Systematic Literature Review of Students' Affective Responses to Active Learning: Overview of Results

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***Abstract*—This full "research" paper presents an overview of results of a systematic literature review of students' affective responses to active learning in undergraduate STEM courses. We considered 2,364 abstracts of conference papers and journal articles published since 1990, and 412 studies met our inclusion criteria. The studies span the STEM disciplines and report various types of active learning. Their research designs include primarily quantitative methods (especially instructor-designed surveys and course evaluations), and they find that students' affective responses are overwhelmingly positive. Few studies excelled on our quality score metric, and there few statistically significant differences by discipline (but biology studies and chemistry studies scored significantly higher in quality than electrical engineering studies). We include several possible directions for future work.**

Keywords—systematic review, undergraduate, STEM, active learning

I. Introduction

STEM education research has observed unprecedented growth over the past three decades. New research in support of active learning has been developed, and more faculty members have been made aware of active learning pedagogies [1-3]. Despite this burgeoning evidence, the translation to classroom practice has been slow [4-7], and lecturing remains the primary mode of instruction in STEM higher education [8]. Various factors have been hypothesized to influence faculty adoption of active learning pedagogies, including students' affective responses to active learning – their emotions, attitudes, and feelings. For instance, student *resistance* to active learning has been identified as a critical barrier to instructors' use of these pedagogies, while student *satisfaction* has been shown to motivate use of active learning instruction [2, 9, 10].

Many studies have investigated students' affective responses to active learning, reporting empirical evidence including self-reports of learning and satisfaction as measured on end of semester course evaluations. Our review of the literature seeks to investigate students' affective responses to active learning, to learn more about evidence used to measure affective response, and to compare students' responses to various types of active learning. Three research questions guided our review:

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

In this paper, we present an overview of our systematic literature review, answering (in part) questions 1, 2a, and 3.

II. Methods

We conducted a systematic literature review (SLR) on students' affective responses to active learning in undergraduate STEM courses. SLR is a stand-alone research methodology to address research questions by synthesizing primary studies. The term SLR refers to an evolving collection of synthesizing methodologies which includes, but is not limited to, meta-analysis [11]. We have followed established guidelines for conducting SLRs [12, 13], which include: formulating research questions, establishing study protocols (including inclusion and exclusion criteria), selecting search terms and databases, searching databases, applying inclusion and exclusion criteria to select studies, and using mixed methods to synthesize and report findings. Fig 1 describes our process of systematic literature review.

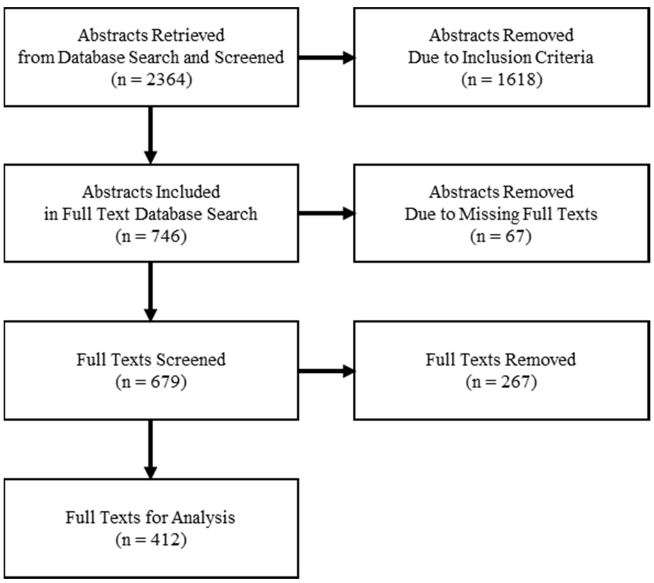

Fig. 1. Systematic literature review screening chart, after PRISMA [15].

We began by searching for studies published between 1990 and 2015. Table 1 provides most of the keywords used to conduct the search. An asterisk denotes how we truncated terms, and quotations indicate where we searched exact phrases. We combined fields 1 through 4 and used field 5 to exclude studies that were not conducted in higher education. We searched six databases to identify candidate studies: Academic Search Complete, Compendex, Education Source, ERIC, Inspec, and Web of Science; EBSCOHost was the vendor platform used for all except Compendex (Elsevier) and Web of Science (Clarivate Analytics). We excluded dissertations, books, and book chapters, and our resulting set of 2,187 possible studies consisted primarily of journal articles and conference papers. We then solicited studies through email listservs and identified 177 studies this way.

Two researchers read each of the 2,364 abstracts to consider whether it met the following inclusion criteria:

- Describes an active learning intervention during lecture class time. (This excluded interventions that were completed as homework, online, or in labs.)
- Studies an undergraduate STEM course, with STEM being determined by the course content rather than the student majors. Must include course-level (not program-level) data. (This included studies of multiple courses or course offerings, if they collected course-level data.)
- Reports empirical evidence of affective student response to active learning intervention (e.g., course evaluations). Must be a systematic data collection. (This excluded studies reporting anecdotal data and reflections as well as studies that did not describe a systematic means of collecting data from all students.)

TABLE 1. KEYWORDS FOR LITERATURE SEARCH

Field 1	*Field 2*	*Field 3*	*Field 4*	*Field 5*
"active learning" "collaborative learning" "cooperative learning" flipped "inquiry based learning" "just in time teaching" "peer instruction" "problem based learning" "student response system" "think-pair-share"	affective "affective outcome" "affective response" "course evaluation" discomfort motiva* "student attitudes" "student evaluation" "student feedback" "student perception" "student resistance" "student response"	Astronomy bioengineering biology chemistry "computer science" engineer* "engineering education" "environmental science" geoscience "life sciences" "materials science" math physics statistics "STEM education"	college "higher education" institution undergraduate university	"high school" k-12 "middle school" "pre college" "primary education" "secondary education" "vocational education"

Disagreements were discussed with the full research team until we reached consensus, and a total of 1,618 studies were excluded (some abstracts where a consensus could not be reached remained in the study so that the full-text could be examined in more detail). Two different researchers read the full text for each of the remaining 679 studies (67 studies were excluded because they did not have a full text paper), again applying the inclusion criteria. As before, disagreements were discussed with the full research team until we reached consensus. After excluding 267 studies, 412 studies remained in our sample (431 studies satisfied our inclusion criteria, but we missed coding 19 of those studies due to our own error).

Next, we used a selection of articles to create criteria for coding the studies. After three rounds of refining the coding form and its categories, at least one researcher coded each of the 412 qualifying studies for details such as discipline, class size, type of active learning, type of affective response, and conclusions regarding student responses. Summary results of the coding are presented in this paper, and more detail about the software, coding procedures, coding form, and data management for this collaborative systematic review project are reported elsewhere [14]. Finally, we developed three "quality score" rubrics – one to apply to quantitative studies, one for qualitative studies, and one for studies that used mixed methods – to assess the quality of each study, and at least one researcher used coding data and other study details to calculate a quality score for each of the 412 studies.

The analysis for this paper includes descriptive summaries of the 412 studies and chi-squared, Kruskal Wallis, and Wilcoxon rank sum tests. These quantitative tests determine whether students' affective response to active learning differed and whether the quality scores were statistically significantly different ($p < 0.05$) by STEM discipline.

III. Results

Our final data set comprises 412 studies which report students' affective responses to an active learning intervention in an undergraduate STEM course. Here we provide descriptive summaries of those studies and results of significance tests.

A. *Course Characteristics*

Fig 2 shows the percentage of 13 STEM disciplines represented among our data set (some studies include multiple disciplines). Engineering and science disciplines are represented at about the same proportion: 44% and 48% respectively. Math and statistics courses are represented more than any other single discipline (12%), and electrical engineering has the second highest representation (10%).

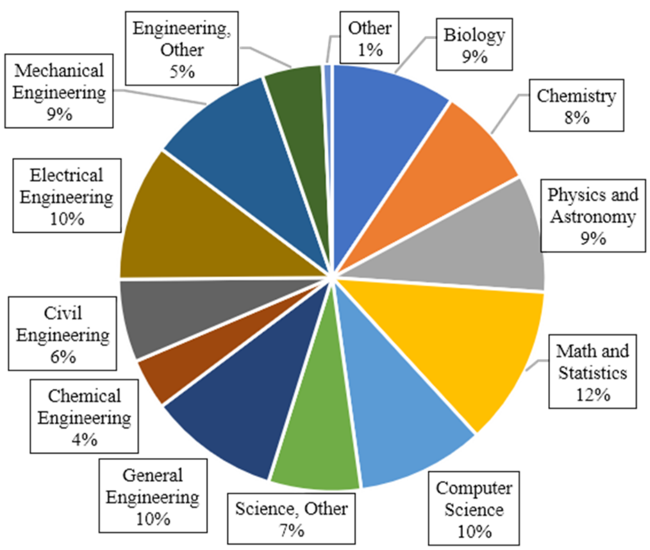

Fig. 2. Percentages of each discipline represented amoung our 412 studies. General engineering includes first-year and other engineering disciplines not listed separately.

Sample size reported in these studies varied considerably (M = 202, SD = 385). Some papers sampled less than 15 students (7% of studies) while other studies sampled more than 500 (7% of studies). The median sample size was 83 students, with 63% of papers sampling between 30 and 500 students.

Students' year of study also varied, with many studies focused on first-year students (39%). Second-year, third-year, and fourth-year students consisted of 23%, 20%, and 17% of the studies respectively. Many studies included courses that covered multiple students' year of study (14%). Most courses studied were primarily for STEM majors (55% of studies) and many were required classes (63%). Only a few studies included courses for non-STEM students (12%).

B. *Study Characteristics*

Fig 3 provides an overview of the types of active learning reported in the studies (note, some studies reported multiple activities). The most common types were "Working in groups or pairs" (72%) and "Problem solving" (54%). The type of active learning reported did not differ in terms of students' affective response ($\chi^2(35, N = 412) = 25.09, p = 0.89$).

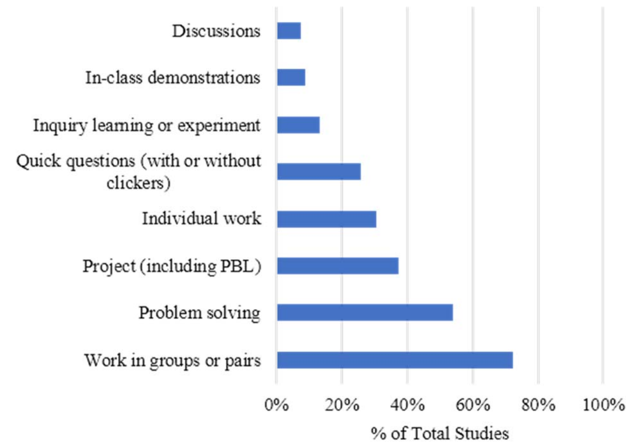

Fig. 3. Distribution of type of active learning.

Fig 4 shows different types of students' affective response measured. The most commonly reported affective response was "Self reports of learning or help to learning" (78%). Although self-report of learning gains is often viewed as a weak measure of cognitive outcomes, we chose to include it here as an affective measure due to concerns about instructor course ratings, which would depend on students' perceptions of their learning.

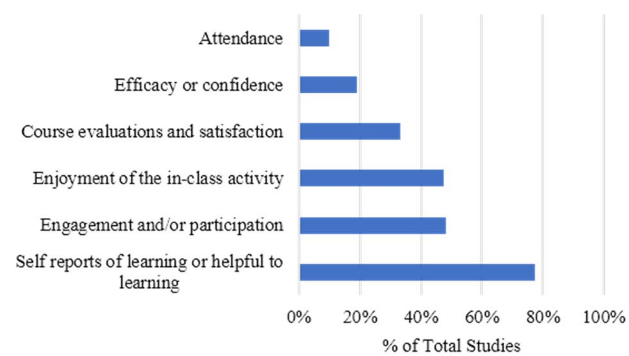

Fig. 4. Distribution of affective outcomes measured

Data sources relied heavily on surveys, including instructor-generated survey questions (70%), end of term course evaluations (21%), and other validated instruments (18%). Qualitative approaches for data collection included interviews and focus groups (13%) and observations (13%).

In terms of methodology, most studies used quantitative research designs (52%). Some used mixed methods approaches (36%), and most of these supplemented their quantitative research design with a qualitative analysis of some short answer survey questions (72%). Fully qualitative studies were rare (11%). This distribution of primarily quantitative research design did not significantly differ by course discipline ($\chi^2(24, N = 412) = 22.53, p = 0.55$).

C. Student Responses to Active Learning

A majority of studies reported a *mostly positive* (174 studies or 42%) or *positive* (172 studies or 42%) affective response to active learning. Only 14% of studies reported a mixed/neutral result, and just 2% reported a mostly negative or negative affective response. These mixed/neutral to negative responses (65 studies) will be the focus of a future publication, as described subsequently. Course disciplines did not differ in terms of students' affective response to active learning ($\chi^2(60, N = 412) = 61.85, p = 0.41$).

Although it was not the focus of this review, since 153 of 412 articles we reviewed also reported students' *cognitive* responses (i.e., learning gains), we coded these conclusions as well. As we found when analyzing students' affective responses, these 153 studies report students' cognitive responses that are overwhelmingly positive: 71% reported a positive or mostly positive cognitive response to active learning, while 24% reported a mixed/neutral response to active learning. The remaining studies reported an inconclusive or mostly negative response.

D. Quality Scores

Depending on the study's main research methodology, we calculated a quality score for it by applying our quantitative, qualitative, or mixed-methods rubric (the three rubrics are included in the Appendix). The resulting quality score ranged from 0 to 12. Most quality scores for studies were low (M = 3.60, SD = 2.13), and 80% of the studies received a score less than or equal to 5.

Fig 5 illustrates the distribution of quality scores by course discipline. The results are varied, and statistical tests confirm that quality scores were significantly different by course discipline ($\chi^2(12, N = 412) = 24.63, p = 0.02$). An additional pairwise Wilcoxon rank sum test was used to determine which course disciplines differed from each other. Only the two pairs of electrical engineering–biology and electrical engineering–chemistry were significantly different ($p < 0.05$). As shown in Fig 5, electrical engineering received a higher proportion of lower quality scores within their discipline, and biology and chemistry received a higher proportion of higher quality scores within their respective discipline.

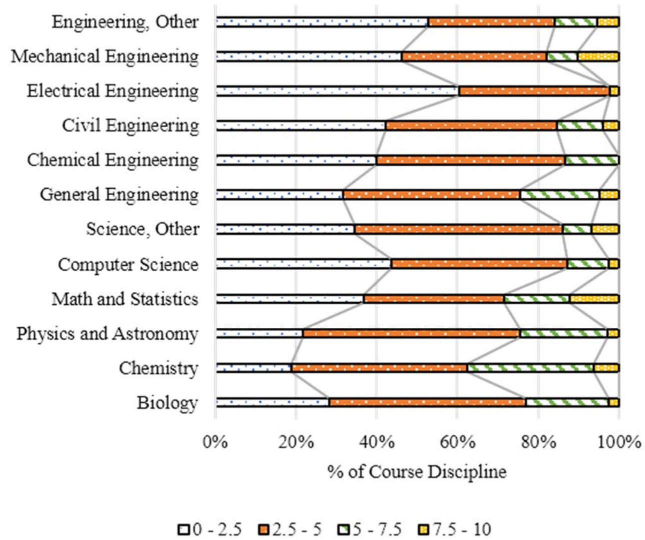

Fig. 5. Distribution of quality scores by discipline

IV. Discussion

We conducted a systematic literature review of the affective responses to active learning by undergraduate students in STEM courses. This paper reports the characteristics of 412 qualifying studies published as conference papers or journal articles since 1990.

In answer to our first research question (*What affective responses are used to evaluate the effectiveness of active learning*?), the studies describe a wide variety of students' affective responses to active learning in STEM courses (Fig 4), including self-reports of whether the activities helped them learn better, participation, enjoyment, satisfaction, efficacy, and attendance. In answer to research question 2a (*What evidence is used to measure these students' affective responses to active learning*?), responses were measured through primarily quantitative means, most frequently surveys including questions created by the instructor, end of term course evaluations, and validated instruments. There were no statistically significant differences by discipline in quantitative, qualitative or mixed methods study approach. This is at least in part due to the high representation of quantitative methods.

In response to our third research question (*How are contextual features of a course connected with positive or negative student affective responses*?), we note that the papers describe a wide variety of active learning approaches (Fig 3), including group work, problem-solving, projects, questions, demonstrations and discussions. There were no statistically significant differences in student response by type of active learning, course level, class size, or discipline, perhaps because there was little variation in students' affective responses. These results corroborate our previous work examining students' responses to active learning, where we found that the type of active learning used did not strongly predict how students responded [16]. We also tested positive, negative and neutral responses by discipline, and found that STEM discipline doesn't relate to student affective responses to active learning.

The students' affective responses to active learning were overwhelmingly positive, with 84% of studies reporting positive or mostly positive results (346/412 studies), but we acknowledge that publication bias is a serious concern and is a limitation to this type of systematic review. Typical methods for testing and quantifying publication bias, such as funnel plots [12], are not possible given the variety of outcomes measured and reported in the studies. We argue that since the primary goal of most of the primary studies was to present positive *cognitive* evidence of student learning, there may be lower risk of publication bias in reports of student *affective* responses studied here. Nonetheless, the sheer volume of positive affective responses spanning STEM disciplines, course levels, and types of active learning suggest that undergraduate students can, and frequently do, respond positively to active learning in STEM. Our future work will seek to understand the specific strategies and circumstances that have led to positive student responses so that we can make specific suggestions for instructors to reduce student resistance to active learning.

The vast majority (80%) of the studies earned less than half the possible points on our scoring rubric. Admittedly, the authors of these studies did not likely write their papers with the intention of ever being evaluated as rigorous research studies, but nonetheless the overall quality of the studies is disappointing. These studies spanned the STEM disciplines, with comparable representation of studies in engineering and science courses. There were few statistically significant differences by discipline, but we did find that electrical engineering studies scored lower in quality than biology studies and chemistry studies. This could be due, in part, to the greater access to venues such as the Frontiers in Education Conference for instructors wishing to publish their classroom studies, perhaps with a lower barrier to the scholarship of teaching and learning. It is generally expected that conference papers would be of lower quality than journal articles, and the sheer volume of conference papers in electrical engineering may have reduced the mean quality score for that discipline.

V. Future Work

Here we outline three proposed directions for our systematic literature review. Since we identified a large number of studies (412), many with fairly low quality scores, our syntheses will focus on analyzing a subset of studies to identify productive implications for research and practice.

A. Instructor Strategies to Reduce Student Resistance

Our previous work affirmed the importance of two main types of strategies that instructors use to reduce student resistance to active learning: explaining the importance of the activity (explanation) and facilitating students' involvement during the activity (facilitation). In a survey study of 179 students in four engineering courses at different institutions [16], we found that clear explanations were valuable to the students' perceptions of active learning. We conducted a separate survey study of 1,051 students in 18 courses at different institutions, and we found that facilitation strategies were more effective in encouraging active learning and in positively influencing final course evaluations than explanation strategies, but they were used less frequently [17]. Interviews with these same instructors revealed new strategies as well as additional details about those studied using the student survey [18].

This next stage of our systematic review analysis will focus on a subset of 34 of the 412 papers that mentioned strategies for reducing student resistance to active learning. We anticipate building a stronger evidence base for existing strategies as well as identifying additional strategies for STEM instructors to reduce student resistance to active learning.

B. Resources for Instructors Wishing to Study Resistance to Active Learning in their Own Students

The 412 studies indicate much ambiguity and diversity of thought regarding methodologies to study students' affective responses to active learning. That is, the 412 articles presented a variety in:

- the ways students' affective responses were conceptualized,
- the ways by which students' affective response was studied methodologically – from the almost exclusive use of quantitative methods, to the limited use of mixed methods, to the rare use of purely qualitative methods – including a number different designs within these,
- study designs – including experimental, sampling practices, use of validated instruments, etc., and
- the quality of a study design.

For example, while some studies had a large sample size or used validated instruments that matched the stated research questions, others had very small sample sizes that relied on instructor-generated instruments or protocols that had not been piloted.

In light of these observations, we considered how the best of the studies could inform instructors and researchers wishing to study students' affective responses to active learning in the future. This next phase of our analysis will focus on the studies that scored the highest on our quality rubrics for quantitative, qualitative and mixed methods studies. We anticipate identifying specific instruments and offering guidance for instructors seeking to conduct their own studies of students' affective responses to active learning.

C. Negative and Mixed Results

Our review shows that the majority of the studies report a positive or mostly positive affective student response to active learning (84%). The remaining studies reported either a mixed/neutral result or a mostly negative affective response to active learning. Instructor fear of negative student response (including resistance) to active learning remains the most understudied barrier to the adoption and continued use of active learning. Addressing this fear calls for examining negative affective responses in detail to build a better understanding. Although the percentage of studies reporting mixed/neutral to negative responses totals to 16%, as another phase in this research, we plan to qualitatively examine these 65 studies to (a) identify the common ways in which students demonstrate negative affective responses and (b) more importantly, identify specific reasons behind students' negative responses as reported in the 65 studies.

We will accomplish these research objectives in two overarching steps. First, we will qualitatively code the studies to identify the most common types of negative affective responses (e.g., in-class disengagement and negative course evaluations). Second, we will reexamine these common types of negative affective responses to identify reasons behind negative response as reported in the studies. We plan to leverage extant literature and relevant theories to build an explanation of why students demonstrate negative affective responses to active learning. This work will be particularly useful for faculty developers and practitioners in designing active learning instruction that mitigates students' negative affective responses to encourage adoption and continued use of active learning in STEM undergraduate education.

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APPENDIX: QUALITY RUBRICS

We developed three quality scoring rubrics (quantitative, qualitative, and mixed methods) based on previously published research quality criteria and systematic review rubrics [19-21]. We then applied one rubric to each article, based on the primary research methodology reported within the article. Table II presents the rubrics.

TABLE 2. QUALITY SCORING RUBRICS FOR STUDIES WITH QUANTITATIVE, QUALITATIVE, OR MIXED-METHODS RESEARCH DESIGNS.

Quantitative	**12**
Study design: +1 points for each: a pre-post design, a control group, multiple class sections	3
Sample size: +1/2 for >50% participants responding; +1/2 for a sample size of >200	1
Data sources: +1 for using two data sources, +2 for using 3 or more, +1 for using validated instruments	3
Results presentation: +1 for each: lists survey questions, lists percentages responding different ways, reports significance, repots effect size	4
Limitations: +1 for identifying limitations	1
Qualitative	**12**
Study design: +1 for each: multiple researchers evaluate data, acknowledges IRB/consent forms, describes methods for data analysis	3
Sampling: +1 for each: describes a sampling strategy, provides rationale for studying selected course	2
Data sources: uses multiple data sources, describes data collection technique (e.g., protocol)	2
Results presentation: discusses positionality; describes context; provides students' characteristics, incudes data excerpts	3
Limitations: +1 for identifying limitations	1
Mixed Methods	**12**
Quant points: +1/2 for each: a pre-post design, a control group, lists survey questions, lists percentages responding different ways, reports significance, reports effect size	3
Qual points: +1/2 for each: multiple researchers, acknowledges IRB/consent forms, describes a sampling strategy, discusses positionality, describes context, incudes data excerpts	3
Mixed methods specific: +1 for each: uses >2 data sources, analysis combines quant and qual data, cites mixed methods sources for data collection or analysis method, discusses purpose for mixed methods, discusses the relationship between the quant and qual data sources	5
Limitations: +1 for identifying limitations	1