Impact of an Embedded Expert Model on Course Transformation in Engineering

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Introduction and Background

The need to improve undergraduate STEM (Science, Technology, Engineering, and Math) education is widely recognized [1, 2]. Concerns about the quality of STEM education have been fueled by high levels of attrition in STEM majors, particularly among women and students from underrepresented minority groups, as well as the need for a more scientifically literate citizenry. There is now a substantial literature on teaching practices that can improve student learning and academic success and close long-standing achievement gaps in STEM courses (e.g., [1, 3, 4]). Nonetheless, actual adoption of these practices among university instructors has been quite slow [5, 6].

In this paper, we describe the methods and results of a multi-faceted intervention designed to foster widespread adoption of empirically validated instructional methods in Engineering. The intervention was part of a broader initiative at the University of Kansas (KU) to reform foundational undergraduate courses around evidence-based, student-centered teaching methods. The redesign of foundational courses has been a key part of the institutional vision as articulated in a 2011 strategic plan. To that end, the university invested in a program that is an adaptation of a successful initiative, the Science Education Initiative (SEI), implemented at the University of British Columbia and at the University of Colorado Boulder [7, 8]. The core of the SEI model is to embed discipline-based teaching experts (e.g, specially prepared postdoctoral teaching fellows) in academic departments to collaborate with faculty colleagues on course transformation. The SEI was quite effective in producing sustained change in faculty use of evidence-based teaching methods [8, 9] but involved a level of investment that may not be feasible at all institutions (e.g., multiple experts per department over a period of five to nine years). The approach developed at this institution involves a smaller infusion of expertise and resources than the SEI (i.e., fewer experts per department over shorter durations), and amplifies the impact of the experts by building intellectual communities around course transformation at multiple levels.

The University of Kansas launched its adaptation of the embedded expert model in the 2013-2014 academic year, beginning in the College of Liberal Arts and Sciences (CLAS) and expanding in 2014-2015 into the School of Engineering. The embedded experts are postdoctoral scholars with Ph.D.'s in the discipline that are hired by a unit (department or school) for three years to collaborate with faculty members on the incorporation of student-centered, active and collaborative teaching practices into four-to-five undergraduate courses. To date we have had Postdoctoral Teaching Fellows (PDTFs) in seven departments in the College of Liberal Arts and Sciences, and in the School of Engineering. Most PDTFs did not have extensive training in pedagogical innovation prior to their positions. Thus, the institution's Center for Teaching Excellence (CTE) created the Teaching Scholarship Collaborative to provide pedagogical training, professional development, and an intellectual community for the Teaching Fellows, modeled after the SEI program. To support change with fewer resources and embedded experts than the SEI, the KU Course Transformation Initiative also focuses on building intellectual communities of scholars around course transformation within and across departments. Department-level communities include course teams that collaborate on learning goals and transformation strategies, and faculty teaching working/reading groups. CTE hosts a university-wide consortium on course transformation (C21) that engages faculty members, the PDTFs, course design and technology specialists, graduate students, and undergraduate students, all of whom bring different knowledge, experiences and perspectives to the course transformation process. Beginning in Fall 2015, a five-year IUSE grant from the National Science Foundation enabled further enhancement of the initiative and support for the PDTFs through course transformation mini-grants, the hire of a program coordinator, and the expansion of the intellectual community to a network of seven US and Canadian institutions called TRESTLE. The TRESTLE network includes the two institutions that developed the original SEI model and convenes a course transformation institute each year as well as a series of online colloquia and conversations across the year and offers course transformation models and resources on its website (https://trestlenetwork.ku.edu/).

School of Engineering Context

The School of Engineering encompasses 6 departments: Aerospace Engineering (AE), Civil, Environmental, & Architectural Engineering (CEAE), Chemical & Petroleum Engineering (C&PE), Electrical Engineering & Computer Science (EECS), Engineering Physics (EPHSX), and Mechanical Engineering (ME). The School is home to approximately 130 tenure-track faculty and 2500 undergraduate students. In 2014, the School of Engineering created the *Engaged Learning Initiative (ELI)*, to support and encourage shifts in teaching practices across the School, with broad goals of improving student learning, retention, and progression. When we say "shifts in teaching practices," this refers to increased adoption of active learning pedagogies and student centered, evidence-based techniques. The ELI has included a number of approaches to encourage such pedagogical shifts, including: the design and construction of six state-of-the-art active learning classrooms, completed in fall 2015; a series of financial incentives accessible to faculty through a request for proposals mechanism; development of an undergraduate teaching fellows (UGTF) program to support courses implementing significant active learning experiences [10]; implementation of curricular peer mentoring and hiring of a Postdoctoral Teaching Fellow into the School of Engineering to serve as an embedded expert. While these interventions are all highly synergistic with each other and with broader university-level interventions, the introduction of a Postdoctoral Teaching Fellow in the School of Engineering served as a keystone to the Engaged Learning Initiative.

The first engineering Postdoctoral Teaching Fellow was present in the school from August 2014 – May 2015 (PDTF A), and the second from August 2016 - present (PDTF B). Both PDTFs were hired through an open external search process, with the explicit goal that the person in the position would serve as a change agent. Therefore, this role was conceived to be very different from one of instructional development staff or of discipline-based educational researcher (DBERer). Coincidentally, both PDTFs had disciplinary backgrounds in mechanical engineering, although the position was open to applicants from any engineering (or closely related) discipline.

Implementation of the postdoctoral teaching fellow program in the School of Engineering had some interesting aspects that were different from implementations in other units across campus. One PDTF was employed in the School of Engineering at a given time, therefore, that PDTF was responsible for collaborating with 6 Departments rather than one unit. Also, in contrast with implementations in other units on campus, course transformation efforts were not predetermined before hiring of the PDTF, but were encouraged to occur organically based on instructor willingness and interest. In addition to responsibilities associated with collaborating with faculty on course transformations, the engineering PDTF also played a significant role in implementing and assessing the School's UGTF program and in the development and teaching of a graduate course on engineering education.

Importantly, it was made a priority by both ELI and University leadership to ensure that the engineering PDTF was well-connected to the broader university initiatives and support structures around course transformation. The engineering PDTF was a regular participant in the university-level C21 course transformation community, as well as in cross-discipline working groups, such as the Teaching Scholarship Collaborative and others.

Details of PDTF Role

The PDTF role in the School of Engineering was one of change agent. To this end, the PDTF worked on a series of change initiatives, or "fronts." Consistent with the university-wide embedded expert program, the primary front was course transformation collaborations: working one-on-one with instructors to reshape course designs to be student-centered and based on evidence-based teaching practices. In addition, the PDTF worked on three fronts that were more specific to the engineering model. These fronts were: encouragement and support of teaching innovation and scholarship; supporting implementation of student-centered teaching practices through support of the engineering undergraduate teaching fellows (UGTF) program; and development of local community around course transformation and best practices in teaching.

Course Transformation Collaborations

The cornerstone of the PDTF role was one-on-one collaboration with faculty on course transformations. By "course transformation," we mean the process of changing the design and implementation of an existing course to adopt some basic best teaching practices, including careful alignment between learning goals, course content/activities, and assessments, and reducing time spent lecturing in favor of class time spent on activities and student problem-solving/design.

The PDTF was involved in a variety of course transformation efforts across the majority of the engineering departments in the School. Some engineering faculty were already working to transform their courses when the PDTF became involved; other faculty only began this work with PDTF encouragement and involvement. We describe the courses that the PDTFs were involved with both in terms of number, and also in terms of the level of support - as either "high" involvement or "consultant" involvement from the PDTF. High involvement included PDTF collaboration on courses that lasted at least a full semester, included regular meetings with the instructor, and some documentation of learning outcomes. Three specific course transformation collaborations will be described here: *CE 301: Statics & Dynamics*, *ME 320: Dynamics*, and *EECS 140: Digital Logic Design*.

PDTF A collaborated with the instructor of *CE 301: Statics and Dynamics*, to move from a traditional lecture-based format to include active and cooperative learning. *CE 301: Statics and Dynamics* is a 5-credit entry-level mechanics course for civil, environmental, architectural, petroleum, and aerospace engineering students and is taken by sophomores and juniors. Typically there are 80-120 students enrolled. This class is a stepping stone for most engineering disciplines that includes classic problems on equilibrium, analysis of structures, analysis of how bodies accelerate and react to forces, problems on conservation of energy, momentum, and many other relevant concepts. This course transformation focused on engaging students both inside and outside of the classroom by incorporating elements of a flipped class and allotting dedicated in-class time for daily group activities. Additionally, a hands-on group project in which students designed, built, and tested a popsicle stick bridge was implemented in this course offering. The course transformation also included implementation and analysis of exam wrappers.

PDTF B collaborated with instructors on *ME 320*, a junior-level Dynamics course and *EECS 140*, a freshman-level Digital Logic Design course. For the Dynamics course, the PDTF worked with an experienced professor who had been incorporating active learning for several years. He had just shifted to using Team-based learning (TBL) [11], and the majority of the collaboration involved analyzing student learning data to understand the impact of TBL on student learning. A smaller part of the collaboration focused on the development of a "non-disposable assignment," something that the students would work on that would live on beyond the time they turned it in. For this, a "Team Manual" assignment was developed wherein each student team developed a chapter. The manual was then given to the next students in the class to support their success in the TBL environment. Finally, the PDTF and professor collaborated on several engineering education conference papers over a two-year period. This collaboration has focused more on the collection and analysis of student learning outcomes and the development of new assignments to facilitate deeper learning; the instructor had already bought in to active and collaborative learning.

In *EECS 140: Digital Logic Design*, the PDTF worked with a full-time lecturer to transform the course from traditional lecture to include active learning, and then to a fully flipped format where all information delivery occurs outside of class and students spend nearly the entire class period working on in-class problems. The PDTF assisted the lecturer with obtaining a mini-grant from the CTE to hire a student to assist with creating the in-class problems and to pay the lecturer some additional salary. The PDTF visited class during both the active and flipped format sessions to provide feedback early on in the semester and met with the instructor weekly to discuss the course. The PDTF also developed an exam wrapper and a mid-semester survey, facilitated the distribution, and compiled and analyzed the results. The PDTF collected all exams and recorded scores on each question of the exam, to allow for comparison across semesters on questions linked to the same learning objective. This collaboration focused more on the transformation of a course from traditional to a fully-flipped model. Data analysis continues on this project as well as dissemination of the work through discipline-based conference papers.

Support of Teaching Innovations and Teaching Scholarship

The Engineering PDTF was in a unique position to engage instructors with implementation of teaching innovations and teaching scholarship. One example of supporting innovative teaching is a department-wide "tiered-mentoring project" that began when one of the authors invited graduate students to act as mentors to student teams in an undergraduate steel design course [12]. Based on the positive outcomes of both this project and the UGTF program [10], the PDTF and mentor wanted to expand the benefits of peer mentoring to more students in the department. The PDTF facilitated the widening of this project to include courses at every level of the Civil Engineering structures sequence (Statics and Dynamics, Strength of Materials, Structural Analysis, and Steel Design). Since it was not feasible to have each student fill a one-on-one mentoring role in the larger implementation, we opted for a video project. Each student (individually or in small groups) created video content that either demonstrated how to solve problems about a certain topic or discussed and illustrated why the content was important later on in the curriculum. The videos were shared with students in the prerequisite courses. The topics for the content of the videos were decided on with collaboration from the instructor of the prerequisite courses to insure the content and timing of the videos (when they were available) were relevant. Results from student surveys about the project indicated that this project significantly benefited students who came into the course with a C in the prerequisite course, compared to those who came into the course with an A or B in terms of their expertise on the concept and their confidence in their understanding of the concept [13]. These findings were encouraging because students with a C in a course are not eligible for mentor positions in the UGTF program; therefore the video projects represented an effective means of involving them in mentoring and helping them receive some of the well-documented benefits of being a mentor.

As part of encouraging faculty involvement in teaching innovations and teaching scholarship, the PDTF played an important role in connecting faculty to resources available through the institution's CTE, enabling faculty to access course transformation mini-grants (financial support for teaching efforts) and travel grants for departmental faculty teams. By providing this linkage, the engineering PDTF was able to connect 13 engineering faculty with over $21,000 in course transformation mini-grant supports, and two departmental teams of engineering faculty with funds ($8000) to visit other institutions to learn about innovative teaching practices occurring in their discipline elsewhere. Many of the course transformations and projects mentioned above led to engineering education conference papers, which was a new area of scholarship for the majority of faculty involved.

Support of the UGTF program

The Undergraduate Teaching Fellows (UGTF) program was developed with the goal of serving as a support structure for faculty willing to implement significant active learning components into their undergraduate engineering courses, and also to serve as an incentive to faculty for engaging in such work. For these reasons, it was important for the engineering PDTF to be involved with the UGTF program, as a key component of the Engaged Learning Initiative.

The UGTF program was loosely modeled after the Learning Assistant and Peer-Led Team Learning models [14-16]. It was kicked off in Spring 2015 when four undergraduate students were placed in two engineering courses (*CE 301: Statics and Dynamics* and *ME 320: Dynamics*) to support active-learning activities such as group problem-solving, demonstrations, and team-based learning. Since then, the program has grown to approximately 30 UGTFs supporting 13-17 courses per semester across all departments in the School of Engineering (Table 1), and has consistently received positive feedback from faculty, UGTFs, and students in UGTF-supported courses.

Table 1. Summary of UGTF-supported Courses

Fall 2016-Spring 2018 Program Summary (4 semesters)				
Course	**Credit Hours**	**Students Enrolled**	**Student Credit Hours**	**UGTFs**
AE 421: Aerospace Computer Graphics	3	50	150	1
AE 507: Aerospace Structures	3	45	135	1
AE 508: Aerospace Structures II	3	31	93	1
C&PE 121: Introduction to Computers in Engineering	3	210	630	6
C&PE 211: Material and Energy Balances	4	235	940	6
C&PE 221: Chemical Engineering Thermodynamics	3	197	591	6
C&PE 327: Reservoir Engineering	4	86	344	1
C&PE 511: Momentum Transfer	3	287	861	6
C&PE 521: Heat Transfer	3	264	792	7
C&PE 522: Economic Appraisal of C&PE Project	2	325	650	6
C&PE 523: Mass Transfer	4	196	784	2
CE 301: Statics and Dynamics	5	264	1320	7
CE 310: Strength of Materials	4	201	804	6
CE 455: Hydrology	3	99	297	2
CE 461: Structural Analysis	4	116	464	5
EECS 140: Introduction to Digital Logic	4	99	396	2
EECS 168: Programming	4	426	1704	8
EECS 212: Circuits II	4	300	1200	8
EECS 268: Programming II	4	34	136	1
EECS 316: Circuits for Non-majors	3	146	438	4
ME 211: Statics and Introduction to Mechanics	3	254	762	7
ME 320: Dynamics	3	179	537	6
ME 412: Thermal Systems	3	60	180	2
ME 628: Mechanical Design	3	205	615	3
ME 682: System Dynamics & Control Systems	3	228	684	4
TOTALS		**4537**	**15507**	**108**

The PDTF developed and facilitated a training program for the UGTFs. Since the UGTF role is quite different than a traditional undergraduate TA role (no grading, primarily in-class help with active learning), there was not a training available on campus that was specific to their role. The newly developed training program for UGTFs includes 3 meetings over the course of the semester and a peer review. The goal of the training is to support the UGTFs and enable them to be as effective as possible.

The first meeting is a joint "Kick-off Meeting," with faculty and UGTFs present from STEM departments across KU designed to get instructors and UGTFs on the same page about how UGTFs can be most effective, and has been iterated on to include breakouts sessions on several topics such as inclusivity, sexual harassment and reporting requirements, video analysis of the UGTF role, a LEGO communication activity, and a faculty break-out session. The second meeting is held about one month into the semester and is focused around common issues that come up in team-based learning or cooperative group active learning activities. The peer review happens during the second month of classes. UGTFs are assigned another UGTF to observe in class. They are provided a worksheet with places to track the UGTFs activities (number of questions asked, answered, types of questions asked, number of teams interacted with) and also to provide open-ended feedback. The third and final meeting includes a discussion of the peer review, gathering feedback on the peer review process and on the UGTF program as a whole, discussing case studies, and contributing to the "UGTF Handbook" that UGTFs for next semester will get.

The Classroom Observation Protocol for Undergraduate STEM (COPUS) [17] was used to quantify how professors and students were spending time in classes that received UGTF support. To perform the COPUS, a trained observer visited each course three times in a two-week period. For each COPUS observation, the observers indicated in each two-minute interval of class time whether or not 13 student behaviors and 12 instructor behaviors occurred. Data from the three observations of each course were averaged, and then the thirteen behaviors were collapsed into four categories. For students, those categories were *receiving*, *working* (included individual thinking/working, clicker question in groups, working in groups, and other group), *talking to class* (answering questions, asking questions, whole class discussion, and student presentation), and *othe*r (waiting, other). For instructors, those categories were *presenting* (lecturing, real-time writing, and demo/video), *guiding* (follow-up, posing question, clicker question, answering question, moving around to groups, and one-on-one), and *other* (waiting, other). Indicators of more active learning are increased time *working* for students and *guiding* for instructors, and less time *receiving* for students and *presenting* for instructors. *Talking to class* is a category that can be seen in both active and traditional type classrooms and is not necessarily an indicator of active learning.

Surveys were distributed in Fall 2016, Spring 2017, Fall 2017, and Spring 2018 to students enrolled in courses supported with UGTFs, as well as to the UGTFs themselves and the faculty members associated with UGTF supported courses. Completion of the surveys was completely voluntary. Approximately 345 students, 68 UGTFs, and 18 faculty members completed the surveys.

Development of Local Community

A key strength of the broader university-level course transformation initiative has been the successful formation of a community of transformation on that topic. However, it has proven difficult to achieve a high level of engagement of engineering faculty in the university-level C21 community. In an effort to provide an incubator for changing teaching practices in engineering, the PDTF developed an Engineering Teaching Working Group (TWG), which was intended to serve as a local community for engineering faculty engaged in course transformation work. The PDTF facilitated meetings of the TWG 3-4 times per semester to explore teaching-related topics. The goal of this group was to build community around teaching, to share lessons learned and successes around teaching, and a mechanism with which to connect engineering faculty with broader teaching resources on campus. The engineering teaching working group has about 30 faculty who are a part of the group with about 10 who regularly attend meetings.

Impact of the Intervention

Course Transformation Activity and Teaching Scholarship

Table 2 shows the numbers of course transformations and scholarship activities that the PDTF was involved in. "Heavy" course transformation included those courses that the PDTF was involved with for at least an entire semester- meeting regularly with the instructors, regularly collecting student learning data, designing and administering surveys, assisting with special project implementations (Tiered mentoring), etc. "Consult" includes more one-time type of consultations where the PDTF consulted on specific topics or issues but the support was not on-going. To date, 11 courses have been involved in "heavy" transformations and 15 courses with "consult" level interaction, involving 16 unique instructors. Twelve conference papers have been published as a result of this work, involving 11 unique faculty. Unique faculty is specified instead of total faculty because some faculty have engaged in course transformations on more than one course or for multiple terms. Similarly, some faculty have been involved in more than one scholarship activity. The “unique faculty” count is meant to illustrate how many new faculty are engaging with this work each year. During the academic year 2015-2016, there was no PDTF present as there was a year gap between when PDTF A left the position and when PDTF B started the position. Finally, it is of note that in Fall 2018 there were less “heavy” course transformations and more “consult” level transformations. This is due in part to the fact that the PDTF was developing and teaching the first offering of an “Engineering Education” graduate course, and thus was less available for heavy course transformation assistance.

Table 2. Course transformation and teaching scholarship activity. * Indicates unique instructors/faculty involved; not the total involved for that year.

	Course Transformation: Heavy	Course Transformation: Consult	Unique Instructors Involved in Course Transformation	Conference Papers	Unique Faculty Involved in Teaching Scholarship
2014-2015	2	0	2	1	2
2016-2017	3	4	7*	3	2*
2017-2018	5	5	5*	3	5*
Fall 2018	1	7	2*	5	2*
Totals	**11**	**15**	**16**	**12**	**11**

Evaluation of UGTF Program

Overall averages from COPUS observations of UGTF supported courses from Fall 2016-Fall 2018 indicated that students in UGTF supported courses spent 38% more time working (41.3% compared to 3.8%) and 23% less time receiving (42.4% compared to 65.1%) than students in the comparison courses (courses without UGTF support). Instructors spent 19% less time presenting (34% compared to 53%) and 19% more time guiding (63% compared to 44%) in UGTF supported courses compared to the comparison courses.

Not all courses involved in the UGTF program also collaborated with the PDTF. Figure 1 shows COPUS results for courses in the UGTF program that were collaborating or consulting with the PDTF and those in the UGTF program who were not working with the PDTF. Courses with interaction from the post-doc showed significant (Mann-Whitney U-test, $p < .05$) changes in student activities- significantly less “talking to class,” (this is one person talking to the whole class and not necessarily an indicator of active learning) (15.5% compared to 8.6% $p=.01$), and significantly more “working” (52.4% compared to 36.7%, $p=.02$). There were no statistically significant differences in instructor activities, although there was more “guiding” in the courses that interacted with the post doc (57.9% compared to 69.1%, $p = .05$). These results indicate that a program like the UGTF program enhances the use of active learning, but the addition of support from the PDTF is a catalyst for bigger change.

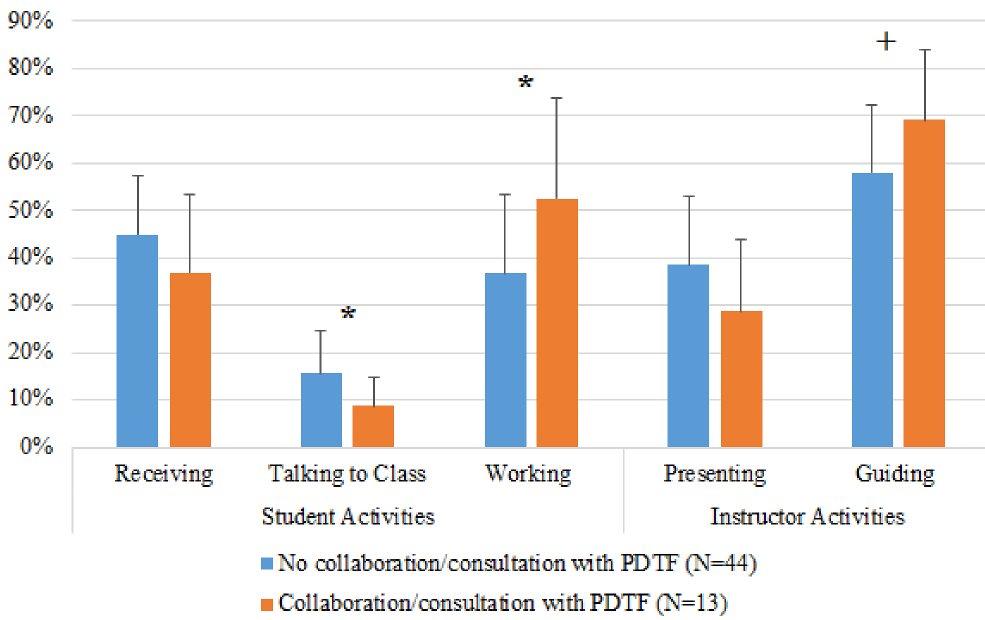

Figure 1. COPUS results on courses in UGTF program that collaborated with the PDTF (orange) or did not collaborate with the PDTF (blue). *Indicates statistical significance ($p < .05$) by Mann-Whitney U test; + indicates near statistical significance ($p = .05$).

DFW indicators

We investigated DFW (drop, fail, withdraw) rates in three courses the PDTF was involved in and compared that to two courses where there was no involvement (Figure 2). The time period from Fall 2006-Spring 2014 was defined as "pre PDTF" and Fall 2014-Spring 2018 as "post PDTF." We compared ME 320, CE 301, and EECS 140 where the post doc has been involved for multiple semesters, to two courses in similar departments where the PDTF has not been involved. Even though the PDTF was not involved in ME 306 and EECS 268, those courses have had access to and at least to a small extent, utilized other resources such as the UGTF program. In the courses with PDTF interaction, the DFW rates have declined. In the comparison courses, the DFW rates have risen or stayed the same across the same time period.

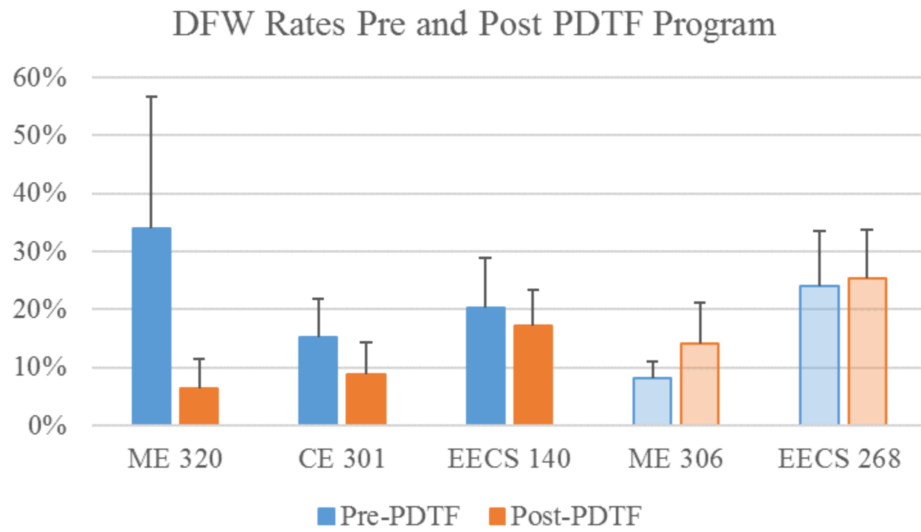

Figure 2. DFW rates in courses with PDTF collaboration (dark bars) and courses without PDTF collaboration (light bars). Pre-PDTF (blue) indicates the time period before the PDTF was present as a resource, and Post-PDTF (orange) indicates the time period after the PDTF arrived as a resource.

Feedback from Stakeholders

In order to obtain information about how various stakeholders within the School of Engineering viewed the initiative, we developed a survey for students, UGTFs, and faculty to provide feedback about their experiences with the UGTF program and for faculty to provide feedback about their work with the PDTF and their opinions about the PDTF model.

Survey responses on the UGTF program revealed a high level of satisfaction from students in courses supported by UGTFs, the UGTFs themselves, and the faculty involved. The student respondents in courses supported by the UGTF program reported overwhelmingly (89%) that their learning was better supported with UGTFs in the classroom, compared to courses where they were not available. The majority (over 90%) of respondents who served in the UGTF role reported having an improved understanding of the course content and improved confidence in their abilities related to the course content. Almost all faculty respondents (97%) reported being more satisfied with course outcomes compared to before the UGTF resource. Importantly, faculty reported that the UGTF program allowed them to do more active learning: *"I was able to incorporate more challenging in-class problems than I would otherwise be able to do with a class this large,"* and "*The UGTF significantly impacted the level of help available to teams and individuals during group work done in class.*

Anonymous surveys on the effectiveness of the PDTF role were sent to all faculty in the Teaching Working Group, and anyone that the PDTF had worked with which was approximately 40 people. Eight responses were recorded, so this survey data is discussed with the small sample size in mind. Faculty were asked about the types of interactions they had with the PDTF, the nature of the PDTF's work on courses, and the nature of the PDTF's work on educational research (Figure 3). Most respondents interacted with the PDTF in multiple areas, and they were allowed to choose more than one response on the survey. The majority (6/8) of respondents interacted with the PDTF through the Teaching Working Group. Half of the respondents (4/8) interacted through either an "ongoing collaboration on one or more courses," "collaboration on a project such as the UGTF program or Tiered-mentoring project," or "collaboration on engineering education research. The most common type of work on coursework was "Analysis of student learning" and "Assistance with data collection." The most common type of work on research was "data collection" and "data analysis."

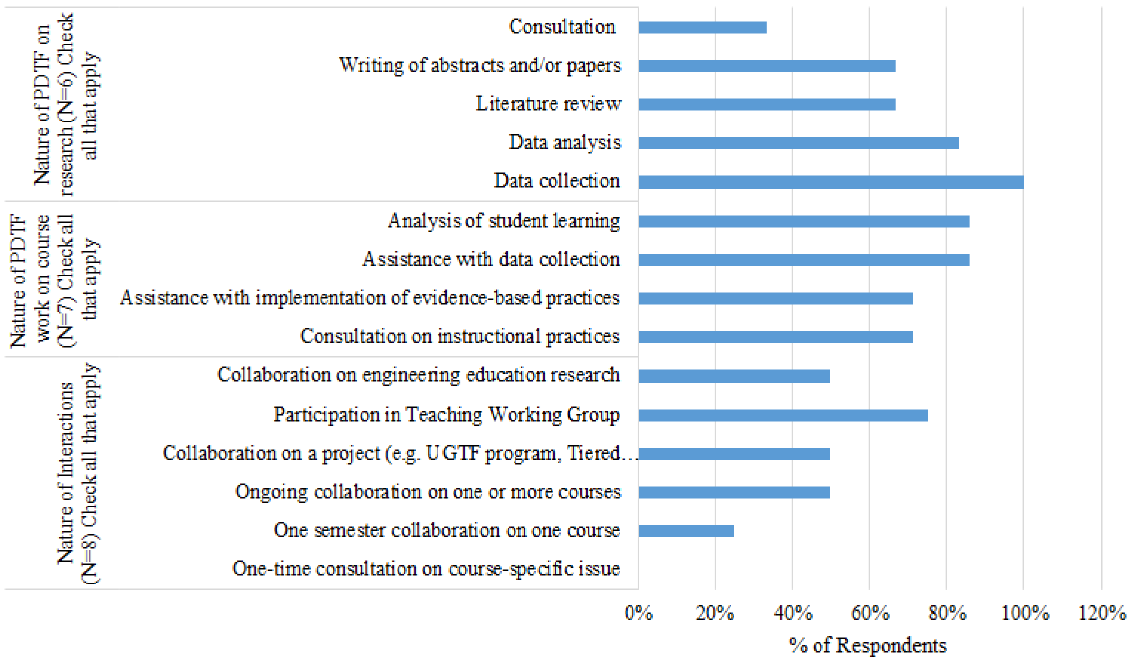

Figure 3. Survey responses from faculty on nature of collaborations with PDTF.

Faculty were asked what the one most valuable aspect of the PDTF role was (Figure 4). The most common answers were "collaboration on engineering education work" and "course-level collaborations." Faculty were also asked about the qualifications for the PDTF role. The PDTF was required to have a Ph.D. in engineering or closely related field, and faculty were asked if they thought this requirement was important. The majority (75%) of respondents reported "yes," and 25% reported "maybe." Faculty were asked if they were "more likely," "equally likely," or "less likely" to work with the PDTF if they had a Ph.D. in a non-engineering discipline: 50% responded they would be "equally likely," and 50% responded they would be "less likely." Finally, faculty were asked if their interactions with the PDTF have changed their ideas about teaching. The majority (75%) of respondents answered "yes," and 25% answered "maybe."

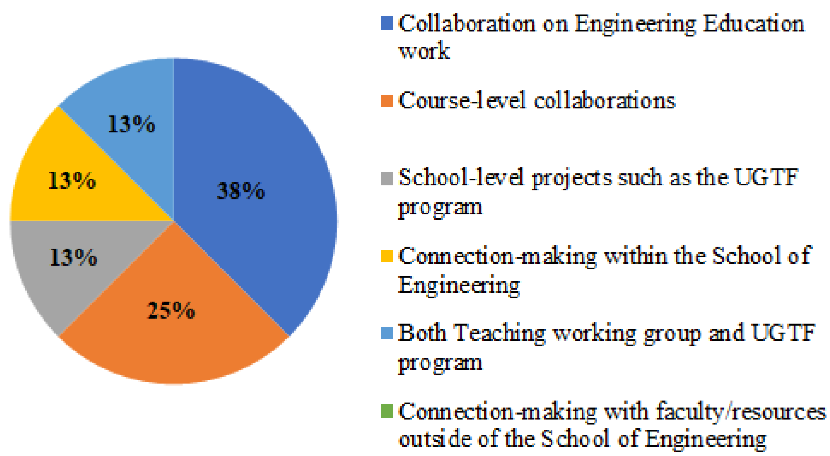

Figure 4. Faculty responses on the most valuable aspect of the PDTF role.

Conclusions and Recommendations

The School of Engineering's Engaged Learning Initiative has been enormously successful in fostering the integration and adaptation of student-centered, evidence-based teaching practices as well as improved student performance. The cornerstone of this initiative has been the Postdoctoral Teaching Fellow, an embedded expert in the School of Engineering functioning as a change agent. The PDTF role has been intentionally structured to be very different than one of instructional developer or discipline-based educational researcher. Situated in the School of Engineering as a disciplinary expert available to collaborate and consult with faculty on their courses and teaching practices, the PDTF was not available to make extensive changes to existing materials or to develop new course materials. Therefore, the PDTF model maintained course ownership under the instructor, but served as a catalyst and a linkage with broader resources. Because this approach resulted in pedagogical shifts and course transformations that are "owned" by the faculty and departments, the results are expected to be more sustainable than models in which changes are produced, packaged, and handed over to the faculty/departments. The following conclusions and recommendations are offered.

The outcomes resulting from the Engaged Learning Initiative and Postdoctoral Teaching Fellow intervention were quite striking. Since 2014, 16 individual instructors have collaborated with the PDTF on course transformation, and 11 unique instructors have been engaged in treating their teaching in a scholarly fashion, resulting in significantly greater engagement with societies such as the American Society of Engineering Education. It is worth drawing out that engagement of instructors with publishable scholarship around their teaching has served as a meaningful incentive towards their engagement with course transformation. A comparison of how class time was used in a set of courses for which the instructor (a) had no interaction with the PDTF or (b) did interact with the PDTF showed meaningful increases in the amount of time that students spent working in-class, and corresponding decreases in the amount of time that instructors spent presenting or lecturing, in courses in which the instructor had interacted with the PDTF. In other words, instructor interactions with the PDTF did translate to significant changes in teaching practices. Perhaps most impressively, an analysis of DFW rates in three courses that had a high level of collaboration with the PDTF showed a strong trend of decreased DFW rates after the collaboration, while a set of comparison courses that had no involvement with the PDTF showed increased DFW rates over the same timeframe. We emphasize that the PDTF did not collaborate with instructors on grading schema, therefore, these changes are considered to be outcomes of improved teaching practices. Feedback from instructors and students on various aspects of the Engaged Learning Initiative indicated that the programs and PDTF role were influential in positively impacting their success in the classroom, and importantly, instructors indicated that their interactions with the PDTF were critical to achieving change.

Based on our experiences with implementation of the Postdoctoral Teaching Fellow model in the School of Engineering at the University of Kansas, we make the following generalizations and recommendations:

- Instructor feedback generally indicated that the PDTFs' disciplinary (engineering) expertise was a positive factor in their collaborations. We note that the majority of the PDTFs' course collaborations occurred with instructors in Civil Engineering and Mechanical Engineering, which are the disciplines with the most content overlap with that of the PDTFs (mechanical engineering). A meaningful exception was a high-level collaboration with an instructor in the EECS department. We generalize these observations to indicate that the disciplinary background of the PDTF does carry implications for whom collaborations may be most accessible to (perceived or otherwise).
- Engagement of faculty in course transformation activities occurred through a variety of different "ins" - some instructors were ready for collaboration without urging, and others were encouraged to collaborate at various levels through engagement with scholarly work around their teaching or through assistance accessing mini-grant or travel-grant incentives available centrally, and others were encouraged through participation in the local community (Teaching Working Group). We learned the importance of maintaining a variety of such "ins" to maximize instructors' willingness to engage in the work.
- The most notable outcomes discussed in this paper were the trend of reduced DFW rates in courses for which the instructor collaborated with the PDTF, and measurable differences in how class time was spent in courses that utilized such collaborations. We conclude that the PDTF intervention was highly successful in changing teaching practices in such a way to support student success and retention.

The work that we have described has been extremely successful in producing pedagogical shifts and improving student outcomes in the School of Engineering. This is especially notable given that only one Postdoctoral Teaching Fellow was active in the School of Engineering at any given time - representing a relatively small infusion of resources into a large, complex organization. Despite this, the outcomes have been quite significant, and have laid critical groundwork for continued change.

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