Creating and Scaling an Evidence-based Faculty Development Program

Dr. Casey Jane Ankeny, Northwestern University

Casey J. Ankeny, PhD is an Assistant Professor of Instruction at Northwestern University. Casey received her bachelor's degree in Biomedical Engineering from the University of Virginia in 2006 and her doctorate degree in Biomedical Engineering from Georgia Institute of Technology and Emory University in 2012 where she studied the role of shear stress in aortic valve disease. Currently, she is investigating cyber-based student engagement strategies in flipped and traditional biomedical engineering courses. She aspires to understand and improve student attitude, achievement, and persistence in student-centered courses.

Mrs. Lindy Hamilton Mayled, Arizona State University

Lindy Hamilton Mayled is a PhD candidate at Grand Canyon University. She is pursuing her PhD in Psychology of Learning, Education, and Technology. Her background in in K-12 education where she has served as a high school science teacher, Instructional and Curriculum Coach, and Assistant Principal. Her research and areas of interest are in improving STEM educational outcomes for Low-SES students through the integration of active learning and technology-enabled frequent feedback. She currently works as the Project Manager for the NSF faculty development program based on evidence-based teaching practices.

Lydia Ross, Arizona State University

Lydia Ross is a doctoral candidate and graduate research assistant at Arizona State University. She is a third year student in the Educational Policy and Evaluation program. Her research interests focus on higher education equity and access, particularly within STEM.

Dr. Keith D. Hjelmstad, Arizona State University

Keith D. Hjelmstad is Professor of Civil Engineering in the School of Sustainable Engineering and the Built Environment at Arizona State University.

Prof. Stephen J. Krause, Arizona State University

Stephen Krause is professor in the Materials Science Program in the Fulton Schools of Engineering at Arizona State University. He teaches in the areas of introductory materials engineering, polymers and composites, and capstone design. His research interests include faculty development, evaluating conceptual knowledge change, misconceptions, and technologies to promote conceptual change. He has co-developed a Materials Concept Inventory and a Chemistry Concept Inventory for assessing conceptual knowledge and change for introductory materials science and chemistry classes. He is currently conducting research on a large scale NSF faculty development project. His team is studying how workshops on strategies of engagement and feedback with support from internet tools and resources affect faculty beliefs, classroom practice, and development of disciplinary communities of practice and associated student achievement. He was a coauthor for the best paper award in the Journal of Engineering Education in 2013 and this year has received the Michael Ashby Outstanding Materials Educator Award from the Materials Division of ASEE.

Prof. James A. Middleton, Arizona State University

James A. Middleton is Professor of Mechanical and Aerospace Engineering and Director of the Center for Research on Education in Science, Mathematics, Engineering, and Technology at Arizona State University. For the last three years he also held the Elmhurst Energy Chair in STEM education at the University of Birmingham in the UK. Previously, Dr. Middleton was Associate Dean for Research in the Mary Lou Fulton College of Education at Arizona State University, and Director of the Division of Curriculum and Instruction. He received his Ph.D. in Educational Psychology from the University of Wisconsin-Madison in 1992, where he also served in the National Center for Research on Mathematical Sciences Education as a postdoctoral scholar.

Prof. Robert J. Culbertson, Arizona State University

Robert J. Culbertson is an Associate Professor of Physics. Currently, he teaches introductory mechanics and electrodynamics for physics majors and a course in musical acoustics, which was specifically designed for elementary education majors. He is director of the ASU Physics Teacher Education Coalition (PhysTEC) Project, which strives to produce more and better high school physics teachers. He is also director of Master of Natural Science degree program, a graduate program designed for in-service science teachers. He works on improving persistence of students in STEM majors, especially under-prepared students and students from under-represented groups.

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Abstract

     This evidence-based practice paper will explore a successful faculty development program. For more effective teaching and learning in undergraduate engineering education, there is a strong need for evidence-based faculty professional development to shift from instructor-centered teaching to student-centered, active learning, which is more effective [1]. The NSF's Improving Undergraduate STEM Education (IUSE) program funded a large-scale faculty development program at a large, public university which uses a train-the-trainer approach, similar to Pimmel, et al., to engage faculty in a year-long modeling program with a semester of eight biweekly workshops, followed by a semester of six biweekly Community of Practice innovation discussions.

     Here, we describe the creation, scaling, and evaluation of this evidence-based faculty development program. More specifically, we outline the benefits and barriers to faculty development; structure and management; strategies, topics, and materials; assessment; and lessons learned and takeaways.

     In the "benefits and barriers" component, the foundational research by Prince, Freeman, Smith, and others in the area of engagement and active learning is explored as well as how the represented university addressed barriers to implementation. The "structure and management", section provides a program overview in more detail, including recruitment, organization, and workshop and community of practice structure. The "strategies, topics, and materials" component describes the project's models of change, including Rogers' model of Diffusion of Innovation and Coburn's model of sustainable innovation scaling. Links to all workshop materials on topics such as learning objectives, Bloom's taxonomy, interactive classes, implementing active learning, cooperative learning, student motivation, and inclusive learning environments are included. The "assessment" section provides an overview of how the faculty development program was evaluated. Specifically, the instruments and the outcomes from the instruments are explored. Key lessons learned from the project as well as important points about support and sustainability are highlighted.

     In summary, this paper outlines not only evidence-based strategies for the classroom but the structure, implementation, scaling, and evaluation of a faculty development program based on lessons learned from a successful, large-scale example.

Introduction

This evidence-based practices paper outlines a successful NSF IUSE (Improving Undergraduate STEM Education) program geared toward providing large-scale faculty development called Just-in-Time Teaching with Two Way Formative Feedback for Multiple Disciplinary (JTFD) Programs. Further, it is scaled from a single-disciplinary program called Just-in-Time Teaching with Two Way Formative Feedback (JTF) which resulted in high student performance and persistence across four institutions [2]. This work responds to the need for evidence-based faculty development to encourage the shift from teacher-centered instruction to student-centered active learning which has been shown to be more effective [1,3].

Presentation of this work will include delivery of key information in the following areas: (1) foundational research to support program structure including two change models (Rogers' Diffusion of Innovation and Coburn's sustainable innovation scaling), (2) benefits and barriers that were identified and addressed throughout the program, (3) the structure and management of the program, (4) evidence-based strategies, topics, and materials, and (5) assessment.

Program Foundation

This faculty development program is based on two change models: Rogers' model of Diffusion of Innovation (DOI) which occurs on the individual level [4] and Coburn's model of sustainable innovation scaling which occurs at the organizational level [5]. Wenger et al.'s, model of Community of Practice was implemented as to encourage the sustainability of innovation central to Coburn's model [6].

Briefly, Rogers outlines a model of personal adoption of innovation which includes five aspects. First is knowledge or awareness where there is exposure to innovation. In our faculty development program, this occurs during the workshops. Secondly, to adopt innovation, one must exhibit a growing interest. Next, the individual must either accept or reject the innovation followed by the implementation or trial phase where the innovation is tested. Lastly, the innovation is sustained through the confirmation or adoption phase. The second through fifth aspects were exhibited throughout the program and captured through assessment as discussed in the assessment section of this paper.

Further, this program embodies the three aspects of Coburn's model of sustainable innovation scaling: depth, sustainability/spread, and shift of innovation [5]. "Depth" refers to the deep change exhibited in faculty beliefs and practices. "Sustainability of innovation" refers to the change in beliefs, norms, and principles of individuals across an organization. Lastly, "shift of ownership" refers to the change of ownership from external facilitators to individuals within the organization. Our faculty development program allows for faculty beliefs to change at a deep level though repeated exposure and interaction with evidence-based practices as well as implementation of these practices in the participants' classrooms. The innovation has proven to be adaptable to seven different contexts supporting sustainability of these student-centered strategies. We have spread the innovation throughout the engineering schools by reaching seven

disciplines and approximately 84 faculty members who engage in teaching once per semester. Moreover, we have seen a shift of ownership from the project team across our organization. Assessments discussed later in this paper support this projects ability to scale innovative teaching and learning practices according to these two models of change. Lastly, the communities of practice, as suggested by Wenger et al. [6] been structured around the following three elements: 1) a domain of knowledge given by a set of issues (in this case, student-centered, active learning), 2) a community of people who care about this domain, and 3) the shared practice in which community members are engaged in learning and improving their domain.

Benefits and Barriers

Throughout the implementation of this faculty development program, the study team has addressed several barriers and benefits to implementation. Common barriers to implementation include time limitations, lack of support, and lack of incentive. In order to address, time limitations we have offered simple, time effective strategies as outlined in program materials (https://drive.google.com/drive/folders/0B4Bzw8pheq_YODJXSUFNWUNXNFE). Communities of practice as well as the study team offer support. Also, department chairs were approached during the recruitment phase so that departmental buy-in would be in place. Lastly, to encourage participation, the study team drafted a letter outlining the professional development program certifications to be included in promotion and tenure packages. Further, participants were given a small monetary award for their participation. Solutions to barriers to implementation actually became benefits for participants. Participants were being recognized for their commitment to teaching and developed the necessary support for implementing evidence-based practices in the classroom.

Structure and Management

There are several key aspects to consider in terms of project structure and management including: organization, recruitment, and workshop and community of practice structure. In our project, we use the train-the-trainer model [7] where disciplinary leaders pairs where trained in two cohorts in the following areas were trained by project leaders: Cohort 1 [Aerospace Engineering (AE), Mechanical Engineering (ME), Civil Engineering (CE), and Construction Engineering (Con)] and Cohort 2 [Biomedical Engineering (BIO), Chemical Engineering (CHE) and Material Science and Engineering (MSE)]. As shown in Figure 1 below, disciplinary leader pairs in Cohort 1 were trained during Year 1 and followed through Year 2. During Year 2, the disciplinary leaders then trained 8 to 12 of their colleagues. Lastly, during Year 2, the process was repeated for Cohort 2.

Recruitment of disciplinary leaders and disciplinary groups was facilitated at a departmental level. Letters outlining the program organization, topics, time commitment, and benefits of participating were sent by departmental directors during the recruitment process. In order to encourage involvement, participants received small monetary compensation as well as a letter outlining significant professional development by participating in the program that could be included in promotion and tenure packets.

During the training process, disciplinary groups participated first in a series of workshops followed by a semester of guided discussions or communities of practice. There were eight workshops over the first quarter covering the following topics: 1) Program Introduction, 2) Introduction to Active Learning and Disciplinary Communities of Practice, 3) Bloom's Taxonomy and Writing Effective Learning Objectives, 4) Engagement I: Making Class Sessions More Interactive, 5) Engagement II: Implementing Active Learning, 6) Engagement III: Cooperative Learning – Structure Teams, Motivation and Learning, 7) Promoting Inclusive Practices in the Classroom, and 8) Muddiest Points and Other Tech Tools: Facilitating Innovation. Workshops were held every other week, lasted approximately one hour and were highly interactive. Interactions included breakout sessions with report-outs. Key preparation materials were disseminated via a Blackboard site to all participants.

	Cohort 1 Tier 1 Disciplinary Leader Pairs (DLPs): AE, CHE, ME, CON	Cohort 1 Tier 2 Disciplinary Faculty Groups (DFGs): AE, CHE, ME, CON	Cohort 2 Tier 1 Disciplinary Leader Pairs (DLPs): BIO, CHE, MSE	Cohort 2 Tier 2 Disciplinary Faculty Groups (DFGs): BIO, CHE, MSE
Year 1 F15-Sp16	Trained by Project Leaders & Classroom Implementation			
Year 2 F16-Sp17	Continued Assessment of DLP Faculty Classroom Practice	Trained by Disciplinary Leader Pairs & Classroom Implementation	Trained by Project Leaders & Classroom Implementation	
Year 3 F17-Sp18		Continued Assessment of DFG Faculty Classroom Practice	Continued Assessment of DLP Faculty Classroom Practice	Trained by Disciplinary Leader Pairs & Classroom Implementation
Year 4 F18-Sp19				Continued Assessment of DFG Faculty Classroom Practice

Figure 1: Implementation Timeline

The communities of practice covered similar topics, including "Opportunities and Issues in Implementation of Bloom's Taxonomy and Active Learning", "Assessing Student-Centered Learning vs. Instructor-Centered Teaching", "Implementation of Tech Tools and Impact of Summative and Formative Assessment", "Discussion of Observations of Active Learning Classrooms of Project Leaders", "Implementation of Cooperative Learning and Motivation", and "Implementation Wrap-up of Faculty Beliefs, Instructor Role in Classroom, & Value of Community of Practices". Disciplinary pair leaders served as moderators for a group discussion among disciplinary groups.

Strategies, Topics, and Materials

Here, we highlight the specific evidence-based strategies, topics, and materials provided in the workshops. During the "Introduction to Active Learning and Disciplinary Communities of Practice" workshop, participants learn about Eric Mazur's work in this space [8] as well as work with Chickering's "7 Principles for Good Practice" [9]. In an activity, participants are asked to select one or two principles and discuss how they would implement them in the classroom as well as discuss challenges associated with the seven principles: 1) encourage interaction between students and faculty, 2) develop engagement and cooperation among students, 3) encourage student reflection during active learning, 4) give prompt feedback, 5) effectively manage student's time on task, 6) communicate high expectations, and 7) respect students diverse talents and ways of learning. Other topics in this workshop include aligning learning goals with instruction and an overview of active learning.

In "Bloom's Taxonomy and Writing Effective Learning Objectives", participants learn how to write measurable and clear learning objectives using Bloom's Taxonomy. In the activity associated with this workshop, the participants work in a group to write learning objectives for their course, report out to the entire group, and then have a short discussion about implementing learning objectives in the classroom.

In "Engagement I: Making Class Sessions More Interactive" and "Engagement II: Implementing Active Learning, participants learn about key features of pedagogies of engagement: active, collaborative, cooperative learning and problem-based learning. Participants also explore the rationale for using them. Moreover, participants learn to use evidenced-based active learning strategies in their own classroom. Through break-out sessions, create an active learning exercise and share and receive feedback from other participants. Participants will also will learn about issues associated with active learning in the classroom and learn how to resolve them.

In "Engagement III: Cooperative Learning – Structure Teams, Motivation and Learning", participants learn about the structure of cooperative learning including: positive interdependence, individual accountability, group processing, social collaboration or teamwork. They also learn the benefits and issues related to cooperative learning as well as the benefits and issues related to problem-based learning. Lastly, the principles of evidence-based motivation research will be described and participants will learn to evaluate student behavior issues on attitude and learning with respect to motivation theory and classroom practice. They will develop strategies to address student attitude issues and enhance motivation in courses, classes, and activities. Further, participants will learn to evaluate issues and effectiveness of implementation of motivation strategies and activities in their classes.

In "Promoting Inclusive Practices in the Classroom", participants learn about why course climate is important in teaching, identify and address microaggressions, identify and implement inclusive strategies for: classroom environment, teaching behaviors, and assessment strategies. Participants also are exposed to student interview clips and work together in groups to discuss

the challenges of identifying inclusive needs and the challenges of facilitating inclusive classroom practices.

Lastly, in "Muddiest Points and Other Tech Tools: Facilitating Innovation", participants learn about formative and summative feedback and their effectiveness as well as how to use various tech tools for instruction. Participant work in groups to discuss how to implement tech tools in their classroom and report out to the group using tools demonstrated during the session.

Following the semester of workshops, disciplinary groups meet every other week to follow-up on these topics. Question prompts are provided to help focus the conversations and are available for use through the grant repository: https://drive.google.com/drive/folders/0B4Bzw8pheq_YODJXSUFNWUNXNFE.

Assessment

As mentioned in the introduction, Rogers' Diffusion of Innovation (DOI) and Coburn's sustainable innovation scaling (SIS) are the cornerstones of this faculty development program and therefore we aligned our assessment with aspects inherent to both DOI and SIS. Key assessments include pre-post measurements of the participants with surveys, questions, and class observations. Here, we summarize our assessment methods. More detailed information may be found at the following website: https://drive.google.com/drive/folders/0B4Bzw8pheq_YODJXSUFNWUNXNFE. Briefly, we are using a number of evaluation methods and surveys including:

- Education Research Awareness Survey
- Social Network Survey (*in progress*)
- Short Answer Classroom Practices Survey
- Value, Expectancy, and Cost of Testing Educational Reforms Survey (VECTERS)
- Classroom Observations: Reformed Teaching Observational Protocol (RTOP)
- Feedback from Community of Practice Sessions

The Education Research Awareness Survey asked participants to rate their awareness of the areas below as: "*very unfamiliar", "a little unfamiliar", "a little familiar", "very familiar*":

- Instructional design
- Research on how people learn
- Research on active learning
- Use of student teams
- Research on student motivation
- Learning objectives
- Bloom's Taxonomy
- Professional learning communities

To assess changes in faculty on the awareness survey, we first combined the Likert-scale items into two categories: "unfamiliar" and "familiar". Changes in awareness were then tested using paired samples t-tests for each of the items. For ease of interpretation, these shifts in

numbers were then calculated as percentages changed. (Significance tests are from the original t-tests). As shown in Figure 2, there was a statistically significant increase in awareness in 11 of the 13 survey items. More specifically, there was a statistically significant increase in the "a little familiar" and "very familiar" ratings. Most notably were increases in awareness about student motivation (+51.3%) and professional communities of practice (+43.3%).

Awareness Area	% of Participants in Top Two Likert-Scale Items Pre	% of Participants in Top Two Likert-Scale Items Post	Change in %
Research on Effective Teaching	63.0	92.3	29.3*
Research on Instructional Design	33.3	69.2	35.9*
Research on How People Learn	55.6	84.6	29.0*
Research on Active Learning	55.6	88.5	32.9*
Research on Student Teams	70.4	92.3	21.9*
Research on Student Motivation	33.3	84.6	51.3*
Research on Learning Objectives	88.9	96.2	7.3
Research on Bloom's Taxonomy	70.4	96.2	25.8*
Research on Professional Learning Communities	25.9	69.2	43.3*
Use of Cooperative Learning	51.9	88.5	36.6*
Use of Active Learning	63.0	84.6	21.6*
Use of Objectives	77.8	88.5	10.7
Use of Bloom's Taxonomy	48.1	84.6	36.5*

**Statistically significant at the .05 level

Figure 2: Education Research Awareness Data: The above table shows the percentage of participants that rate awareness in the areas as either "a little familiar" or "very familiar" before (pre) or after (post) faculty development (n=26).

We also analyzed use of particular strategies and tools before (prior to the Fall semester) and after (immediately following Spring semester) faculty development through the use of short answer questions regarding classroom practices. To measure these changes, the open-ended responses of participants were coded for use of tool of technology. Simple counts were performed to create descriptive statistics for each tool/strategy that participants reported using. Figure 3 shows an increase in the number of participants using strategies after faculty development. Most notable are increases in active learning (+333%) and writing learning objectives (+200%). We also saw a 38% decrease in lecture as a result of faculty development. In terms of tools as shown in Figure 4, we saw an increase in video use and a decrease in PowerPoint use. Moreover, participants added to our list of technology tools demonstrating two-way learning. As an aside, four participants mentioned specifically that they used technology as a way to implement active learning.
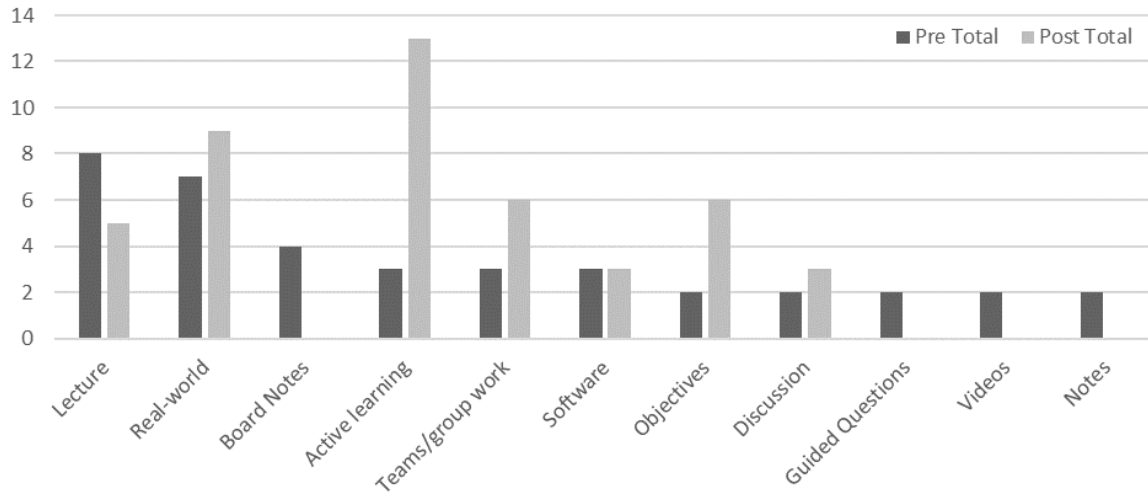
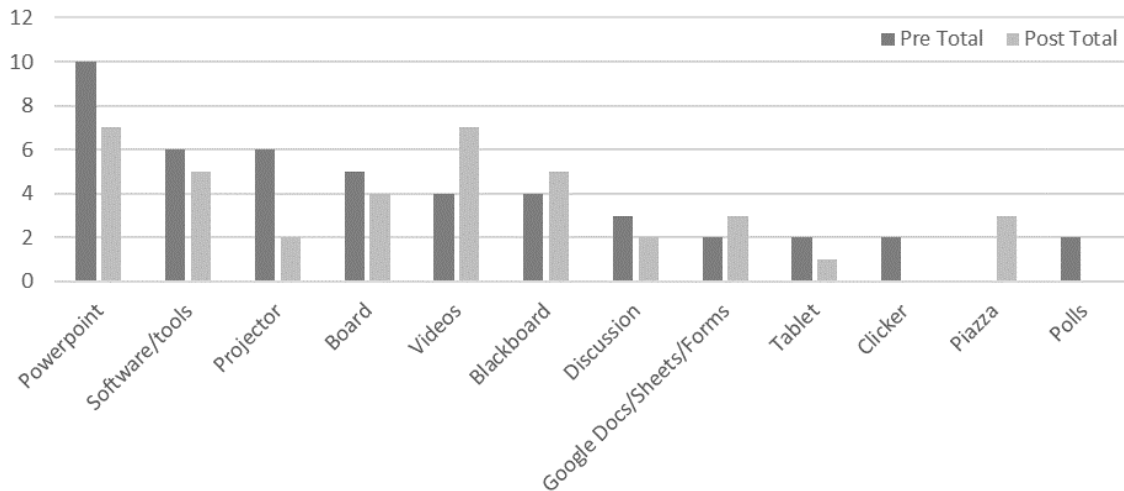**Figure 3: Count of Participants using Strategies before and after Faculty Development**

Figure 4: Tech Tools used by Participants before and after Faculty Development

We also implemented a survey centered on the expectancy/value theory of faculty motivation to implement class innovations. The VECTERS (Value, Expectancy, and Cost of Testing Educational Reforms) survey measures faculty level of use and dispositions toward integrating (1) real-world applications, (2) formative feedback, and (3) student-to-student classroom discussions. Participants answered on a scale of one to four where one means "not at all" and four means "entirely". Participants were asked the extent to which you use this strategy/tool in this current classroom routine as compared to their anticipated future use.

Moreover, they were surveyed before and after the faculty development program. Overall scores for each construct (expectancy, value, and cost) were computed for each of the three strategies: real-world applications, student-to-student discussions, and formative feedback. Changes in these constructs were measured using paired samples t-tests. Additionally, the same statistical technique was applied to measure the change in current and planned future use of each of the three strategies, which was reported as a single item question on a four-point Likert scale from the participants. These changes were then calculated as percentage changes for ease of interpretation. As shown in Figure 5, there were statistically significant increases in expectancy (or faculty expectations of successful implementation) and value with respect to implementing real-world applications in the classroom as well as statistically significant decrease in the cost related when comparing responses prior to and after faculty development. Moreover, there was a 12% increase in current use of real-world applications and a 15% increase in planned use after the faculty development program.

	Real-World Applications	Student to Student Discussions	Formative Feedback
Expectancy	+8%*	+4%	+8%*
Value	+8%*	+5%	+8%*
Cost	-13%*	-7%	-7%
Reported Use	+12%*	+4%	+4%
Planned Future Use	+15%*	+4%	+2%

*Significant at the .05 level

Figure 5: VECTERS Results: There are statistically significant increases in expectancy and value percentages for implementation of real-world applications and formative feedback as well as a decrease in "cost" for implementing real-world applications after the faculty development program. There is a statistically significant increase in both reported and planned future use of real-world applications.

Participants' classrooms were observed at three points during the faculty development program: prior to workshops, after the workshops, and then during the communities of practice. The protocol used for observation was the Reformed Teaching Observational Protocol (RTOP) [10] which is a measure of faculty implementation of student-centered behaviors in their own classroom practice. The RTOP scales ranges from 0 (highly instructor-centered teaching) to 100 (highly student-centered teaching). As shown in Figure 6, there was a statistically significant increase in student-centered teaching throughout the faculty development program. More specifically, there was an increase of 5% from the start of the program to the end of the workshops and a 16% increase from the end of the workshops to the end of the communities of practice, overall signifying an increase of 22% throughout the program.

	Fall 2016 (pre)	**Early Spring 2017 (mid)**	**Late Spring 2017 (post)**
Minimum	31.00	34.50	42.50
Lower Quartile	45.63	47.13	60.00
Mean	56.34	59.23	68.84
Upper Quartile	65.13	67.75	79.00
Maximum	88.50	95.00	89.00

Note: Total RTOP score is out of 100 points, n=26.

Percent Change in Average RTOP Scores

Pre to Mid	**Mid to Post**	**Pre to Post**
5%*	16%*	22%*

*Statistically significant at the .05 level

Figure 6: RTOP Results: Results from 26 participants show a statistically significant increase in student-centeredness through the faculty development program. "Pre" refers to prior to faculty development, "mid" refers to after the workshops, and "post" refers to after the communities of practice.

Assessment of the communities of practice through surveys demonstrate favorable outcomes. For instance, 100% of faculty agreed that the tools, strategies, and interactions in the JTFD project would be of value to their future instructional practice and career success. 96% of faculty agreed that the JTFD project has been successful in creating Communities of Practice which support innovation, implementation, and open dialogue between colleagues. 96% of faculty agreed that discussions and community-building with other faculty is valuable. 94% of faculty agreed that the implementation of the six discussion sessions gave them the opportunity to interact with faculty they would not otherwise experience. Moreover, faculty showed interest in continuing their communities of practice and suggested ways to sustain them captured in the following quotes:

- "Communicate with my colleagues in the CoP [Communities of Practice] and in the new faculty committee."

- "Talk to other faculty. Get involved in curriculum design units"

- "To continue to talk about teaching experiences and ideas with my colleagues."

Lastly, participation in the program overall as well as participant opinion of the program in general was high. More specifically, for Cohort 1, 43 faculty from four disciplines participated in eight workshops and six implementation community of practice discussion sessions with an attendance of 80% in Fall and 73% in Spring. There was 100% completion (with exception of two paternity leaves and one promotion). Faculty experienced a change in their teaching and learning beliefs. For example, participants viewed themselves "as more of a motivator than an orator" and "more of a facilitator and a communicator."

The results presented above support successful implementation of Rogers' Diffusion of Innovation (DOI) based on adoption of innovation on an individual level and Coburn's sustainable innovation scaling based on change at the organizational level. Complete analysis of these change models and this faculty development program has been completed by Krause, et al. [11]. In brief, the work above supports the five stages of DOI: awareness, interest, evaluation, trial, and adoption. In terms of "awareness", we saw a 31% increase in evidence-based instructional strategies as a result of this program. In terms of "interest" and "evaluation", we assessed through the VECTERS survey a 4% to 12% gain in motivation to implement three evidence-based instructional strategies (EBIS): real-world applications, student-to-student discussions, and formative feedback. In terms of "trial", 91% of faculty "agreed" or "strongly agreed" that the program provided them with new ideas for implementation of EBIS. Lastly, participants exhibited "adoption" as observed through class observation with the Reformed Teaching Observation Protocol (RTOP). The number of EBIS increased 22%.

With respect to SIS, we uncovered evidence of increased depth (deep change in faculty beliefs or practices), increased sustainability of innovation or changes in the norms across the organization, as well as a shift of ownership from external facilitators to individuals within the organization. More specifically, with respect to "depth", we saw a 26% increase in faculty use of EBIS. In terms of "sustainability of innovation", we found that 96% of faculty participants agreed that the program had resulted in the successful development of communities of practice which support innovation, implementation, and open dialogue. We also saw a shift of ownership to the individual in that 100% of the participants "agreed" or "strongly agreed" that the tools, strategies, and interactions acquired through this faculty development program will be of use in future instruction and aid in career success.

Conclusion

This work outlines a successful professional development program which uses the train-the-trainer delivery platform based on Rogers' Diffusion of Innovation (DOI) and Coburn's sustainable innovation scaling (SIS). Further, our assessment supported all five stages of DOI as well as the three aspects of SIS. The outlook of the project is very positive as captured by the extensive program assessment and the overall structure and characteristics of the program have the potential to transfer to other institutions.

Acknowledgment

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