includes empirical evidence of affective student reaction to that active learning intervention (e.g., course evaluations). Must be a systematic data collection.	Course evaluation, student responses, student perceptions, student feedback, student attitudes, student behaviors, affective response, affective outcome, or student evaluations.

In addition to searching databases, the team emailed recent NSF IUSE grantees and the ASEE Educational Research and Methods Division list-serve to solicit papers. The database search and email solicitation resulted in 2,365 papers combined. Each papers' abstract was then screened by two researchers based on meeting the above inclusion criteria, with an adjudication round in the case of disagreement. We used RefWorks, an online citation management program, to track abstracts during this process. RefWorks allowed multiple researchers to screen and comment on abstracts. It also facilitated import and export of papers' metadata by grouping papers into folders based on whether they needed to be screened/adjudicated or if they had been rejected/accepted based on meeting inclusion criteria. We identified over 480 papers which satisfied all our criteria.

### **Coding full texts**

Concurrent with our abstract screening process, we developed a full text coding guide to capture the important characteristics of each paper, as described in Table 2. The coding guide was initially based on our research questions and common themes we noted from the paper screening process. We used Google Forms as a platform to create a survey, because it was free, easy to manage permissions, and the data is automatically sent to Google Sheets for analysis.

We tested the form through three rounds of pair-coding to revise the protocol and ensure inter-rater reliability across team members. The first round involved five researchers pair-coding 10 full texts of varying quality and length. In this round, we largely concentrated on basic revisions of the form, such as removing questions that papers did not address clearly, adding and clarifying responses, and removing/combining redundant questions. The second and third round involved six and three researchers respectively and another 10 full texts per round, again with two reviewers analyzing each paper. These rounds emphasized inter-rater agreement and resulted in more precise clarifications and changes. Two questions central to our research project, the type of active learning used and affective responses/measures, are discussed further below.

Because there is a wide variety of strategies for active learning, the coding question about "type of active learning used" captured characteristics, rather than specific implementations. For example, one option was "quick questions," which could include clickers, raised hands, or another method of participation. The initial types of active learning were based on previous research [7]; however, we added and clarified options during the screening process. For example, we defined project as a long-term (multi-week) assignment that is often worked on both in and out of class, while problem-solving refers to smaller time-period assignments more commonly occurring during class time.

Responses for affective measures were also initially based on previous research [8], but we modified them to accurately capture themes in the full texts. Our pair-coding resulted in the following changes: (1) satisfaction and course evaluation were combined, and refer to how students rated the class or instructor (because most papers did not distinguish these ideas); (2) students' self-reporting learning was considered an affective measure, not a cognitive one, because it defines what students felt they learned; and (3) use of the term motivation was broken down into motivation to participate, attend class, continue in STEM, or another meaning.

Table 2: Full text coding guide.

	Coding Question	Example responses
Course info	Course discipline	Biology, Math, Civil Engineering, Intro Engineering, ...
	Course year	First year, second year, third year, fourth year
	Course characteristics	Required, probably required, elective, for majors, for STEM students, for non-STEM students
Study methodology	Sample size	Sample size, class size, and percentage of population reporting
	Evidence or data sources	Validated instruments, institution's end of term course survey, Instructor-generated survey, interviews, observations
	Design	Quantitative, qualitative, mixed methods, pre-post, comparison group, multiple sections/semesters, lists questions or protocol, lists number/percentage responding in different ways, reports statistical significance, reports effect size, identifies limitations
Affective response	Activities	Summary of in-class activities
	Type of active learning	Individual, groups or pairs, problem solving, project, inquiry learning/experiment, quick questions, in-class demonstrations
	Affective responses, measures, or outcomes	Attendance, course evaluations/satisfaction, enjoyment, self-reports of helpful to learning, efficacy/confidence, intent to persist in STEM/follow-up course, engagement/participation
	Conclusion	Positive, mostly positive, mixed/neutral, mostly negative, negative, inconclusive
Misc.	Instructor strategies	Instructor strategies for active learning
	Cognitive study information	Study design on cognition and conclusion (positive, mostly positive, neutral, mostly negative, negative, inconclusive).
	Comments	Additional comments, including a rationale if the text needed to be re-screened for inclusion.

Note: Questions also included an “other” or “unclear” response option. Coders selected all (possibly multiple) applicable responses. The misc. items were optional, as few papers included the information and our focus is on affective response to active learning.

After the three piloting rounds were complete and the team reached agreement on the coding form, the team assigned each remaining full text to one coder. When additional researchers joined the team, we paired these individuals with one of the original coders on 5-10 full texts, compared results, and discussed any discrepant findings. The simple management and data display features of Google forms made this process easy.

## Conclusion

We are currently in the process of coding the remaining full texts and examining papers that have been flagged as not meeting our inclusion criteria during the coding process. At least two researchers will examine the flagged papers to assess whether they should be excluded. In case of disagreement between the researchers, the entire team will reconvene and evaluate these papers. Biweekly team meetings are being used for gathering updates on coding progress, discussing any emergent issues related to the coding process, and evaluating flagged papers.

Our future steps include holding an in-person team meeting to analyze the coding results and synthesize the findings of the systematic review. This process will involve critiquing within and across the studies. For critiquing within the studies, we will focus on evaluating the quality of the studies to understand major biases and weaknesses. We will also note strengths of the highest quality studies. We will decide which studies to highlight in the manuscript text, and at what level of detail they should be included to balance space considerations with providing detail that supports the conclusions. For critiquing across studies, we will compile characteristics of the studies using the information parsed in the coding form. Cumulatively, the within and across critiques will build an understanding of what types of student affective responses are collected most often, in what ways, in what contexts, and with what outcomes. We anticipate being able to draw conclusions about which types and combinations of active learning and affective outcomes have been thoroughly studied, compare the strength of this evidence based on the quality of the individual studies, and make recommendations about gaps where more research is needed.

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