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In-Class Peer Tutoring: A Model for Engineering Instruction*

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The in-class experience in engineering education has undergone modest improvements from traditional lecture and note taking in the last 25 years. Active learning is becoming more prevalent and can improve students' conceptual understanding of engineering topics, but its full potential has not been realized in science, mathematics, and engineering courses. The impact of active learning can be limited due to the lack of social learning resources, such as individuals who can answer questions during active learning exercises. Peer tutors used during class time to assist students during active learning exercises can provide this missing resource. Constructivist learning theories suggest that interactions with tutors may allow for the ability to address and interact with students pre-existing beliefs and conceptions that are the basis on which these students make sense of new material. In a similar vein, tutors provide opportunities for formative assessment that is considered as essential to student learning. Additionally, a wealth of empirical evidence demonstrates that peer tutoring positively impacts learning, self-concept, and attitudes towards the subject matter. In Fall 2007, Washington State University (WSU) researchers implemented an in-class peer tutoring (ICPT) program in statics and mechanics of materials. ICPT addresses the limitations of active learning and utilizes an effective and accessible resource—the students. In ICPT, undergraduate engineering students with relevant experience act as tutors for small groups of students during in-class active learning exercises. Extensive data from surveys, focus groups, and interviews indicate that the program is valued highly by students, improves students' mechanics self-efficacy primarily through mastery experiences, and provides an important resource for student learning. Tutors also benefit from the program, and have indicated in interviews that they had a better understanding of the material, improved communication skills, and self-fulfillment. WSU's ongoing ICPT program can act as a model for other universities, demonstrating the potential of peer tutoring to transform engineering education.

Keywords: tutoring; formative assessment; personalized student learning; active learning

1. INTRODUCTION

THE CLASSROOM experience of engineering undergraduates has the potential to impact student learning, retention, and attitudes towards the discipline. Students who leave engineering often cite poor teaching as one of the primary reasons for their departure [1]. Progress has been made in identifying best instructional practices, such as active learning [2], which have been shown to impact student learning. Active learning is characterized by students working independently or in groups during class on brief exercises that require them to process concepts more fully than simply taking notes. Formative assessment is an important part of active learning exercises where students receive feedback through purposive social interactions from other well-prepared students and/or the instructor. However, instructor feedback is limited due to the large student–teacher ratios, typically on the order of 60–400 to 1 in sophomore level engineering statics and mechanics courses at large universities. While active learning has been shown to be effective, its potential impact is limited by the ability for students to receive feedback on their learning during conceptually challenging exercises. Topping [3 pg. 20] supports this claim and suggests that 'Peer feedback is available in greater volume and with greater immediacy than teacher feedback.'

This concern is potentially addressed by more formally utilizing undergraduate students as tutors in the classroom setting. In a personal conversation with Jean Lave, noted researcher in learning theories [4, 5], about undergraduate education and innovative programs, she indicated that institutions of higher education must utilize a largely untapped resource, undergraduate students, to help other undergraduate students. This notion is supported by McKeachie, 'What is the most effective method of teaching? . . . Students teaching other students,' and 'There is a wealth of evidence

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that peer learning and teaching is extremely effective for a wide range of goals, content, and students of different levels and personalities' [6]. Remarkably, Bloom found that the only educational intervention shown to have a 2-sigma increase on student performance is one-on-one tutoring [7]. Additionally, students are an abundant, cost-effective, and available resource. For example, undergraduate-to-undergraduate peer tutoring has been shown to be more cost-effective than other programs with similar goals and proposed outcomes [8].

In-class peer tutoring (ICPT) programs lie at the intersection of the concern over improving retention, building upon proven practices of active learning, formative assessment, and tutoring, and utilizing the directly available and affordable resource of undergraduate students. ICPT was developed based on research on classroom practices and is characterized by utilizing undergraduate engineering students with relevant experience as tutors for small groups of students working on active learning exercises during scheduled lecture time. Although undergraduates often serve as tutors and teaching assistants, and informally may assist other students with courses, widespread formal utilization of undergraduate students in curriculum and instruction is virtually nonexistent.

A tutor is loosely defined as a person charged with the instruction and guidance of another, and tutoring takes many forms in grades K-16. Tutors can be of the same or more experience (cross-age) than the tutee. Tutoring programs utilize a broad range of training programs, from none, to extensive training on subject matter and interaction with students. In the case of ICPT the tutors are more experienced in the subject matter and receive training through weekly meetings with the faculty teaching the course.

2. THEORETICAL PERSPECTIVES ON ICPT

Educational learning theories support tutoring, specifically peer tutoring. Of particular relevance are the constructivist view of learning and Vygotsky's sociocultural theory of learning and the zone of proximal development. Both theories support the idea of using tutors who have recently mastered a topic. Constructivist learning theories suggest that individuals learn new materials and ideas within existing mental frameworks [9]. These frameworks are complex interwoven sets of ideas and beliefs based on previous experiences. In order for learning to be effective, instruction must take into account these existing frameworks. Although some curricular developments, such as cooperative learning and personalized electronic homework systems, attempt to address these individual differences, they have not been broadly implemented. Most importantly, they are inherently inflexible because the learner cannot respond and interact with the instructor in a personalized way. Tutors, however, can listen and respond to individual ideas and beliefs much more than existing systems can.

In his seminal work describing a sociocultural theory of learning, Vygotsky described the zone of proximal development [10]. The essence of this concept is the distance between the actual developmental level, as determined by independent problem-solving, and the level of potential development, as determined by problem solving under adult guidance, or in collaboration with more capable peers. Vygotsky argues that students learn most effectively when they operate within this zone. In other words, students should spend time in the zone that is just outside of what they can do on their own, and this time should be supported by those who can help students achieve a greater level of understanding. It is also important that the individuals helping students represent differing levels on the expert-novice spectrum [11]. Vygotsky posits that the mental models of 'near peers,' or those who have just learned certain material, are different than the mental models of experts in the subject, and that therefore, they use different language to discuss what they have learned. Therefore, one reason that peer tutoring works may be that tutors and tutees speak a similar language, whereas teachers and students do not [12]. From a different perspective, unlike adult-child instruction, in peer tutoring the expert party is not far removed from the novice party in authority or knowledge; nor has the expert party any special claims to instructional competence. Such differences affect the nature of discourse between tutor and tutee, because they place the tutee in a less passive role than does the adult/child instructional relationship. Being closer in prior knowledge and status, the tutee in a peer relation feels freer to express opinions, ask questions, and risk untested solutions. Thus, the tutee plays a more active role than in the teacher/student relationship. Conversations between peer tutors and their tutees are high in mutuality even though the individuals are not completely equal in status. These interactions are likely to occur in the zone of proximal development.

3. HOW CAN ICPT BUILD UPON ACTIVE LEARNING, FORMATIVE ASSESSMENT, AND TRADITIONAL TUTORING? BUILDING ON BEST PRACTICES

Active learning is any method that requires students to be engaged in the learning process during instructional periods [13]. Active learning activities may include solving problems, working on conceptual exercises, and focused discussions before and after lecture. Many studies have shown the benefits of active learning [e.g. 14, 15]. Not only does it improve conceptual understanding of engineering topics, it improves student involvement, attitudes, and retention [13].

In engineering classes, ICPT can build on the success of active learning. Students enrolled in the class have the added benefit of a smaller student-to-tutor ratio, and the peer tutors benefit from explaining problems to the students. Peer tutors have typically just taken the course, so they may be able to address common misconceptions more quickly than the instructor. Smith et al. [16] emphasizes the need for students to teach one another, have peer support, and get to know their classmates in order for them to succeed. ICPT can enhance the existing benefits of active learning, including providing a sense of community for the students and increasing student involvement and retention. ICPT creates an environment where students teach one another, and provides additional peer support they would not get in a traditional lecture class. The use of in-class peer tutors has the potential to improve the typical engineering model for active learning.

Formative assessment, or continuous feedback provided to students in the absence of associated decision making (i.e. evaluation), often occurs in conjunction with active learning, and may be enhanced and improved with ICPT. Substantial national interest exists in developing formative assessment, and specifically personalized feedback mechanisms, in higher education. Research suggests that it is critical to student learning. For example, the National Academy of Engineering named 'Personalized Student Learning' as one of the greatest challenges for the next century. The importance of formative assessment is also highlighted in the book How People Learn, 'Studies of adaptive expertise, learning, transfer, and early development show that feedback is extremely important,' 'Opportunities for feedback should occur continuously . . .as part of instruction' and further that 'Feedback is most valuable when students have the opportunity to use it to revise their thinking as they are working on a unit or project.' [11 pg. 140] The value of using peers for feedback is also supported by Topping 'A peer assessor with less skill at assessment but more time in which to do it can produce assessment of equal reliability and validity to that of a teacher.' [3 pg. 20] In an overview of the importance of classroom assessment based on research findings and a framework for formative assessment, the potential impact of formative assessment is described:

> 'There is a body of firm evidence that formative assessment is an essential feature of classroom work . . . We know of no other way of raising standards for which such a strong prima facie case can be made on the basis of evidence of such large learning gains.' [17 as quoted in Atkin, Black et al. 2001 pg. 12], and further that, ' . . . such practices are currently under-developed in most classrooms.' [18 pg. 13]

Formative assessment requires either the tutee seeking help or the tutor actively engaging the tutee without prompting from the tutee. Based on our observations of tutor-tutee interactions, the most common interactions are tutee initiated. Factors that promote help seeking behaviors have been researched extensively. The most common finding among children and adults is that individuals who 'experience difficulty should be more likely to ask for help when a task is presented as an opportunity to develop understanding and competence (task focus) than when it is presented as a test of ability (ego focus)' [19 pg. 262]. Nadler [20] also found that help seekers seek the least help when the helper is similar to themselves. Although at first this finding may seem contradictory to ICPT, Nadler [20] suggests that the help seeker was less likely to seek help due to 'evaluation apprehension' concerns, or negative subsequent evaluation from the helper. This may be the case with classmates, but is not as likely with peer tutors. Tutors are encouraged by faculty not to judge or evaluate students during their interactions with students and the limited contact between tutors and tutees (approximately one class period per week) makes this kind of interaction highly unlikely. Students do not see tutors as similar or threatening.

Previous research summarizes the effects of peer tutoring on academic and attitudinal outcomes [21]. Academic outcomes are performance on classroom and standardized exams and attitudinal outcomes include attitudes towards school. In all studies discussed below the effect of the tutoring was measured using effect size (ES), which is defined as the difference between the means of two groups divided by the standard deviation of the control group. In other words, an ES of one means that the average child in the tutored group scored at the 68th percentile of the students in the untutored or control group.

Tutoring programs have increased academic achievement for both tutors and tutees. Cohen et al. [22] found an average ES on tutor achievement in mathematics, reading, and other topics to be 0.40, with effects ranging from –0.5 to 2.5. The topics included in the other topics category were not reported in this article. Math tutoring programs had an ES of 0.60, compared to 0.29 in reading and 0.30 in other topics. Robinson et al. [23] found effect sizes on mathematics achievement on standardized exams to range from 0.75 to 1.17 for 4th through 10th grade. Cohen found that the average ES on tutees for mathematics achievement on classroom exams was 0.62 [22] and Robinson found effect sizes on classroom and standardized mathematics achievement ranging from 0.74 to 1.37 [23]. Interestingly, Robinson also found that tutors displayed improved achievement in topics other than those they taught, such as science and social studies, with effect sizes ranging from 0.29 to 0.48. Not only do tutees benefit from tutoring, the tutors themselves are better able to master a topic and communicate their mastery through explanation.

In all studies analyzed by Cohen et al. [22], researchers found that tutors and tutees participating in tutoring had better attitudes towards the subject matter being taught. The average ES for tutees was 0.29 and for tutors 0.42. Tutors and tutees were found to have increasingly positive attitudes towards tutoring programs [for a summary see 21]. Time on task, attendance, and retention were also found to be positively affected by tutoring programs [23].

Tutoring programs have been shown to have mixed effects on socioemotional outcomes, most notably self-concept. Self-concept refers collectively to the beliefs and assumptions that a person holds of themselves and is an overall evaluative judgment of one's own self-worth. In seven studies analyzed by Cohen et al. [22] in their meta-analysis, they found that self-concept was more favorable for students in tutoring programs than for students in traditional classrooms. In 12 cases, tutors were found to have higher self-concept than for those who did not serve as tutors. The average ES for students and tutors was 0.09 and 0.18, respectively. In their summary of research on tutoring and mathematics, Robinson et al. [21] found that tutors had a higher self-concept (ES = 0.59 to 0.64).

Specific features of tutoring programs and characteristics of students have been shown to affect various tutor and tutee outcomes [22]. Tutor training programs were shown to have minimal effects, while cross-age tutoring was shown to have increased effect sizes on achievement [22]. Cross-age tutoring utilizes students in higher grade levels, as opposed to students in the same course or grade level. Increased effect sizes on achievement were found in cross-age tutoring programs for tutees (ES = 0.49 vs. 0.29) and less so for tutors (ES = 0.35 vs. 0.28). Although the effects of tutor training on achievement are not remarkable, tutor training programs have been found to result in 'more instructionally sound interactions, including a more interactive style of explanation of regarding mathematics operations' [23 pg. 342]. Additionally, mathematics achievement was affected much more by tutor training programs than reading achievement [22].

All tutors and tutees in the studies referenced above were from either elementary or secondary school and occurred outside of the formal classroom setting. Tutoring has been shown to be beneficial for elementary and secondary school, but there is a lack of research on the effectiveness of tutoring in higher education, particularly on the use of tutors in the formal classroom setting. Although there are obvious differences between elementary and secondary school and higher education, some extrapolations can be made to higher education. Despite such extrapolations, there remains a strong need for research on the effectiveness of tutoring and ICPT in higher education. ICPT in particular has the potential to be a strong tool in engineering education, as the need for social support to be successful in such a challenging discipline is consistent and well documented [1, 24, 25].

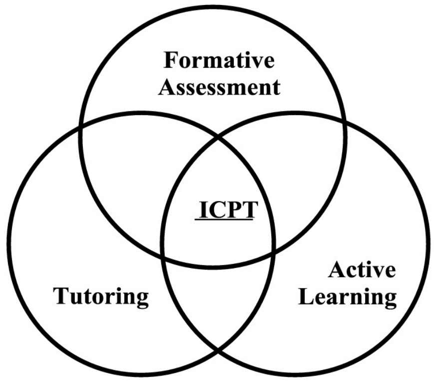

Fig. 1. ICPT at the Intersection of Formative Assessment, Active Learning, and Tutoring.

The three constructs of formative assessment, active learning, and traditional tutoring, and the ICPT program at the intersection of these constructs, are shown in Fig. 1. The intersection of formative assessment and active learning is the learning interactions that take place during active learning either between students or students and teachers. Although these interactions are valuable, their impact is often limited due to the lack of knowledge of the students and the inability of the teacher to reach all of the students. The intersection between formative assessment and tutoring is learning interactions that take place between the tutor and tutee.

Historically, these interactions almost never take place in the classroom. The intersection of active learning and tutoring is similar to that of active learning and formative assessment, and is characterized by interactions between students and between students and other teachers. However, the value of these interactions is limited if formative assessment is not occurring. Tutors are potentially a better resource than other students because they have recently mastered the topic and assigned problems, and they have identified common areas of difficulty in the problems (see discussion of preparation below).

4. IMPLEMENTATION OF ICPT AT WSU

The ICPT program utilizes students who have recently taken a particular course (tutors) to assist students (tutees) in learning the material from the course. ICPT was implemented in statics and/or mechanics of materials (MOM) at WSU every semester since fall 2007. The program was also implemented in statics at Oregon State University every semester since spring 2009. Data presented herein is from the 2007–2008 academic year. The class size ranged from 39–60. At WSU in fall 2007 and spring 2008, one instructor taught both MOM

Table 1. Course Enrollments and Number of Peer Tutors in ICPT Courses

	Statics Fall 2007	**MOM Fall 2007**	**Statics Spring 2008**	**MOM Spring 2008**
Course Enrollment	60	39	58	55
Number of Peer Tutors	5	8	6	3

courses and one instructor taught both statics courses. A summary of student enrollment and number of tutors used in each course is summarized in Table 1.

In Fall 2007, the first term the program was implemented, the ratio of students to tutors was approximately 5:1. In following semesters, this ratio was changed to approximately 10:1 based on student feedback. Students reported that this many tutors were not necessary because sufficient opportunity for feedback from tutors was available with lower tutor to student ratios. Although a ratio of 10:1 is the goal, ratios sometimes differed slightly based on availability of effective tutors. Tutors were compensated with gift certificates of $150 in Fall 2007 and reduced to $100 for later semesters based on tutor feedback. The current reimbursement scheme and implications are discussed below.

In most cases, the instructor selected students from the same course he/she taught the previous semester. In cases where the instructor did not teach the course the previous semester, one of the instructors teaching the ICPT course the previous semester assisted in recruiting the tutors. Tutors were selected based on academic achievement in the course (receiving an A or B in the course), attitudes towards learning, and general impressions by the instructor. Students who were top achievers were not necessarily deemed the best potential tutors, and equal weight was given to the instructor's evaluation of how well a student would be able relate and communicate with students. The selection process was informal for the duration of the program. Selection of tutors became easier as the program progressed. One instructor who implemented the ICPT program has indicated that students often approach her requesting to be peer tutors. It appears that these students have a strong interest in helping other students and see the value in participating in the ICPT program as a tutor, including learning the material more thoroughly through the tutoring process and improving their communication skills.

ICPT sessions occurred approximately once per week, after one or two lectures on the topic. The instructor provided exercises to tutors about one week prior to the ICPT session. One or two days prior to the ICPT session, the instructor met with all peer tutors. In these meetings, the instructor provided insight into normal stumbling blocks for students during such exercises, and tutors asked for clarification on aspects of the problem that they did not understand. The tutors were also instructed to walk around and ask the students if they had any questions, especially those students who were staring at their paper and not writing anything. Studies suggest that formal training does not improve outcomes for tutors or tutees [22]. As a result, the tutors only received training during these weekly meetings; there was no formal training of the tutors.

The active learning activity utilized during an ICPT session lasted from 20 to 40 minutes during the 50-minute class period and consisted of typical homework problems and conceptual problems such as ranking tasks. Activities were challenging enough so that most students could not complete them on their own. In the MOM course at WSU, an active learning activity during the class period consisted of a typical homework problem and two or three ranking tasks. Ranking tasks are comparative exercises in which students are provided with six similar scenarios and asked to rank the scenarios based on a specific criteria. For example, students were given six identical simply-supported beams with the same distributed load. They were then asked to rank locations in the cross-section based on the bending moment, shear force, normal stress, or shear stress at these locations and explain their reasoning for their ranking. Ranking tasks were chosen because they were challenging enough that students needed to interact with each other and tutors to successfully complete the exercises.

A typical ICPT process could be illustrated with the Spring 2009 Mohr's circle topic in MOM. The first step was the instructor provided the Mohr's circle in-class assignment to the peer tutors the Friday before the session. The peer tutors did the assignment before the weekly meeting with the instructor. Monday and Wednesday's classes were devoted to lectures on what Mohr's circle is, how it is derived, and how to draw Mohr's circle. The instructor then met with the peer tutors on Wednesday and went over the solution to the in-class assignment. The instructor first asked the tutors what their solution was, and then asked if they had any questions. The instructor also pointed out concepts that students typically have difficulty with related to Mohr's circle. During Friday's class, the instructor spent approximately 20 minutes going over an example, and the remaining 40 minutes were dedicated to the ICPT session. The peer tutors walked around helping the students, often sitting down with them and providing one-on-one help. The instructor was present during all ICPT sessions, and provided feedback and help to the students as well.

5. EVALUATION OF WSU'S ICPT PROGRAM

Since its inception in Fall 2007, WSU has assessed the ICPT program with a variety of methods. These methods include a survey with Likert scale and open-ended questions, focus groups with tutors, and individual interviews with students who experienced peer tutoring. Currently, data is available for Fall 2007 and Spring 2008 at WSU only. The survey and focus groups are considered assessment, primarily because they are not guided by a specific theoretical framework and associated research questions. However, the individual student interviews are part of a newly initiated research program on the ICPT program funded by the National Science Foundation. Although we will be conducting concept inventories in the future, the current study did not assess improvements in student learning.

The survey included seven Likert-scale questions (listed in Table 2) a gender question, and two open ended questions. Likert-scale responses ranged from completely agree, somewhat agree, neutral, somewhat disagree, and completely disagree responses, with associated values of 5–1, respectively. Question 4 is a reverse question for reliability. A response of 1 to this question would indicate that the student strongly disagreed with this statement. Survey questions 1–6 were developed to assess student attitudes about the ICPT project. The sole purpose of these questions was to determine if students who had experienced the ICPT program found the tutors valuable. Although these Likert-scale questions were not taken from a previously validated survey or based on a specific theoretical framework, results still add value to understanding the impacts of the ICPT program. Interpretation of results must be in concert with survey development. For example, from the survey results we know that most students agree with the statement, 'The peer tutors have been helpful to me in this course.' At this time, it is uncertain in what ways the tutors are helpful, which will lead to future research efforts in this area. Survey questions 7 and 8 are based on the Classroom Life Survey [26–28] and were used to investigate student attitudes about the contribution of tutors to the classroom environment. Average and median responses for each question are listed in Table 2. Although averaging Likert-scale responses is not considered reliable due to the potentially non-scalar quantity of the responses (i.e. the distance between 5 and 4 may not be the same as the distance between 4 and 3), average values are still helpful in the interpretation of the pool of responses. Results for Questions 1 and 3 show that students see the value of the peer tutors. More than 80% of students in all four courses either completely or somewhat agree with these two questions.

Survey data was analyzed to determine the relationships between survey questions. A correlation analysis was performed on the eight questions noted in Table 2, age and gender. Responses to Questions 1 and 3 as well as 2 and 6 indicate that, although students think that tutors are helpful and wish they were used in other courses, it is not as clear to these students that they have learned more or their performance has improved as a result of the peer tutors. This discrepancy is an interesting area for future research.

Only Question 3 was positively correlated ($p < 0.05$) with gender. However, the correlation coefficient (0.20) was indicative of a weak correlation. Questions 1–4 and 6 were highly correlated ($rho > 0.70$ and $p < 0.001$). The Cronbach Alpha reliability coefficient was calculated for this group of variables and found to be 0.92. The high reliability of this group of questions makes sense, as all questions are related to the value of the tutors in helping the students and improving their learning. Responses to Question 5 are mostly positive, with an overall average response of 4.2. However, responses to this question were not highly correlated to the other survey questions. Questions 7 and 8 were moderately correlated ($rho = 0.581$, $p < 0.001$). These questions were adapted from a previously validated classroom life survey [28] and social capital survey [24], and were expected to be correlated.

Some typical open-ended responses to the question 'In what ways did the peer tutors help you this

Table 2. Results of Student Responses from the ICPT Survey using a Likert Scale. Average and median values are shown (median values in parentheses). Number of survey respondents shown in parentheses after each course

Survey Question	Statics Fall 2007 (27)	MOM Fall 2007 (35)	Statics Spring 2008 (25)	MOM Spring 2008 (44)	Average
1. The peer tutors have been helpful to me in this course	4.0 (4)	4.6 (5)	4.2 (4)	4.3 (5)	4.3
2. I have learned more in this course because of the peer tutors	3.5 (4)	3.9 (4)	3.7 (4)	3.8 (4)	3.7
3. I wish that my other engineering courses used peer tutors	4.0 (4)	4.5 (5)	4.2 (4)	4.2 (4)	4.2
4. The peer tutors did not add any value to this course	2.2 (2)	1.5 (1)	2.0 (2)	1.9 (1)	1.9
5. The peer tutors were able to answer my questions	4.0 (4)	4.4 (5)	4.3 (5)	4.2 (4)	4.2
6. My performance in this course was improved because of the peer tutors	3.6 (4)	3.9 (4)	3.4 (4)	3.8 (4)	3.7
7. The peer tutors want me to do well in this course	4.6 (5)	4.4 (5)	4.5 (5)	4.1 (4)	4.4
8. The peer tutors have gone out of their way to help me	4.0 (4)	4.1 (4)	4.1 (4)	3.7 (4)	4.0

term?' were, 'They were able to explain things in terms I could understand,' and '[They] explained concepts to me.' Results of this survey indicate that students perceive that peer tutors are valuable in the course and helpful in learning.

At the conclusion of the Fall 2007 semester a focus group was held with tutors to assess the program. Tutors were asked about factors that motivated them to participate in the tutoring program and what level of reimbursement was appropriate. Although the tutors indicated that they participated in the ICPT program to improve their understanding of the material and their communication skills, as well as for self-fulfillment, they also agreed that some form of financial reimbursement was necessary. All tutors present agreed that $100 was a reasonable amount. Since that time we have offered tutors $100 for participation in the program, and many tutors do not end up accepting their gift certificate at the end of the experience. When asked why, students commonly respond that they received enough personal benefit that they did not think financial reimbursement was necessary. This is a remarkable and very important pattern. The sustainability of this program is greatly enhanced if there is little or no cost.

5.1 Ongoing and planned research

Research is currently being conducted to investigate actions and reasons for actions of peer tutors during ICPT sessions, the link between ICPT and social capital, and the impact of the ICPT program on student MOM self-efficacy and knowledge of engineering statics and MOM.

Preliminary results indicate that tutors who think that a good peer tutor is one that is interested in helping students learn spend more time preparing for the tutoring sessions, are more pro-active in helping students, and have a stronger sense that they have provided value to the students. In contrast, tutors who think that a good tutor is one that is academically prepared spend less time preparing, are less pro-active, and report providing less value to the students.

Social capital consists of the resources embedded in social networks that are accessed by members of that network. Initial results of the project on social capital indicate that students view the ICPT program as an essential and productive resource in the WSU engineering program. In today's financially distressed environment, utilization of affordable resources is particularly important. The knowledge that students bring into class from previous courses is a vital and largely untapped resource.

The impact of the ICPT program on students' MOM self-efficacy, or confidence in their ability to be successful in MOM, is also being investigated using in-depth interviews. Initial results indicate that students' interactions with peer tutors positively influence their MOM self-efficacy. It appears that students see these interactions as what Bandura calls mastery experiences [29], characterized as successfully solving problems and resulting in students having more confidence.

Substantial learning improvements have resulted from the use of tutors [22, 30] in settings that vary broadly, but are all different in some way than ICPT. The presence of relevant social resources in the classroom setting has substantial potential for improving student learning in this setting through interactions between tutors and students. Although the impact of the ICPT program on student learning has not been studied to date, future research will focus on these impacts by investigating performance differences on common exams and concept inventories. Additionally, student demonstration interviews [31–33] will be used to evaluate students' conceptual understanding and how development of this understanding relates to the ICPT experience.

7. CONCLUSIONS

An abundance of educational research exists supporting the value of peer tutoring to students and tutors and that tutoring is a cost effective method for improving education. Preliminary evidence from the ICPT program at WSU suggests that students and faculty see tremendous educational value in the program. Even in the presence of existing research, tutors are not commonly used in the classroom setting to support learning in engineering education. ICPT is a relatively easily implementable program that can serve as a model for instruction in engineering education.

Substantial theoretical and empirical evidence from previous studies, as well as from the WSU assessment process, suggests that the ICPT program has a strong potential to have significant benefit to students and tutors. It appears that students see tremendous value in the tutors and that tutors learn from their experience. More research is needed to investigate the efficacy of this program on important student outcomes. Two new research projects on the WSU ICPT have already begun, one focused on the impact of the program on student social capital, and the other on peer tutoring and students' self-efficacy in MOM.

In order for higher education programs to be sustainable, several factors must be in place. The program must be beneficial to students, be easily implementable by faculty, and be affordable. The emerging finding that students do not require financial reimbursement highlights the sustainability of the ICPT program. Results show that the program is valuable for students and tutors, and is easily implemented by faculty. The WSU ICPT program can act as a model for other engineering programs, and thus impact the culture of engineering education.

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