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Impact of Undergraduate Teaching Fellows Embedded in Key Undergraduate Engineering Courses

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Abstract

Research has shown the positive impact of peer mentoring on student learning in STEM. With the goal of improving student learning and retention, the School of Engineering (SoE) has undertaken a program in which Undergraduate Teaching Fellows (UGTFs) are utilized in key courses across the School. The UGTFs support in-class activities, such as team-based problem-solving, hands-on activities and demonstrations. This program has grown from four UGTFs in Spring 2015 to 28 UGTFs in Spring 2017, with UGTFs embedded in 13 courses across the SoE.

This paper explores the impact of the UGTF program by investigating three primary questions. First, *has the program resulted in greater adoption of active learning techniques?* We hypothesized that the program would allow faculty to engage with active learning techniques at a higher level or spark a change in course structure. This question was investigated by analyzing faculty surveys, UGTF surveys, and class observations. Next, *are students and faculty more satisfied with the course outcomes given the UGTF resources?* This was investigated by analyzing student surveys and course evaluations. We hypothesized that students and faculty would have greater satisfaction with the courses. Finally, *has the program positively impacted student learning?* This question was investigated by tracking changes in learning outcomes over time for each of the 11 courses with UGTF support in 2015. Outcomes for four key courses were focused upon: CE 301 (Civil Engineering Statics and Dynamics), CE 310 (Civil Engineering Strengths of Materials), ME 320 (Mechanical Engineering Dynamics), and ME 211 (Mechanical Engineering Statics). Learning outcomes were assessed by comparing student performance in downstream courses based on whether students took the prerequisite course with or without UGTFs.

Results of this investigation showed that students and faculty groups both responded very positively to the UGTF program, perceiving that the program resulted in improved student outcomes. Class observations performed using the Classroom Observation Protocol for Undergraduate STEM (COPUS) showed that in courses utilizing UGTFs, the majority of class- time was spent on activities other than listening, indicating that the UGTF program was successful in supporting student-centered teaching practices. The data that was examined for downstream course performance was suggestive of positive learning gains, but not conclusive at this stage as many students who were in courses with UGTFs have not yet taken the following courses.

Introduction

The University of Kansas School of Engineering (KU SOE) has engaged in building and growing an Undergraduate Teaching Fellows (UGTF) Program since 2015. The UGTF program is an adaptation of existing peer mentoring models (Gafney & Varma-Nelson, 2008; Otero, Pollock, & Finkelstein, 2010), and is primarily aimed at supporting in-class activities, such as team-based learning, demonstrations, and student problem-solving. This program has grown rapidly and this paper seeks to explain the implementation of the program and the impact it is making on student learning and course transformation.

The KU SOE has placed a high priority on supporting pedagogical shifts to student-centered, evidence-based practices across its undergraduate curricula through its Engaged Learning Initiative (ELI). As part of the ELI, the SOE opened the LEEP2 building in Fall 2015, which boasts six state-of-the-art active-learning classrooms. The six new classrooms are structured to accommodate team-based learning and group problem solving (Figure 1). These facilities have been an important component of producing pedagogical shifts in the KU SOE, but as more faculty have shifted to student-centered teaching practices, a need for additional in-class instructional support has become clear. Supporting the shift in teaching practices towards student- centered models was a key motivation for creating the UGTF Program at KU.

Figure 1: Active learning classroom in the KU SOE

The KU SOE program was piloted with four UGTFs in two classes in Spring 2015, and has since grown to a cohort of 28 UGTFs supporting learning activities in 13 classes across the SOE in Spring 2017 (Table 1). A total of 3,603 student credit hours are being impacted by the UGTF program in Spring 2017. Therefore, a key strength of the UGTF program is the breadth of its impact on supporting student learning using a relatively small number of hired personnel.

Table 1. Courses and Number of Student-Credit Hours Impacted by UGTF Program Fall 2016 and Spring 2017

Course	Credit Hours	*Fall 2016* Students Enrolled	*Fall 2016* Student Credit	*Spring 2017* Students Enrolled	*Spring 2017* Student Credit
C&PE 121: Intro to Computers	3	102	306	108	324
C&PE 211: Mat and Energy Balance	4	120	480		
C&PE 221: Chem Engineering Thermo	3			104	312
C&PE 327: Reservoir Engr	4			43	172
C&PE 511: Momentum Transfer	3	167	501		
C&PE 521: Heat Transfer	3			149	447
C&PE 522: Economic Appraisal Project	2	205	410		
C&PE 523: Mass Transfer	4			106	424
CE 301: Statics and Dynamics	5	94	470	33	165
CE 310: Strength of Materials	4			99	396
CE 455: Hydrology	3			53	159
CE 461: Structural Analysis	4	42	168		
EECS 168: Programming	4	125	500	73	292
EECS 268: Programming II	4	110	440	78	312
ME 211: Statics	3	98	294	46	138
ME 320: Dynamics	3	48	144	38	114
ME 628: Mechanical Design	3			116	348
ME 682: Controls	3	103	309		
TOTALS		**1214**	**4022**	**1046**	**3603**

UGTF resources have been prioritized by assigning UGTF personnel to classes that are considered gateway courses to departmental curriculum (meaning success in the course largely predicts degree success), courses that have high DFW rates, courses in which a significant number of students are enrolled, and courses where the UGTF resource may serve as a faculty incentive to make pedagogical shifts towards evidence-based practices. With these criteria, engineering fundamentals courses have primarily been targeted. From a procedural standpoint, a request for proposals is issued each semester to which faculty and instructors are invited to apply for UGTF resources for the following semester. UGTF allocation decisions are made by SOE leadership.

The SOE has developed a semester-long training program for the UGTFs, to ensure that they are adequately trained to interact with students to scaffold their learning. The pilot version of the UGTF training program consisted of three one-hour meetings over the course of the semester. The first meeting, held prior to the start of classes, focused on inclusion training and role-playing activities illustrating positive interactions with student teams during active learning and especially how to lead dysfunctional teams to a more functional dynamic. The second meeting, held mid- semester, focused on student motivation and engagement. The final meeting, near the end of the semester, used handouts and videos developed by the Learning Assistant Alliance (www.learningassistantalliance.org) available through Physport (www.physport.org/periscope) to illustrate and discuss effective mentoring strategies. For

Spring 2017, the SOE collaborated with other STEM departments that utilize UGTFs across the University to hold a joint training session at the beginning of the semester for both faculty and UGTFs. This training consisted of training on inclusivity, activities illustrating effective UGTF interactions and questioning techniques, and time for the faculty and UGTFs to plan for the semester. In addition to this training session, two more training sessions are planned, and will focus on role-playing activities to practice effective mentoring and an opportunity for peer review and discussion.

To promote faculty engagement and the use of evidence-based practices in courses with UGTFs, faculty were provided with resources outlining best-practices for working with the UGTFs. A SoE teaching working group was created, with a goal of engaging faculty colleagues working with UGTFs in a recurring peer-driven conversation focused around teaching excellence.

Background

Peer mentoring has been shown to improve learning, retention, and identity development for students (Collings, Swanson, & Watkins, 2014; Gafney & Varma-Nelson, 2007; McCavit & Zellner, 2016; Talbot, Hartley, Marzetta, & Wee, 2015; Van Dusen, Langdon, & Otero, 2015). Three primary models of peer mentoring in higher education are prevalent in the literature: first- year mentoring projects, Peer-led Team Learning (PLTL), and the Learning Assistant (LA) model.

The PLTL model focuses on the utilization of students who have previously completed a course to lead small groups of current students with the goal of completing workshop-type problems (Gosser Jr, Kampmeier, & Varma-Nelson, 2010). Typically, these sessions are run regularly in conjunction with lecture classes over a semester. Research has shown improvements in student learning due to PLTL implementation. For instance, in a study across 16 universities, the students in a PLTL-implemented course experienced an average increase of 10-20% in passing grades, in comparison to a typical course (Gafney & Varma-Nelson, 2008). The benefits extend to the leaders as well; through a variety of surveys, focus groups and interviews, it was revealed that peer leaders not only improved their content knowledge, but also experienced an improvement in interpersonal communication, leadership, team-work skills, problem-solving abilities, self- expression, and professional growth (Gafney & Varma-Nelson, 2007; Hug, Thiry, & Tedford, 2011; Micari, Streitwieser, & Light, 2005).

The LA model refers to peer mentoring primarily used during active learning in the classroom, and includes instruction on pedagogy for the mentors (Otero et al., 2010). In the courses incorporating the LA model, the learning assistants will directly engage with the class in order to answer questions, help guide students through the course content, foster student engagement, and promote discussion between the students. The reception of the students exposed to the LA model has been largely positive, with general increases of satisfaction with the courses, the teaching of the courses, and their own ability to learn (Talbot et al., 2015). However, a study of over 4500 students across 13 institutions (Van Dusen et al., 2015) revealed that female students and students of Asian and other minority backgrounds experienced significantly lower improvements than their counterparts did. The effects of learning assistants was also seen in the downstream courses. While the students coming from an LA-implemented course were seen to score higher in the following course (compared to those that had completed a comparable non-LA-implemented course), those that served as learning assistants in this prerequisite course showed even greater performance (Amaral & Vala, 2009; Otero et al., 2010). Further benefits to the learning assistants include the realization of different student perspectives and the ability to develop their own methods of learning (Close, Conn, & Close, 2016).

The Undergraduate Teaching Fellows (UGTF) program was designed with the LA model in mind, as significantly larger learning gains for students in courses with LA support compared to without have been observed in biology, physics, and chemistry (Otero et al., 2010; Talbot et al., 2015; Van Dusen et al., 2015). UGTFs are utilized in a similar manner to mentors in the LA model, but the program does not include the training on pedagogy that is integral to the LA program. The objective of the study described in this paper is to gauge the effectiveness of the UGTF program in supporting faculty adoption of student-centered pedagogies and in supporting student learning.

Methods

To examine the effectiveness of the UGTF program, a three-part approach was taken in this study, incorporating class observations, surveys, and analysis of student performance in downstream courses (courses that the students took later in the curriculum). These three approaches are each described in the following sections. This research was approved by the Human Research Protection Program at the University of Kansas.

COPUS Observations

The Classroom Observation Protocol for Undergraduate STEM (COPUS) (Smith, Jones, Gilbert, & Wieman, 2013) was used to quantify how professors and students were spending time during class. To perform the COPUS, a trained observer visited each course three times in a two-week period. For each COPUS observation, the observers indicated for each two-minute interval of class time whether or not one or more of the 13 student and 12 instructor behaviors (listed in Table 2) occurred.

Table 2. Student and instructor behaviors tracked on COPUS observation

COPUS Student Behaviors	COPUS Instructor Behaviors
Listening [L]	Lecturing [Lec]
Answering Questions [AnQ]	Real-time writing [RtW]
Asking Questions [SQ]	Demo/Video [D/V]
Whole class discussion [WC]	Follow-up [Fup]
Student Presentation [SP]	Posing question [PQ]
Individual thinking/working [Ind]	Clicker question [CQ]
Clicker question in groups [CG]	Answering Question [AnQ]
Working in groups [WG]	Moving around to groups [MG]
Other group [OG]	One-on-One [1o1]
Predicting the outcome of something [Prd]	Administrative [Adm]
Test/Quiz [TQ]	Waiting [W]
Waiting [W]	Other [O]
Other [O]	

Data from the three observations of each course were averaged, and then the listed 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 *other* (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), *admin* (receiving or returning material, scheduling quizzes or examinations), and *other* (waiting, other).

Survey Data

Surveys were distributed to faculty and students involved in courses with UGTF resources and to the UGTFs for evaluation of the UGTF program. The survey questions for faculty focused on the utilization of UGTFs in their course, their communication and preparation efforts with the UGTFs, the changes they were enabled to make to their course because of this resource, and their satisfaction with course outcomes and the UGTF(s) they worked with. For the students in courses with UGTF resources, the survey questions focused on their interactions with UGTFs (how often and what type), if they felt there were enough UGTFs in the classroom, and if they perceived their learning to be better supported in courses with UGTFs. Finally, the survey questions for UGTFs focused on their interactions with students and faculty, the preparation and communication with the instructional team, the impact of the experience on their own understanding and confidence in the course material, on their connection to other students and faculty in their department, and on the development of professional skills. In addition, on all surveys, open-ended feedback was requested on how to improve the program or what additional resources and/or training would be helpful.

Student Learning

In an effort to understand the impact of the UGTF program on student learning, and in collaboration with the Office of Institutional Research and Planning, downstream performance of students in a subset of UGTF-supported courses was tracked. Performance in downstream courses based on student grades was compared for students who (a) enrolled in the upstream course prior to the introduction of UGTFs and (b) students who enrolled in the upstream course while it had UGTF resources. The downstream course analysis was conducted for four courses: ME 211 (Statics), ME 320 (Dynamics), CE 301 (Statics and Dynamics), and CE 310 (Strengths of Materials).

For each of these courses, the first semester in which UGTFs were utilized and a downstream course were identified. Comparisons were made between grade distributions in the downstream course before and after utilization of the UGTFs. Additionally, the performance of students were tracked by grade (ie. how did students who earned an A, B, C, or D in the upstream course perform in the downstream course?). Upon reviewing the data, the need to collect data over additional semesters became clear. Due to the relative newness of the program and the fact that not all students took the downstream course immediately after the upstream course, the numbers of students in the downstream analysis was often very small. In addition, other variations in instructor and teaching practices in the various downstream courses occurred, and the effects of these variations were not clearly separable. Therefore, data for one course sequence is presented, as it was the most well-controlled in terms of teaching methods for both the upstream (ME 320 - Dynamics) and downstream (ME 682 – Control Systems) courses. In other words, teaching practices in ME 682 remained mostly constant while the format of ME 320 was changed (UGTFs were introduced).

A comparison of student performance in the downstream course (ME 682) was made between students who took ME 320 in Fall 2014 (no UGTFs) and those who took ME 320 in Spring 2016 (with UGTFs). In Fall 2014, the instructor for ME 320 taught in an active-learning classroom, using a flipped classroom model based on the SCALE-UP approach (Beichner, 2008) and cooperative learning in informal groups. In Spring 2016, the instructor for ME 320 taught in much the same manner, in a similar classroom, but used team-based learning (TBL) and utilized UGTF resources, which enabled him to move to the TBL paradigm.

Results and Discussion

The results of this study are presented and discussed in the following sections, organized by data collection technique.

Class Observations using COPUS Protocol

Figure 2 shows averaged results for course observations made in Fall 2016 using the COPUS Protocol for nine undergraduate engineering courses. Eight of the courses shown utilized UGTFs, while data for CE 310 (Strength of Materials) is presented as a comparison course (UGTFs were not utilized, and the course was taught in a traditional lecture-based format).

Examination of the COPUS results is helpful in showing what faculty were able to accomplish in terms of increasing student engagement when they were supported with UGTF resources. In general, the amount of time that students spent working and talking (e.g., asking questions [*SQ*], answering questions [*AnQ*], etc.) was significantly greater than time spent on listening. While many faculty teaching these courses have been working to increase student engagement over multiple years, the UGTF program has aimed to leverage and support their efforts. It appears, based on the COPUS observations collected, that the program has indeed been successful in supporting implementation of student-centered teaching practices. The authors intend to continue analyzing COPUS observation results over the coming semesters to examine the data for changes and trends.

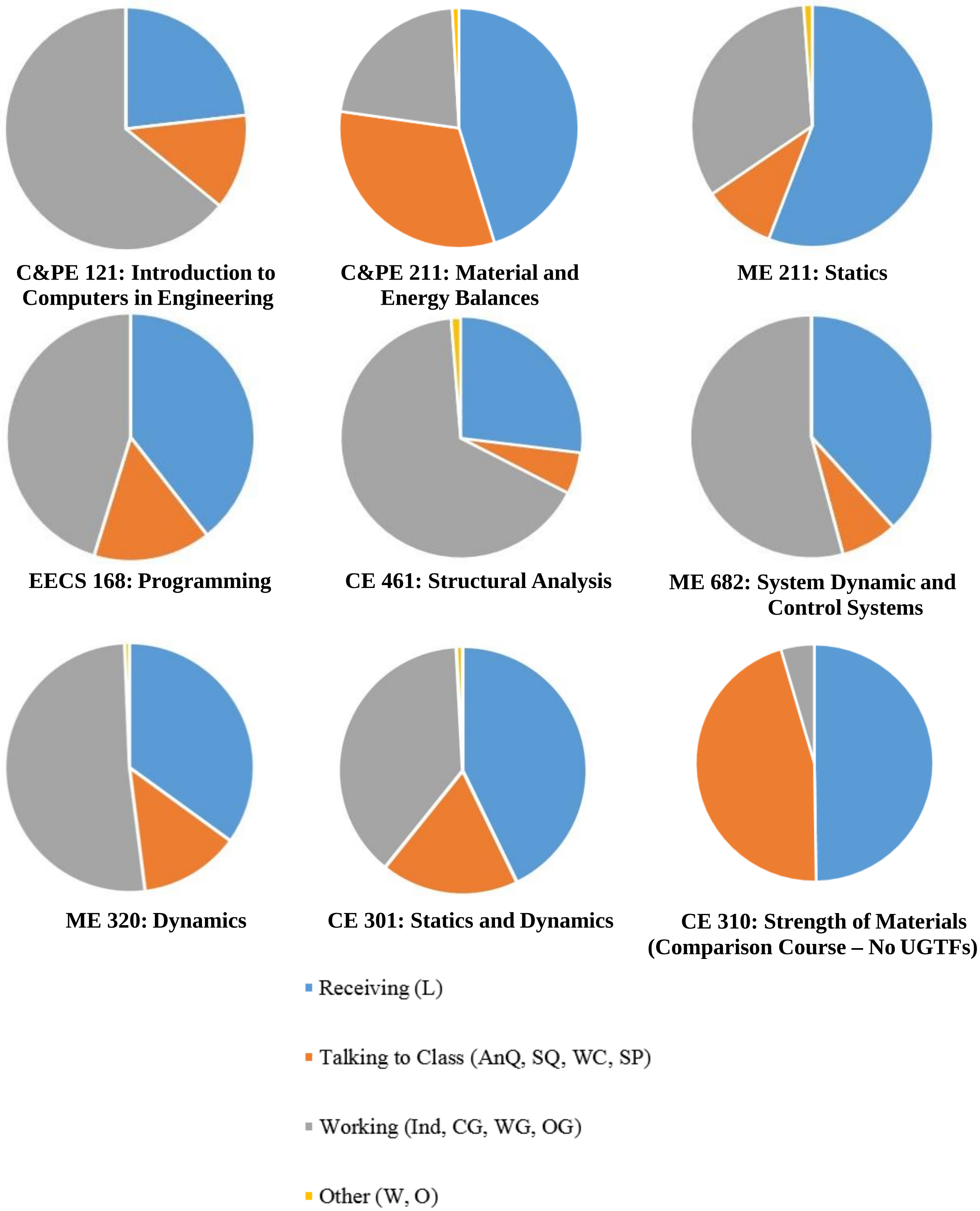

Figure 2: Average percentage (relative distribution) of student activities recorded during COPUS observations

Summary of Survey Findings

The survey results provided insight into how the UGTF program functioned in practice, as well as how the program was perceived by faculty, UGTFs, and students enrolled in courses with UGTFs. Response rates were 40% for faculty and 40% for UGTFs. Thirty students enrolled in courses that had UGTF support responded to the survey. Overall, the survey results showed that nearly all the respondents (faculty, UGTFs, and students) were satisfied with the program, and faculty and student responses indicated that they believed the UGTF presence improved student learning. The majority of the UGTF respondents indicated improved understanding of course content, as well as improved professional skills such as communication and leadership abilities. A summary of key pieces of feedback from the survey results are summarized in Figure 3.

<u>Faculty Input</u>
(n = 4)

- 100% reported that peer mentors were used nearly exclusively to support in-class activities
- 100% reported communicating weekly with UGTFs (but one responded that they did not personally meet a weekly basis)
- 75% reported that UGTFs increased the level of in-class student group work
- Only one faculty reported administering more difficult problem-solving tasks with UGTF resources available
- 100% reported approx. the same amount of time spent on lecture-based activities
- 100% reported that they were more satisfied with the course outcomes when using peer mentors
- 100% reported that their UGTFs were at least adequately prepared from a content mastery perspective
- One responding faculty member requested additional support utilizing the UGTF resources

<u>UGTF Input</u>
(n=8)

- 100% UGTFs reported interacting with students several times per class period (e.g. Q&A and leading group discussions)
- 75% of the UGTFs reported meeting with their faculty at least 1x/week, but 1 UGTF reported not communicating outside of class at all with their faculty for the entire semester
- 100% of the UGTFs felt more connected to the students and faculty in their department at the end of the semester
- 100% of the UGTFs reported having deepened content understanding and greater confidence in their mastery
- Only one respondent did not agree that the program further prepared them for their career
- For each of the three training sessions, approx. 50% of the respondents found the session useful; a common request was for more guidance on logistical challenges (clocking time, etc.)

<u>Student Input</u>
(n=30)

- 63% of students reported that they interacted with UGTFs at least once per class period
- 97% indicated that the most common interaction with UGTFs was Q&A; 60% indicated that UGTFs also asked questions; 30% noted that the UGTFs facilitated group discussions
- 87% agreed that there were enough UGTFs in their course
- 88% of respondents thought that their learning was better supported with the presence of UGTFs
- 79% of respondents indicated that a peer mentor positively impacted the dynamics of their student group (the remainder indicated no effect)
- 3 commenters indicated that some UGTFs needed improved content mastery
- 2 commenters indicated additional UGTF training on leading discussions would be valuable.

Figure 3: Key input received from Fall 2016 survey

The authors were surprised by the survey finding that of the four responding faculty members, 100% reported making no change to the amount of lecture content in their course. These responses could imply a number of things: (a) those courses have already been significantly redesigned to incorporate less lecture; (b) the faculty intend to make changes in the future; or (c) the faculty have no intention to reduce the amount of lecture activities. However, this survey result should also be considered in context of the COPUS observation results, which showed a relatively low level of lecture activity in the courses observed. Therefore, it is reasonable to think that the majority of the faculty have already invested heavily in course redesign, thus lessening the likelihood that lecture components would be further minimized.

Another surprising finding from the survey results was that 100% of faculty felt that the

UGTFs were “at least adequately prepared” from a content mastery standpoint – surprising, given that three students commented that the UGTFs would have been better mentors had they had greater content mastery. This dissonance leads the authors to believe that there was likely a connection between faculty who did not hold regular meetings with UGTFs and UGTFs perceived by students as being under-prepared. This highlights a challenge that has become apparent to the authors – that the UGTF training sessions are likely useful, but UGTF success can also be strongly influenced by the level of faculty involvement, as well as the course structure that the faculty puts in place.

The survey input provided by the UGTFs indicated a perception of their own learning and professional skills being improved. This is a meaningful observation that has been supported by other studies (Hug et al., 2011; Micari et al., 2005; Talbot et al., 2015), and one that merits further study in the context of the KU UGTF program.

Student responses to the survey indicated that only 63% of the students interacted with UGTFs at least once per class period, but 87% of students believed that there were enough UGTFs in the course. These pieces of feedback taken together imply that there is a subset of students who are not interested in UGTF interactions (at least not every class period), and that there are UGTFs or teams of UGTFs who are not actively checking in with students while problem-solving is occurring. This is a realization that can be addressed, at least partially, in future training sessions. It is also possible that some instructors may not be encouraging UGTFs to take an active role in checking in with all student groups, or that there may be days in which UGTF-supported activities do not take place.

Student Learning

As discussed in the Methods section of this paper, performance in downstream courses was examined to assess the influence of UGTFs in four undergraduate engineering courses. In general, it was determined that it is still early in the program to draw strong conclusions regarding the impact of the UGTF program on student learning. Since many of the students who were enrolled in the course with UGTF resources have not yet reached the downstream course, the data for the downstream courses does not reflect as many students as captured in the upstream data.

With this caveat in mind, the data for ME 320 (Dynamics) are presented in Figure 4 and Figure 5. Figure 4 shows the grade distributions for ME 682 (downstream course) as a function of whether students in ME 682 took ME 320 with or without UGTFs. It can be seen that the addition of UGTFs to the ME 320 classroom in Spring 2016 correlated with a reduced percentage of students getting a D or F in the downstream course by 5.4%, and increased the percentage of students earning a C (8% compared to 1.8%), but did not improve the percentage of students scoring an A or B.

This data may be further parsed by examining Figure 5, which shows grades between ME 320 and ME 682 correlated for individual students. The data in Figure 5a shows student grades in ME 682 as a function of what grade the same student received in ME 320, for a semester in which ME 320 was taught without UGTFs. It can be seen that of the three students who earned a ‘C’ in ME 320, one of those students received a ‘D’ in ME 682, and two received an ‘A’ or a ‘B’. Figure 5b shows the same kind of analysis, except for a semester in which ME 320 was taught *with* UGTFs. It shows that of the six students who had earned a ‘C’ in ME 320, one went on to earn a ‘C’ in ME 682, and the other five earned ‘A’s and ‘B’s. This trend, while early, shows a promising result that a ‘C’ in ME 320 after the addition of the UGTFs may be capturing a higher level of learning and preparedness for subsequent courses. In other words, since the format of the downstream course remained effectively constant, the data imply that the *value* of a ‘C’ in ME 320 improved with the addition of the UGTFs.

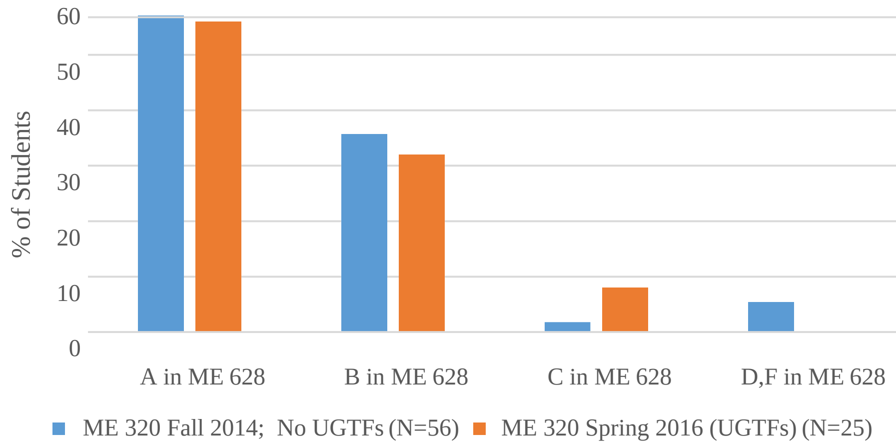

Figure 4. Performance in downstream course (ME 682) based on grades for students who took ME 320 with UGTFs (orange) compared to without UGTFs (blue).

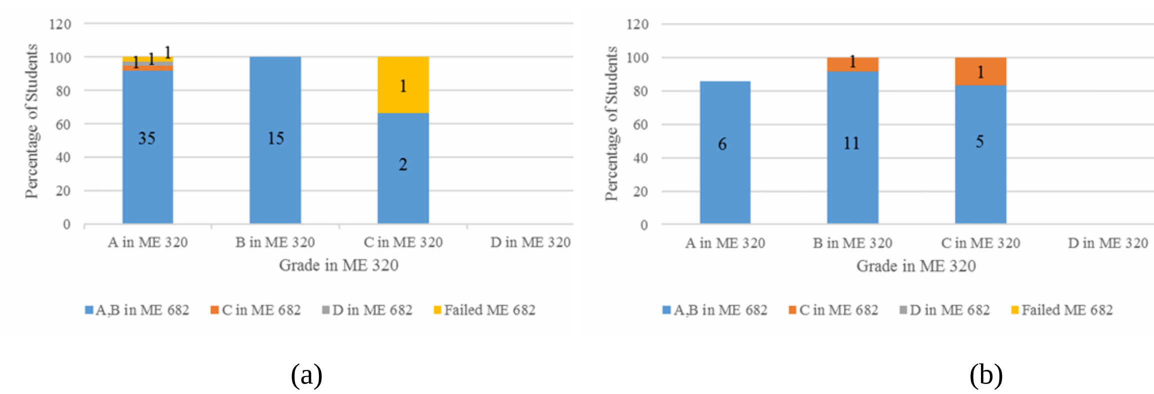

Figure 5. Performance in downstream course based on grades in upstream course in a given semester: (a) ME 320 taught without UGTFs; (b) ME 320 taught with UGTFs

Similar data analyses for the other courses showed mixed trends, leading to no firm conclusions regarding the influence of UGTFs on student learning. This is largely due to significant differences in the data populations included in the upstream and downstream course populations (which will balance with time), and significant pedagogical changes that have also been made in the corresponding downstream courses with time. Since pedagogical shifts are also occurring in downstream courses for those other cases, these analyses did not yield clear trends.

Conclusions

The authors have been studying the impact of Undergraduate Teaching Fellows (UGTFs) embedded in key undergraduate engineering courses. The inquiry has led to the following preliminary conclusions, which will be continually evaluated and retuned over the coming semesters and years:

1. The UGTF program is broadly considered a success by faculty, students, and the UGTFs. Faculty perceive student outcomes as improved due to utilization of UGTF resources, students perceive their learning as being strengthened due to the availability of UGTFs in-class, and UGTFs have concluded that their own content mastery has improved. Additionally, UGTFs report a great sense of belonging in their respective engineering departments, and improved professional skills such as communication and leadership skills.
2. Class observations performed using the COPUS protocol have indicated that the large majority of faculty utilizing UGTFs are implementing teaching practices that are student- centered. Additional course observations are needed in future semesters to examine whether the UGTF resources encourage further shifts towards student-centered teaching practices.
3. An examination of student performance in downstream courses was used as a means to examine whether the UGTF program was having an impact on student learning outcomes. The authors have concluded that while the results show promise overall that student learning outcomes are being positively impacted by the UGTF program, it is not prudent to form strong conclusions around still limited downstream course performance data. Additional data should be collected over two to three additional semesters so that a full set of results can be examined.

Overall, the UGTF program is perceived to be functioning as a success, a conclusion supported by the existing data. Future research should be performed in which survey, COPUS, and downstream course performance data are expanded over additional semesters to increase the significance of the findings. Longitudinal data should also be collected to examine how the UGTF resources may be influencing changes in adoption of student-centered teaching practices in the KU SOE.

References

Amaral, K. E., & Vala, M. (2009). What teaching teaches: Mentoring and the performance gains of mentors. *J. Chem. Educ, 86*(5), 630.

Beichner, R. (2008). The SCALE-UP Project: a student-centered active learning environment for undergraduate programs. *Invited paper for the National Academy of Sciences. Retrieved from http://www7.nationalacademies.org/bose/Beichner_CommissionedPaper.pdf*.

Close, E. W., Conn, J., & Close, H. G. (2016). Becoming physics people: Development of integrated physics identity through the Learning Assistant experience. *Physical Review Physics Education Research, 12*(1), 010109.

Collings, R., Swanson, V., & Watkins, R. (2014). The impact of peer mentoring on levels of student wellbeing, integration and retention: a controlled comparative evaluation of residential students in UK higher education. *Higher Education, 68*(6), 927-942.

Gafney, L., & Varma-Nelson, P. (2007). Evaluating peer-led team learning: A study of long-term effects on former workshop peer leaders. *J. Chem. Educ*, *84*(3), 535.

Gafney, L., & Varma-Nelson, P. (2008). *Peer-led team learning: evaluation, dissemination, and institutionalization of a college level initiative* (Vol. 16): Springer Science & Business Media.

Gosser Jr, D. K., Kampmeier, J. A., & Varma-Nelson, P. (2010). Peer-led team learning: 2008 James Flack Norris award address. *Journal of Chemical Education, 87*(4), 374-380.

Hug, S., Thiry, H., & Tedford, P. (2011). *Learning to love computer science: peer leaders gain teaching skill, communicative ability and content knowledge in the CS classroom.* Paper presented at the Proceedings of the 42nd ACM technical symposium on Computer science education, Dallas, TX.

McCavit, K., & Zellner, N. (2016). Persistence of physics and engineering students via peer mentoring, active learning, and intentional advising. *European Journal of Physics, 37*(6), 065702.

Micari, M., Streitwieser, B., & Light, G. (2005). Undergraduates leading undergraduates: Peer facilitation in a science workshop program. *Innovative Higher Education, 30*(4), 269-288.

Otero, V., Pollock, S., & Finkelstein, N. (2010). A physics department's role in preparing physics teachers: The Colorado learning assistant model. *American Journal of Physics, 78*(11), 1218-1224.

Smith, M. K., Jones, F. H., Gilbert, S. L., & Wieman, C. E. (2013). The Classroom Observation Protocol for Undergraduate STEM (COPUS): a new instrument to characterize university STEM classroom practices. *CBE-Life Sciences Education, 12*(4), 618-627.

Talbot, R. M., Hartley, L. M., Marzetta, K., & Wee, B. S. (2015). Transforming undergraduate science education with learning assistants: Student satisfaction in large enrollment courses. *Journal of College Science Teaching*, *44*(5), 24-30.

Van Dusen, B., Langdon, L., & Otero, V. (2015). *Learning Assistant Supported Student Outcomes (LASSO) study initial findings.* Paper presented at the Physics Education Research Conference.