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Social-Driven Propagation of Active Learning and Associated Scholarship Activity in Engineering: A Case Study*

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This research describes a pilot program for propagating active learning within engineering education starting with a group of nine interested instructors from two departments. The first and second authors served as the discipline-based coaches for these instructors, and the propagation program involved community discussions, one-on-one coaching, classroom observation, assessment of student perspectives, and feedback to and follow-up with the instructors. This approach aligned with the professional development and coaching literature as well as emergent change strategies identified by Henderson and colleagues. This work is important because STEM education has not generally taken a research-based approach to dissemination of pedagogical innovations, and research on sustained change is only in its early stages. Using a case study approach involving instructor interviews, documentary data (i.e., discussion notes), and classroom observation, the program was assessed based upon instructor participation and accomplishments (including scholarship of teaching and learning activities), plans for continued active-learning use, and valuation. Of the nine initial instructors, seven participated in the one-year program until the end, including three who also engaged in scholarship of teaching and learning. All seven used active learning, as confirmed by observation or interview. Based on their interviews, instructors identified the program's "people" focus, in particular one-on-one coaching and community discussions, as strengths of the program, as supported by the coaching literature. A finding of this research is that benefits were achieved despite non-ideal levels of instructor participation in all program aspects. The goal is to share an implementation and assessment approach with other educators considering relationship-driven, emergent strategies for adoption or expansion of active learning.

Keywords: instructional change; active learning; educational scholarship; engineering education; propagation; coach

1. Introduction and Supporting Literature

Active learning (AL) during class requires students to *do* something beyond listening and taking notes [1]. Active learning is desirable because of its documented positive impact on learning and learning environments, and it should be used *to some degree* in STEM courses [2–4]. Despite the known benefits of active learning, lecture is still the prominent approach in STEM courses, with active learning reportedly propagating at a slow rate [5–7]. Fortunately, AL is implementable in numerous ways, from very simple to more-complex techniques [8]. Simple approaches, including think-pair-share and the minute paper, often require little-to-no preparation and can be easily adopted, including by new faculty [9]. With think-pair-share, students work on problems individually and then turn to their neighbors to discuss and improve upon their answers, with eventual sharing with the class [1]. Unfortunately, a survey of Electrical and Computer Engineering (ECE) faculty indicated a somewhat-low usage rate for the think-pair-share technique (i.e., 30% of respondents) [10]. In addition, 54% of those who had ever tried think-pair-share stopped using it, suggesting uncertain long-term adoption of this simple technique [10]. In a recent publication, Dancy, Henderson, and Turpen indicated that a lack of knowledge about how to propagate and sustain the use of research-based instructional strategies is a large barrier to improving undergraduate STEM education in physics [11]. They further indicated that research on promoting sustained change is still in its early stages [11]. They had actually highlighted years earlier that little effort had been invested to that point in ensuring the integration of the myriad of findings from research in STEM-education [12]. These researchers had also called out earlier that the study of change strategies was weak and a dissemination model that considered the complexity of classroom change was needed [13, 14].

To this end, the present project aimed to promote the propagation of active learning within a school of engineering at a major research institution in the Mid-Atlantic region of the U.S. This was done via an inter-departmental pilot program involving one-on-one coaching of faculty from two departments by two fellow discipline-specific faculty (i.e., one from each department) in implementing active

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learning. A disciplinary-based approach with a new-faculty workshop was previously linked to the potential spread of research-based instructional practices in physics and astronomy [15]. The seeds for the present project were planted when the project director (i.e., first author) began working with the project co-director (i.e., second author) in the fall 2016 after attending an active learning workshop together. The former began coaching the latter as he used simple AL techniques for the first time in three ECE courses. Their collaboration led to a transformative experience for the instructor in his approach to teaching [9].

Based upon their successful implementation model and partnership, the project directors proposed to work as change agents to develop, pilot, and assess a unique program to propagate the use of AL within their school of engineering by bringing together a small group of faculty from their two respective departments to collectively implement or enhance their use of active learning. Unfortunately, instructors sometimes face difficulties in implementing active learning, including after workshops – and without support and guidance, they may abandon it and return to traditional teaching [16]. The project directors considered their proposed approach to be thorough and innovative because after teaching workshops, faculty are often left to implement the techniques *on their own*. Thus, their approach didn't end with the "workshop," but instead continued with one-on-one coaching by fellow discipline-specific faculty. The literature indicates that even in today's school districts where large expenditures are made on professional development, teachers receive "sit-and-get" professional development with little planning or follow-up [17].

1.1 Theoretical Framework: Program Components

The model of Henderson, Beach, and Finkelstein for enacting change in STEM education served as a theoretical framework for this pilot propagation program [18, 19]. This model consists of the following four types of change strategies: (1) disseminating curricula and pedagogy, (2) enacting policy, (3) developing reflective teachers, and/or (4) developing a shared vision [18, 19]. Strategies 1 and 2 tend to be prescribed strategies for individuals and environments/groups, respectively. Strategies 3 and 4 tend to be emergent strategies for individuals and environments/groups, respectively [18]. The proposed program aimed for the emergent outcomes of a shared vision and reflective instructors, possibly even instructors who initiated or deepened their work in the scholarship of teaching and learning (SoTL) or other educational scholarship activities. Participation in SoTL is important for instructors, as it leads to more informed instructors who tend to be inspired with new ideas for their ever-changing classrooms, which is good for student learning as well as the larger community due to contributions to scholarly bodies of knowledge [20]. The professional learning and development literature as well as the coaching literature, including athletic coaching, informed and supported the approach as well.

Drawing upon their own experiences (as discussed previously) as well as support and framing from the literature, the project directors established a plan for the propagation program, as shown in Table 1, with the program components typically occurring temporally from top to bottom in the table. The first two items depict initial or planning-based support in the form of community meetings/discussions and one-on-one coaching between the project directors and participating instructors, with these two components intended to complement one another.

Social interactions, including conversations among colleagues, have been identified as influential, powerful, and/or key for the dissemination of teaching innovations [11]. Communities or groups, in which ideas are shared among members and support for individual-based change is created, have been a successful emergent strategy for developing a shared vision as well as reflective instructors who use their experiences to improve [18]. The professional development (PD) literature also identifies communities of teachers as necessary for effective professional development [21]. The PD literature also indicates that adult professional learning must be *personalized* and *sustained*, including support 1) with upfront planning, 2) during classroom implementation, and 3) with evaluation [17, 21, 22]. Likewise, Beach, Henderson, and Finkelstein identified coordinated efforts over an extended period of time (i.e., a semester to an academic year) as important to successfully disseminating pedagogy, along with strategies that aim to change instructor beliefs [14, 18]. This supported the ongoing one-on-one coaching of instructors throughout the one-year program, including classroom observation and collection of student assessment data for evaluation purposes.

Table 1. Active Learning (AL) Propagation Program Components

1. Community discussions on active and interactive learning
2. One-on-one coaching of instructors by fellow, discipline-specific faculty in classroom AL
3. Classroom observation and subsequent formative feedback to instructors
4. Assessment of student perspectives on active learning for formative feedback to instructors
5. Follow-up interviews and discussions with instructors for evaluation and to promote reflection and sustained use

Having peers and colleagues observe one's classroom for formative feedback and improvement is beneficial, if not essential [23, 24]. Classroom observation and subsequent feedback provide informative support and development and are important, necessary elements of instructor coaching [21, 22, 25–27]. Based on the model of Henderson, Beach, and Finkelstein, performance evaluation and feedback are important elements for enacting change, including both prescribed and emergent change [18]. Thus, items 3 and 4 in Table 1 encompass additional program support in the form of classroom observation and the collection of student feedback data on active learning. With item 5, the observational and student feedback data are shared with the instructor, leading to follow-up conversation, gathering of instructor perspectives, and future planning.

Fortunately, the proposal was selected for funding by the University's Office of the Provost. As part of the proposal, the project directors formally recruited a total of nine faculty volunteers for a pilot effort from their two departments who were interested in applying new or enhanced active or interactive techniques in their courses during the fall 2018 and/or spring 2019 semesters, with one-on-one coaching if needed. The number of participating faculty was intentionally limited so sufficient time could be devoted to each instructor in this pilot effort. The program was intended to be a one-on-one program involving customized instructional coaching, classroom observation, and support of instructors (if desired) in the scholarship of teaching and learning, which are time-intensive activities.

Using a case study approach involving documentation of program activities and discussions, classroom observation, and instructor interviews, this paper describes the implementation and assessment of the pilot program from summer 2018 to spring 2019 and presents assessment data and evidence from the pilot [20, 28]. The goal is to share knowledge of this approach with other schools interested in propagating active learning, including "after the workshop." Interestingly, a gap in publications on the implementation of active learning after faculty workshops was recently identified, with a call for more research in this area [7]. Therefore, the present article makes a contribution to the literature in this way also. The following research question was posed about this emergent propagation program with personalized instructor coaching and feedback:

***RQ**: What are the characteristics of a socially-driven propagation program, including instructor participation, achievement, and perceived value?*

1.2 Additional Supporting Literature

1.2.1 Social Channels for Change

As discussed previously, educational reform may occur best through informal communication channels, interpersonal networks, conversations with colleagues, faculty communities, and support provided during change and implementation efforts, as opposed to more formal approaches that characterize the "develop and distribute" change strategy, including workshops [11, 13, 29]. Dancy et al. indicate that more research is needed in developing strategies that utilize social interactions to promote sustained change, which may include guiding instructors in appropriately modifying or adapting innovations if desired [11, 13, 29]. Community-of-practice approaches have been used with noted benefits for implementation and propagation of enhanced teaching approaches. For example, a community-of-practice approach for the propagation of active learning in science courses offered one-on-one support to ease instructors into active learning and promote continued use [16]. A community-of-practice approach was also used across Australian universities to promote adoption and scaling of new and innovative adaptive-learning tutorials for engineering mechanics coursework [30].

1.2.2 Coaching

Coaching began in athletics but now describes a type of relationship involving support and feedback to a "client" taking self-directed action or responsibility for achieving a goal [27, 31, 32]. Coaching is a universal practice used to improve the performance of multiple types of professionals, including instructors, business executives, and athletes [33]. The athletic coaching literature identifies and defines coaching as a "people" business, a "helping" profession, an "educational relationship," and "caring leadership" requiring exceptional interpersonal and communication skills [34, 35]. Revered UCLA basketball coach John Wooden was considered a "master teacher" [36].

In education, coaching is known to be a strong and proven technique for instructor learning and development [21, 26, 37]. Instructional coaches assist teachers in learning evidence-based practices in a "partnership between equals" context [38]. Similar to athletic coaching, effective communication is a component of instructional coaching [27, 38-39]. The instructional coaching literature recently called for more empirical investigation of and research on instructor coaching, including the specific reasons why and how coaching works, lending support to this work [21, 26].

The instructional coaching literature has drawn a direct connection between effective professional development in the form of coaching and the propagation of evidence-based teaching practices in the classroom [26]. However, it should be understood that coaching is expensive in terms of time and human resources, as was anticipated for the proposed propagation program [26]. However, evidence suggests the effectiveness of professional development for instructors, including coaching, is positively associated with the intensity of the support [37].

2. Methods

2.1 Implementation of Program Components

Although the instructors were encouraged and gently reminded to participate in all of the various program components and activities, participation was something that was not (nor could be) forced or required. This is in line with Henderson et al.'s model of emergent (versus prescribed) strategy and the development of reflective teachers with a shared vision. The goal of the pilot was experimental in terms of assessing the characteristics of and results from willing instructor participation. This was important for internal assessment as well as to offer evidence to others wishing to adopt an emergent program or elements of it. The activities in Table 1 comprised the elements of the program to propagate active learning among the pilot group of faculty from the two engineering departments. Each program component is further discussed in the subsequent subsections of this paper.

2.1.1 Community Discussions

Each of the nine faculty members who expressed an interest in participating during the proposal stage was invited to a project-kickoff lunch at a restaurant on campus during the summer of 2018. This lunch served as a community meeting, at which time the project goals and the instructors' individual views on active learning were discussed and gathered, respectively. Although the propagation program did not specifically include a workshop, five of the participating instructors had attended Dr. Michael Prince's active-learning workshop *How to Engineer Engineering Education* just prior to the first community gathering. Since our strategy was emergent, we chose a community discussion versus direct dissemination of pedagogy (i.e., formal training sessions or workshops) for the program, although the discussions did include elements of instruction. As with all program elements, attendance at the community gatherings was encouraged, but in no way were instructors pressured or required to attend. During the first community discussion, the following interview question was posed to the instructors to drive conversation and reflection:

> **Instructor Interview Question:** What are your perspectives and thoughts on any of the active-learning workshops you may have attended in the past, such as Mike Prince's workshop, the NETI workshops (i.e., National Effective Teaching Institute), or others?

The instructors who had previous experience with using simple active learning techniques in the classroom (approximately half) shared their experiences and thoughts with the rest of the group. During and immediately following this meeting, each participant was challenged with identifying a particular lesson, lecture, or course for which he wanted to incorporate a new or enhanced active or interactive learning technique. Although it was preferred that instructors do this during the fall 2018 semester, four instructors opted to do this for their spring 2019 courses, while three opted for the fall 2018 semester. A second community discussion was held during the midpoint of the spring 2019 semester to enable faculty to reflect on and share their experiences to that point and future plans. It was an open discussion, and participants willingly discussed their use of active learning over the past semester and a half.

The two luncheon meetings comprised the community gatherings organized as part of the program, although evidence emerged during the post-program interviews that informal conservations had occurred between the faculty participants about active learning. Given evidence about the impact of community that emerged during the interviews, the project directors plan to formally promote community engagement to a greater extend in future work, as discussed in the Conclusion section.

2.1.2 One-on-One Coaching

Following the initial community discussion, the project director contacted the participating faculty individually to determine potential dates for classroom observation as well as to offer one-on-one planning or coaching in the development, accurate execution, and implementation of classroom activities. Planning and coaching meetings subsequently occurred between the project directors and the participating instructors as desired or requested by the instructors. The project director and co-director are faculty members in the same two departments as the faculty participants (i.e., Industrial Engineering and Electrical/Computer Engineering, respectively) and therefore served as disciplinary coaches working alongside fellow faculty. Example topics discussed with multiple instructors during planning and coaching meetings included the following: (1) student resistance or perceived barriers, (2) preparation of active-learning materials for pilot use, (3) planning for development of videos for the flipped classroom, (4) execution of simple active learning techniques, of (5) development or discussions of student feedback surveys and assessment tools, and (6) review and analysis of survey data collected. The occurrence and content of planning meetings with each instructor was logged by the project director and contributed to assessment of instructor participation.

2.1.3 Classroom Observation and Feedback

The COPUS observation protocol was used to perform structured observation, document the occurrence of active learning and interactive practices, and provide formative feedback to the instructor [40]. In several cases, the instructors were apprehensive or concerned about their first-time or expanded use of active learning. The propagation program was intended to support instructors in taking initial steps in these cases. Thus, with the classroom observation, determining the amount of active learning was not necessarily the goal. Rather, observation occurred by the project director to confirm active learning use and offer feedback and encouragement to the instructor. In line with this, the project director observed the classroom in accordance with the instructor's wishes and timing. The observation of two class sessions per instructor across the total study period was the goal for thoroughness. The project director also typically uses the COPUS when observing classrooms in her role as the Assessment Director of the school to better focus her attention on the many activities occurring in the classroom. Feedback on the active/interactive practices observed and ideas for enhancement were provided to the instructor in person (immediately following the observation) and in writing (very soon afterwards). As the Assessment Director, the project director had extensive prior experience in using the COPUS as a tool to observe classrooms and provide formative feedback on active and interactive classroom practices, having achieved inter-rater reliability scores with other analysts of $\kappa = 0.83$ and $\kappa = 0.96$, indicating strong agreement [41].

2.1.4 Student Feedback

Student perspectives on active and/or interactive learning in the classrooms of the participating instructors were gathered by the project director either by interview or survey. As the Director of Assessment for the school, the project director routinely develops protocols for and conducts surveys, interviews, and focus groups with students and faculty. She interviewed the students and assisted in the development and administration of surveys. Several of the interview and survey assessment questions are shown in Table A in the Appendix. The anonymous student perspectives data was provided to the instructor in writing after the semester ended for additional feedback on his AL use. Coding schemes for questions 1–3 in Table A, which were developed as part of prior work by the first author, were used to content-analyze and summarize the student perspectives data in a rigorous manner [9, 42, 43]. They can likewise be used by others to analyze perspectives on active and flipped instruction in a structured manner for instructor feedback.

2.2 Program Assessment Methods

Using a combination of activity documentation, classroom observation, and instructor interviews, a case study approach was used to investigate the primary research question of characterizing the implementation of an emergent-strategy, individualized-coaching propagation program for active learning [20, 28]. This characterization was done in terms of instructor participation, accomplishments, and value perceived by them.

Of the nine instructors who originally expressed interest in using or expanding their use of active learning, six were tenured or tenure-stream faculty (i.e., three assistant professors, two associate professors, and one full professor). Each of the three non-tenure-stream instructors was an assistant professor. A pre-program survey developed by the project directors was used to gather the instructors' goals, needs, concerns, and prior experience in the use of active learning at the start of the program, in an effort to "meet faculty where they are" [11]. The survey sought instructor input on perceived barriers, as situational characteristics have been identified as large impediments to the propagation of educational reforms, even abandonment of new techniques [44]. In general, the pre-survey information was used to guide the coaching efforts as well as describe the cohort of instructors at the start of the program. A copy of the survey is shown in the Appendix (Table B) for use by others.

Throughout the program, the project director subsequently recorded the activities of and discussions with each participating instructor using documentary notes, which included information on coaching discussions, accomplishments with active learning, and SoTL achievements. Structured classroom observation also occurred using the COPUS observation protocol. At the end of the program, the project director conducted an interview with each instructor to follow up, gather perspectives on active learning and the program, and assess poten-

Table 2. Faculty Interview Questions: Program Impact

1. What are your perspectives on active learning?
2. Did this project have an impact on your likelihood to use active learning longer-term in your classrooms, or your likelihood to try new active learning techniques going forward? If so, what aspects of the project impacted this?

tial sustained use. The interview questions are shown in Table 2 and were intended to allow instructors to reflect on their practices, the program, and its impact. The development of reflective instructors was one of the change strategies that framed this study.

3. Results

3.1 Program Participation Results

Instructor participation in the program was tracked with regard to attendance at the community discussions, occurrence of planning and coaching meetings, and classroom observation by the project director. Participation during the program is detailed in Table 3 and Table 4 for the nine instructors who were originally recruited based on their interest in using or enhancing their use of active learning. Their departments and ranks are also shown. Each instructor originally signed a letter of interest as part of the formal proposal submission to the University. In addition, instructor participation in related educational scholarship activities with the project director during the study period was also tracked and is discussed in the following section.

All nine recruited instructors were invited to the kickoff community discussion, and as shown in Table 3, six attended the event. Of the six, three had *not* used active learning previously during class and were prospective first-time users. Following this event, coaching and planning meetings were held during the first (fall 2018) semester with four of the instructors per their request or agreement. Three of these instructors actually planned to implement new or enhanced active learning during the second semester (instructors I2, I7, & I8). For the other instructor (I1), the planning and coaching meeting was held after the second classroom observation to discuss needed changes to his course flip. These changes were implemented during the second (spring 2019) semester.

Of the instructors who requested planning meetings, the number of meetings per instructor ranged from one to five during the first semester, as shown in Table 3. Classroom observation occurred for three instructors during the first semester, with two not requesting a planning or coaching meeting prior to this (I3& I6). One of these instructors (I3) had used simple active learning previously. Among the instructors observed during the first semester, two observations per instructor were conducted, as shown. The types of active learning observed were the flipped classroom (I1), paired activities and discussion (I3), and software-based activity and whole-class case discussion (I6).

During the second semester, four of the original nine instructors attended the second community luncheon, with two from each department in atten-

Table 3. Instructor Participation Data: Semester 1 (Fall 2018)

Instructor	Dept/Rank	Attended community event	First time AL User?	Coaching/ Planning Meetings	Times observed using AL	Type of AL Observed
1	ECE NTS Asst	√		1	2	* flipped instruction
2	ECE NTS Asst	√		1		
3	ECE TS Asst	√			2	* pair-share problems * paired discussion
4	ECE TS Full					
5	ECE TS Assoc	Did not participate				
6	IE NTS Asst	√	√		2	* software-based activity * whole-class case discussion
7	IE TS Asst	√	√	5		
8	IE TS Asst	√	√	1		
9	IE TS Assoc	Did not participate				
Total	**6**	**3**	**8**	**6**		

NTS: non-tenure stream. TS: tenure stream or tenured. Asst: Assistant Professor. Assoc: Associate Professor. Full: Full Professor.

Table 4. Instructor Participation Data: Semester 2 (Spring 2019)

Instructor	Dept/Rank	Attended community event	Coaching/ Planning Meetings	Times observed using AL	Type of AL Observed
1	ECE NTS Asst	√		1	* flipped instruction
2	ECE NTS Asst	√		2	* Extended problem solving (studio-style)
3	ECE TS Asst				
4	ECE TS Full			1	* Lab demonstrations
5	ECE TS Assoc	Did not participate			
6	IE NTS Asst	√		1	* Extended problem solving (studio-style; video before class)
7	IE TS Asst	√	4	1	* Virtual reality activity w/ Google cardboard
8	IE TS Asst				
9	IE TS Assoc	Did not participate			
Total		**4**	**4**	**6**	

NTS: non-tenure stream. TS: tenure stream or tenured. Asst: Assistant Professor. Assoc: Associate Professor. Full: Full Professor.

dance, as shown in Table 4. During the second semester, four coaching/planning meetings were held with one instructor (I7) for the purpose of developing videos for a virtual reality activity with the assistance of an undergraduate researcher. Observation occurred in the classrooms of five instructors, with two of these instructors also having been observed during the first semester (I1 & I6). Of the instructors observed in the second semester, each one was observed once, except for I2, who was observed twice. The types of active learning utilized are listed in Table 4.

For the program as a whole, classroom observation occurred for six of the seven participating instructors, and active learning was observed and confirmed in all six cases. Although one participating instructor was not observed, he shared as part of his post program interview that he had utilized simple active learning for the first time during the second semester of the program, including paired problem solving and "muddiest point" minute papers. Across the study period, at least two observations occurred for four out of the six instructors observed, in accordance with the goal of observing at least two sessions per instructor. For the two instructors who did not participate, one actively declined to participate, and the other did not respond to email invitations from the project director.

Although these metrics were in many ways simply counts, they were encouraging to the project directors. The following summarized points of satisfaction as well as areas for improvement were gleaned by the project directors based on the above results and discussion:

- 7/9 volunteer instructors (78%) participated to the end of the program, including granting of a post-program interview. *Thus, most of the recruited instructors participated.*
- All 7 used active learning. This included first-time as well as "established" users. This was confirmed via classroom observation of 6 instructors and a post-program interview with the remaining instructor. *Thus, both first-time and established users utilized active learning, with some established users implementing more complex forms of active learning.*
- The two community luncheons were attended by 6 and 4 of the original 9 instructors, respectively. *Enhanced community interaction and participation is an area we are targeting in future work.*

3.2 Scholarship of Teaching and Learning and Use of Student Feedback

Three instructors (along with the project director) submitted engineering education conference papers to the American Society for Engineering Education (ASEE) during the project period, as shown in Table 5. Each paper described the instructor's use of active learning and included student interview data that had been collected by the project director during the project period. For two instructors, this was their first ASEE conference paper. With the project director's direct involvement and coaching, these papers were accepted for publication in the conference proceedings. The other instructor (I2) had submitted ASEE papers previously. Two instructors submitted engineering education proposals during the project period with the direct involvement of the project director as well, although these two instructors had submitted engineering-education proposals previously as well. One of these instructors (I4) indicated in his post-program interview that he wants to (and should) continue these types of educational scholarship activities as long as he is an instructor. Thus, three of the seven participating instructors undertook SoTL activities with the project director during the study period, all with plans for sustained collaboration.

Another instructor (I7) developed, in direct consultation with the project director, a survey administered during both semesters to seek student feedback on various course elements. In fact, input that was received during the first semester was directly utilized to make changes to a lab module during the second semester. Student interviews were done in the classrooms of three instructors to gather additional formative feedback for the instructor (I1, I2, and I4).

3.3 Instructor Interviews

All participating instructors were interviewed at the end of the program by the project director to assess their perspectives on active learning and the impact of the program on their active-learning teaching practices going forward. These interviews also enabled instructors to reflect on their practices and the potential impact the program may have had, in line with Henderson et al.'s emergent change strategy. The first interview question sought to gather instructor perspectives on active learning as follows:

Interview Question 1: What are your perspectives on active learning?

Specific thoughts on active learning held and shared by two or more of the instructors included the following: (1) reduction of lecture monotony and maintenance of student attention, (2) student enjoyment, (3) enhanced student learning, (4) power and advantage of simple techniques, (5) desire to keep using after realization of the benefits, and 6) interest in, but concern over, use of advanced techniques. Based on these responses, the participating instructors valued the active learning. A sample of responses to interview question 1 is given in Table 6.

The second interview question regarding program impacts was posed as follows:

Interview Question 2: Did this project have an impact on your likelihood to use active learning longer-term in your classrooms, or your likelihood to try new active learning techniques going forward? If so, what aspects of the project impacted this?

Specific program impacts and impactful elements shared by two or more of the instructors included the following: (1) helpfulness and positive reinforcement of classroom observation and feedback, (2) interest in SoTL, (3) community support, (4) confidence, motivation, or enablement to try or expand active learning use, and (5) one-on-one support and

Table 5. Scholarship of Teaching and Learning Activity

		Scholarship of Teaching and Learning & Use of Student Feedback			
Instructor	**Dept/Rank**	**Student Survey (feedback)**	**Student Interviews (feedback)**	**Conference Paper Submitted**	**Proposal Submitted**
1	ECE NTS Asst		√	√	
2	ECE NTS Asst		√	√	√
3	ECE TS Asst				
4	ECE TS Full		√	√	√
5	ECE TS Assoc	Did not participate			
6	IE NTS Asst				
7	IE TS Asst	√			
8	IE TS Asst				
9	IE TS Assoc	Did not participate			

NTS: non-tenure stream. TS: tenure stream or tenured. Asst: Assistant Professor. Assoc: Associate Professor; Full: Full Professor.

Table 6. Sample of Responses to Interview Question 1

(I3) Active learning is useful, and simple techniques can be the most useful. The students like active learning based on my evaluations, and they've told me they want to do programming assignments in class. I would like to try an advanced techniques such as project based learning (PBL), but my concern is will students resist when they are being asked to do something they haven't been specifically "taught"? Maybe with time I will decide to try it.
(I2) At a minimum, some amount of active learning should be integrated into a course. Otherwise, the course is not up to standard. The question in my mind at this point is *How much active learning is optimal*? I am flipping a course right now, and it may be the case that it's optimal to do 100% active learning in a course. With the interaction I have with students during a flipped course, I can tell when they aren't understanding something. I need to talk to and engage with them to really figure this out. The constant feedback loop is good. When I don't have this feedback loop, I often think they are understanding something, when in fact they are not, based on exam scores.

Table 7. Sample of Responses to Interview Question 2

(I1) I would not have had the confidence to flip my class without the support of the community and you. I want to continue to meet and work with you to implement new ideas in my classroom. You have helped me to publish my work with active learning.
(I2) Yes. Although I had been sold on active learning just before this project started, participating in the project showed me there is a larger community around me. This is huge to keep going with active learning. I talk with one of the other participating instructors about best practices in the flipped classroom because he flips his classroom too. Before this project, I didn't know that anyone else was doing active learning, and now I do. I think we need to build a "library" of best practices among more peers.
(I6) Having the one-on-one conversation with you motivated me and provided a concrete step for me to get started with the active learning. The observation and feedback were also very useful, because your feedback helped me to see I was accomplishing something.

conversations. Instructor 2's response in Table 7 demonstrates emergent change by way of development of a shared vision as part of a community of instructors, several of whom are flipping their courses [18]. A sample of responses to interview question 2 is given in Table 7.

3.4 Notable Instructor Cases and Accomplishments

Four of the participating instructors exhibited particularly-noteworthy accomplishments during the project period by virtue of significant development of course materials or significant changes in classroom practices. It was also revealed during the instructor interviews that various program components had contributed to and supported these accomplishments. Two of the instructors (I1 and I2, Table 8) had used simple active learning before the program, and they implemented more advanced techniques (i.e., flipped instruction) during the program period. I1 experienced challenges with flipped instruction during the fall semester, but with *coaching* from the project directors, he was able to overcome these challenges in the spring semester, in part by developing custom videos starting with one course topic. I2 fully flipped one of his courses and implemented extended problem solving (i.e., studio-style) in another course, which was motivated by *observation and subsequent feedback* and encouragement from the project director.

I6 and I7 were first-time users of active-learning, and I6 also experienced the benefits from extended, studio-style class time in the form of better problem solvers. I6 revealed that the *one-on-one conversations* with the project director enabled him to use active learning. I7 has invested (and continues to invest) significant time in the development of virtual reality videos (with the assistance of an undergraduate researcher) for in-class demonstrations.

Table 8. Summary of Notable Instructor Cases

Instructor	Dept/Rank	First Time AL User?	Notable Activities	Impactful Program Component	Benefits Realized
I1	ECE NTS Asst		Overcame challenges w/ flipped instruction; created custom videos	Coaching meeting	Positive student feedback on custom videos
I2	ECE NTS Asst		Full flip of classroom Extended in-class problem solving (studio style)	Observation & subsequent feedback	Perception of energy in the classroom with studio work
I6	IE NTS Asst	Yes	Extended in-class problem solving (studio style) Used Top Hat software to drive whole-class discussion	One-on-one conversation	Better student problem solving skills Broader classroom engagement with Top Hat
I7	IE TS Asst	Yes	Developed & piloted virtual reality demonstration activity Developed student feedback survey & used evidence to make changes to lab module	Use of student feedback	Positive course changes

NTS = non-tenure stream. TS = tenure stream or tenured. Asst = Assistant Professor.

I7's development of a custom student survey and subsequent use of the *feedback* led to positive course changes the following semester. These notable cases of individuals who were positively impacted by particular program components provide motivation to the project directors to continue and expand this emergent-style propagation program as part of future work.

4. Summary and Discussion

In this program to propagate the use of active learning and SoTL in a school of engineering, pilot instructors from two departments were recruited and formally supported in the development and/or use of in-class active learning. Instructors were supported via community discussions, one-on-one coaching, classroom observation, gathering of student perspectives, and formative feedback to the instructor. At the end of the one-year program, the project director followed up in person with each instructor to encourage continued use of active learning and conduct an interview to gather instructor perspectives and drive reflection. The project directors designed this propagation program to be unique, comprehensive, and responsive to calls from the literature. Specifically, instructors were *individually and personally supported* by faculty in their own discipline to ensure implementation of active learning after a workshop by Dr. Michael Prince as well as community-based discussions, as advocated in the literature.

A limitation of this socially-focused approach is the time investment on the part of the instructional coaches. Despite the promise of this approach, the time commitment is a contextual factor that must be understood by those considering adoption of this type of program. A recognized limitation of this particular implementation was the small number of formal community-based interactions among the instructors. Thus, in future work, the project directors will engage the instructors to a greater extent in community-based conversations. The value of the community aspect was evident in the instructor interview data as well.

Going forward, the project directors also plan to be more thorough in individual planning with each instructor, in particular identifying at least one tangible, focused goal of interest to the instructor (e.g., improved teaching evaluation scores), as suggested in the instructional coaching literature discussed previously. Monitoring and evaluation of goal achievement will subsequently occur. Also, additional instructor interview questions will be developed as part of future work, including questions to specifically gather more in-depth instructor perspectives on the "people-focused" aspect of the program and other themes uncovered in the interview data. As a formal next step, an externally-funded expansion of this program has been proposed. This proposal entails a three-year program involving an additional department in the engineering school so as to create a shared vision across more departments.

One of the participating instructors suggested immediately working with new faculty upon their starting semester, such as having them observe the classrooms of the participating instructors, including his own classroom. Thus, sustained propagation may occur via social networks led by the pilot instructors who participated in this program.

5. Conclusions

In considering the valuation aspect of the research question, the participating instructors valued active learning and found this program to be particularly supportive to their adoption, use, and/or future use of active learning, as discussed in their post-program interviews. As supported by the coaching literature, the "people" focus of the project, in particular the one-on-one interactions between the project directors and the instructors as well as the community interactions, were strengths of the program as identified by the instructors in their interviews. However, it should be kept in mind that this was a volunteer program involving instructors who sincerely wanted to initiate or expand their use of active learning. Further considering the research question in relation to instructor participation, seven of the nine original faculty (78%) participated in the program until the end. Classroom observation occurred for six instructors, with each one exhibiting active-learning use to some degree based upon the results of the COPUS observation protocol. Although not observed, the remaining instructor indicated his use of simple active learning in his post-program interview. In addition, three instructors engaged in the scholarship of teaching and learning with the project director during the study period, including the development of three conference papers and two funding proposals related to active learning. For two of these instructors, it was their first ASEE conference paper. One instructor developed a formative-assessment classroom survey, with the project director's direct guidance and support, in order to identify desirable changes for his course. Based on the survey results, he made changes during the following semester, exhibiting evidence of the incorporation of feedback data. Four instructors also exhibited particularly-noteworthy achievements by virtue of significant development of course materials or significant changes in classroom practices. Further-more, the following lines of research will continue between the project directors and several instructors who participated in the program, demonstrating continued participation, achievement, and sustainability of these initial efforts. This ongoing work provides additional evidence of the potential impact of this type of propagation program.

- Instructor I7 (IE) is continuing the development of virtual reality videos for in-class activities in conjunction with the project directors and an undergraduate researcher. He has incorporated these VR activities into the educational plan for his NSF CAREER proposal.
- Instructor I1 (ECE) shared with the project director at the 2019 ASEE conference that he wanted to continue to use new active and interactive techniques and publish the outcomes with her assistance, and this work currently continues.
- Instructor I2 (ECE) received a funding award for use of CAD software for active learning during the project. Work between the project director and this instructor will continue by virtue of this new award. During the interview, the instructor indicated the propagation program influenced and inspired his pursuit of similar funding for active learning.

Based on these results, a subsequent conclusion of this research is that benefits were achieved despite non-ideal levels of instructor participation in all aspects of the program. In reflecting on the program, the project directors further concluded that the program's one-on-one coaching relationships positively impacted instructor participation and their application of active learning, including more complex forms of active learning in the face of challenges. This aligns with the power of social interactions in promoting educational transformation suggested in the STEM change literature discussed previously. The project directors' reflection also aligned with the external evaluator's conclusion after attending a community luncheon that *"Ongoing support provided by the project directors at the learning community and the individual coaching levels was instrumental in the success of faculty adoption of active learning techniques. In particular, faculty found feedback they received after observations to be helpful."*

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Appendix

Table A: Assessment Questions: Student Perspectives on Active Learning

1. In this class, the instructor asks you to complete activities, discuss items, and in general participate. Can you discuss the impact of this instructional style on your learning and development?
2. In this class, the instructor asked you to do some learning on your own outside of class and then come to class prepared for hands-on work. Discuss your thoughts on this instructional method relative to learning and satisfaction.
3. Discuss the use of active learning in this course, where you are asked to do things in class beyond listen to the instructor and take notes.
4. Describe the quality of your engagement or interactions during the class sessions where active learning occurred (i.e., simulation and design techniques) versus during the sessions when lecture occurred.
5. What experiences (if any) from the virtual reality activity were particularly impactful for your learning or engagement?

Table B: Pre-Program Assessment Survey

Question	Response Options or Type
Q1. What is your motivation for wanting to use Active Learning in your classroom?	Open ended
Q2. Which of the following barriers do you perceive or concerns do you have in the use of active learning, including from simple to more-involved active learning that you would consider using? (select all that apply)	☐ Ability to cover necessary content ☐ Classroom seating arrangement ☐ Instructor preparation time ☐ Lack of student response or acceptance; students unwilling to participate ☐ Out-of-control conditions in classroom ☐ Others (please list) ________________
Q3. Have you attended any workshops that covered active learning?	☐ Yes (Approx. how many?) __________ ☐ No
Q4. Have you used active learning previously in your courses, or are you currently using it?	☐ Yes ☐ No
Q4.1. For approximately how many years have you used active learning?	Open ended
Q4.2. In approximately how many courses have you used active learning?	Open ended
Q4.3. Please list the course numbers or names (in which you have used active learning).	Open ended
Q4.4. Which active learning techniques have you used in the past during class? (select all that apply) Note: Do *not* include active work during exams. Some techniques below may overlap.	☐ Minute papers (e.g., muddy points, most important items learned, etc.) ☐ Stopped lecture to allow students to review lecture notes & ask questions ☐ Think-Pair-Share (i.e., individual thought, paired discussion/work, & share out) ☐ Individual problem solving or calculations ☐ Group brainstorming, problem solving, or calculations ☐ Pair programming or other paired software use ☐ Individual programming or other individual-based software use ☐ Predict-Observe-Explain ☐ Others (please list) ______
Q5. Is there a new active learning technique you would like to use in the next semester or two?	☐ Yes (but not sure which one) ☐ Yes, I would like to try: (please list) ______ ☐ No
Q6. Have you ever flipped a course or a portion of a course (i.e., a subset of lectures)?	☐ Yes ☐ No
Q7. Have you ever used problem-based learning in a course?	☐ Yes ☐ No
Q8. How can we assist you in using or enhancing you use of active learning? For example, do you have goals we can assist you with?	Open-ended
Q9. Which course would you like to target in the fall or spring to use new or additional active learning in?	Open-ended

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