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Influence of Collaborative Curriculum Design on Educational Beliefs, Communities of Practitioners, and Classroom Practice in Transportation Engineering Education

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ABSTRACT

The development and widespread implementation of best practices in transportation engineering classrooms is important in attracting and retaining the next generation of transportation engineers. Engineering education professionals have uncovered many best practices in the field; however, the process of effectively disseminating and ultimately achieving the widespread adoption of these best practices by others is not yet well understood. Sixty participants, comprising faculty members, Ph.D. students, and public sector employees, attended a Transportation Engineering Education Workshop convened in Seattle, WA to promote the collaborative development and adoption of active learning and conceptual exercises in the introduction to transportation engineering class. Participant assessments were conducted in the

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form of pre-, post-, and follow-up surveys. Results showed immediately positive shifts in participant beliefs about the importance of active learning and conceptual exercises with declines during the follow-up period, an increased density and connectivity of curriculum development networks, and extensive reports of valuable experiences and influences from the workshop.

KEYWORDS: National Transportation Curriculum Project**,** NTCP; Introduction to Transportation Engineering; Adoption of Innovation; Conceptual Change; Active Learning; Workshops

INTRODUCTION

A large body of evidence from suggests that student learning and other outcomes improve when students are doing something other than listening and taking notes in the classroom (e.g. Hake 1998; Hake 2002; Chi 2009). However, despite both evidence for the value of these activities and access to a variety of resources that can be used to support them, most engineering faculty members still engage in primarily a lecture approach (Borrego 2010); transportation engineering is no exception.

The first transportation engineering class at the undergraduate level in a civil engineering program poses significant challenges (Bill et al. 2011 and Kyte 2013). These challenges include making tradeoffs between breadth and depth of learning, addressing a lack of sequential progression across multiple classes, and capturing the interest of students who are required to participate in the class as a program requirement. Implementation of active learning, which can be defined as activities other than merely listening and taking notes as explained further in the next section, has the potential to improve student engagement in the face of these challenges.

The National Transportation Curriculum Project (NTCP), a consortium of researchers from eight colleges and universities, formed as a collaborative effort to respond to these challenges and improve transportation engineering education. In 2012, the NTCP hosted a Transportation Engineering Education Workshop (TEEW) to facilitate the adoption of active learning and conceptual assessment exercises by faculty who teach the first transportation engineering class at the undergraduate level in a civil engineering curriculum. The TEEW provided the opportunity for groups of faculty to develop active learning and conceptual assessment exercises collaboratively in a process scaffolded by short presentations and demonstrations, and punctuated by direct feedback by nationally recognized experts in these areas.

The objective of the workshop was to facilitate changes in transportation engineering faculty members' attitudes and actions. Such change can be encouraged by shifting faculty members' beliefs about the importance of active learning and strengthening a curriculum development network that provides materials and resources related to change. We hypothesized that a workshop in which faculty members 1) acquired tools for the design of active learning and conceptual assessment activities, 2) applied those tools in a collaborative environment, and 3) developed a network of similarly-motivated colleagues would effect positive change in participants' attitudes and actions with respect to active learning and conceptual assessment. Shifts in faculty beliefs towards active learning and the density and connectivity of their curriculum development networks related to teaching practices were evaluated over time, and the impact of the TEEW was assessed with reflective open-ended survey questions. This paper describes the rationale for adoption of active learning and conceptual exercises, the workshop and materials produced from the workshop, and the evaluation of the effectiveness of the workshop.

BACKGROUND

The NTCP is concerned with the development, dissemination, and widespread adoption of curricular materials and best practices in transportation engineering education (Kyte 2013). Figure 1 describes the NTCP starting with inputs such as knowledge and time of faculty and students, resulting in outputs such as conferences and workshops, and outcomes such as building a curriculum development network committed to transportation engineering education. To date, project members have developed learning outcomes and associated knowledge tables for the introductory transportation engineering course (Bill et al. 2011), which were piloted at three institutions (Young et al. 2012). The workshop described here resulted from NTCP members' efforts to engage a broader group of faculty members in this work by 1) developing participants' capacity and enthusiasm for creating and implementing active learning and conceptual assessment activities, and 2) building a network of colleagues engaged in these activities (a curriculum development network).

Active Learning

Engineering faculty members have not widely implemented newer pedagogical approaches that have been proven to be effective, and adoption occurs slowly. Borrego et al. (2010) found that awareness of innovative educational approaches was high among engineering faculty members, but that adoption rates were much lower; that is, the stumbling block is not awareness but rather implementation. One such pedagogical approach is active learning. For the purpose of this paper, active learning is considered to be any student activity other than listening and taking notes, ranging from responding to instructor questions to working on challenging conceptual design problems with other students and more experienced tutors. Evidence exists that active learning in engineering, science and mathematics courses improves student learning and other important student outcomes, such as their belief they can succeed in engineering (e.g. Hake 2002; Prince 2004; Chi 2009).

The most contemporary and by far the most complete analysis of the effectiveness of different active learning environments was conducted by Chi (2009). Chi describes three different kinds of learning environments: active, constructive and interactive. According to Chi, an active learning environment engages students in individual activities that are not particularly cognitively challenging, such as taking notes, or highlighting passages. Students in a constructive learning environment engage in activities that are more difficult than the material students have recently learned, such as combining multiple concepts to solve a more difficult problem than has been solved before. Finally, in an interactive environment, students perform constructive activities with other students. This operationalization of active learning environments is important because Chi found that interactive activities have a greater impact on student learning than do constructive activities, which in turn have a greater impact than simpler active learning activities. As a result, and as defined above, we do not include Chi's definition of an "active" learning environment in our definition; rather, we include the levels she terms "constructive" and "interactive." Further, a critical component of the active learning classroom is the difficulty of the activities in which students engage. If the activities are too simple then students will not work together (Brown 2009), and if they are too difficult then students will become frustrated and give up.

Conceptual Assessment

Conceptual assessments have been implemented in active learning environments to foster student learning of concepts, as opposed to the memorization and strict application of equations. They are characterized by solutions that require minimal or no need for equations and calculations if the user understands the concepts. A ranking task (O'Kuma et al. 2003; Brown and Poor 2010) is an example of a conceptual assessment. In a ranking task, students are provided with four to six scenarios and asked to rank the scenarios based on specified criteria. For example, Figure 2 shows a ranking task related to a specific element of roadway design, superelevation (or “banking”) on horizontal curves. This ranking task is designed to be solved almost immediately by an expert without the use of calculations; a student, however, might require an extended period of time and may need to complete some calculations. Since the task can be completed without calculations, it is considered to be “conceptual” according to our definition above.

A passive approach with single solution problem solving is common practice in engineering courses, despite evidence that it is less effective than the active approach with a conceptual focus. Changing faculty practices is challenging, and change efforts can be informed by frameworks that consider the process of adoption of a new idea or approach.

Adoption of Change

Multiple theoretical approaches provide insights into the change adoption process, including Diffusion of Innovation (Rogers 2003), the Concerns Based Adoption Model (Hall and Hord 2006), and the culture of higher education and the impact on individual change (Godfrey 2003). Two themes that are influential to faculty change cut across these approaches: social networks and beliefs about the importance of change.

Social capital comprises resources embedded in social networks that are available to members of that network (Lin 2001). Social networks are a core component of change because connections with individuals can serve educational purposes (to know more about an innovation), resource purposes (to have access to materials from others), and support purposes (to be part of a community of practice that shares the same goals and vision (Wenger 2000)). In our work, individuals’ networks were assessed specific to the sharing or co-development of curricular materials for their transportation engineering courses; we refer to this as a "curriculum development network."

Faculty beliefs about the importance of educational innovations also are an important component of the change process: "Results of studies … imply that the way teachers adapt or adopt new practices in their classrooms relates to whether their beliefs match the assumptions inherent in the new programs or methods" (Richardson, et al. 1991). In several studies, the level of importance educators attribute to an innovation correlates with whether they adopt this innovation. For example, Thompson (1984) reports that, "Teachers develop patterns of behavior that are characteristic of their instructional practice." In some cases, these patterns may be manifestations of consciously held notions, beliefs, and preferences that act as "driving forces" in shaping teachers' behavior. In other cases, the driving forces may have evolved out of the teacher's experience." Sparks (1988) concurs that "… teachers who saw these practices as important were more likely to use them."

TEEW OBJECTIVES

The agenda and assessment for the TEEW were shaped by the literature described above. We seek to facilitate the development of a common vision and a curriculum development network, which will encourage the increased and enhanced implementation of active learning strategies through the workshop and follow up activities. At the TEEW, we attempted to provide a compelling body of evidence that active learning environments are effective for student learning, and we provided multiple pathways for faculty to implement active learning in the classroom. We measured the workshop's effectiveness by investigating changes in beliefs about the importance of active learning using conceptual assessments, curriculum development networks, and value of the workshop to participants.

The following objectives were established to determine the impact of the TEEW on shifts in faculty beliefs towards active learning and conceptual assessment exercises, in the density and connectivity of this curriculum development network, and in reported classroom practice.

- Change the beliefs of transportation engineering educators regarding the importance of active learning and conceptual assessment exercises in the introduction to transportation engineering class.
- Contribute to the development of a curriculum development network of transportation engineering educators committed to the collaborative development of improved educational resources for the introduction to transportation engineering class.
- Increase the use of active learning and conceptual assessment by transportation engineering educators in the introduction to transportation engineering class.

Active learning exercises are defined broadly as any classroom engagement that is not passive (i.e., merely listening to a professor speak and taking notes). These exercises might include groups of students working together facilitated by the instructor, described as interactive by Chi, or exercises representing a difficulty beyond that which had been previously encountered in class, described as constructive by Chi. For the purposes of this work, we do not include Chi's lowest level of "active" learning. Conceptual assessment exercises are defined as any classroom engagement in which students are not tasked with the direct application of equations and the calculation of solutions; that is, they are required to describe the idea in words or pictures.

METHODOLOGY

To test our hypothesis that a well-designed workshop would effect positive changes in participants' beliefs, practices, and networks, we recruited a diverse group of participants, developed and executed a compelling and highly interactive two-day conference and workshop, and developed and administered a pre-, post-, and follow-up survey.

Participant Demographics and Recruitment

Facilitated group activities were a central element of the TEEW, so it was particularly important to ensure a diverse group of conference participants. The demographic elements considered when selecting participants included school type (public and private, as well as community colleges and, 4-year BS, MS, and/or PhD granting institutions), faculty rank (adjunct faculty members, instructors, and tenured/tenure-track assistant, associate, and full professors), instruction experience, geography (pacific, mountain, central, and eastern time zones), gender, and race/ethnicity. The 60 conference participants (46 engineering faculty members, 5 public sector employees, and 9 Ph.D. students) were distributed from across the United States (Figure 3).

Participants were recruited actively by the conference organizing committee both personally and through advertisements distributed on numerous list serves, including the civil engineering department heads list serve.

Activities

The TEEW activities were designed around two themes 1) the provision of evidence by nationally recognized experts supporting the efficacy of active and conceptual learning, and 2) the opportunity to collaboratively apply the new knowledge acquired. The presentations were intentionally short to keep the energy levels of the participants high and to maintain our focus on participants actively engaging in the content.

For example, one collaborative activity included a group of participants brainstorming the development of a ranking task considering the required sample size for spot speed observations. In this activity, a group of 6 participants was given a broad area of interest (traffic operations in the introduction to transportation engineering class) and then was tasked with selecting a concept and developing an outline for at least one ranking task dealing with that concept. At this stage in the workshop, ideas of context (how the idea is situated and presented) and confoundedness (interrelatedness and complexity) were not yet considered. The brainstorming work of the faculty groups was recorded by hand on large pads of paper, which were digitized and transcribed into .docx files for dissemination to all of the conference participants and other interested parties through the NTCP website (http://nationaltransportationcurriculumproject.wordpress.com/). Additionally, dissemination of the materials developed at the TEEW took place through the ITE Education Council in the form of presentations at the Mid-year and Annual Meetings, newsletter articles, and in a presentation and conference paper presented at the 2013 ASEE annual meeting (Sanford Bernhardt et al. 2013).

The workshop resulted in the collaborative development of 108 draft learning activities and ranking tasks, 60 of which have been digitized and refined. These 60 activities include traffic operations topics such as the fundamental diagram of traffic flow, time-space diagrams, cycle length, and delay, as well as design topics such as stopping sight distance on isolated vertical and horizontal curves, the alignment of horizontal curves in sequence, and vehicle cornering. Additionally, the workshop can serve as a model for dissemination and adoption of best transportation engineering teaching practices and materials moving forward (Sanford Bernhardt et al. 2013).

Evaluation

To measure the impact of the TEEW on conference participants, three surveys were developed and administered in sequence. The pre-survey took place as the initial activity on day one of the conference, the post-survey took place as the last activity on day two of the conference, and the follow-up survey was administered six months after the conference. The categories of questions included beliefs about active learning and conceptual assessment exercises, engagement in this curriculum development network, and qualitative open-ended questions about the value of the workshop structure (Table 1).

Despite extensive evidence of the value of active learning and the link between beliefs and practices, no survey scales were found on teacher beliefs about active learning. Development and implementation of these questions in our study is the first step in establishing the validity and reliability of the questions. Six belief questions were developed and are shown in Table 1. Belief items utilized a 5-point Likert Scale (strongly agree, agree, neutral, disagree, and strongly disagree) accompanied by an open-ended text box where a justification could be added. Some evidence of validity was found in responses from the justification text box, as discussed in the results. Specifically, we found and analyzed evidence of respondents' interpretations of the questions. Belief survey questions were analyzed for reliability using the Cronbach alpha reliability test. Shifts in beliefs across all three surveys were analyzed with paired t and chi-squared tests.

Network data was collected by asking all participants to indicate whether they had "Co-Developed", "Given To", or "Received From" curricular materials for all other conference participants. Network maps were developed with network nodes representing individuals and directional links representing the sharing of teaching materials. The shift in the curriculum development networks was determined by percent changes in the inclusivity (number of points that are included within the various connected parts of the network) and connectivity (general level of linkage among the points in a graph) of the network from the pre- and follow-up survey.

Open-ended survey questions related to the value of the conference and ways in which it influenced participants' practice are shown at the bottom of Table 1. Collecting qualitative data allows researchers to investigate and understand how participants interpreted and acquired value from the experience and how and why their practices changed as a result (e.g., Creswell 1998; Patton 2002). Qualitative survey data was analyzed by developing codes that described the value that participants found in the conference and counting the prevalence of these codes (Huberman 1994).

RESULTS

The next sections detail the results for each of the categories, beliefs about active learning and conceptual assessment exercises, engagement in curriculum development networks, and the value of the workshop (Table 1).

Educational Beliefs

Responses to open-ended questions about active learning almost uniformly included text about students doing something other than listening; examples include "try out what they have learned", "engages students in the class", and provides opportunities for "learning by doing."

Similarly, open-ended responses related to conceptual learning were generally focused on engagement with the concepts or ideas and not just calculating numbers. Example responses are "help students explain what the equation is" and "students be able to apply, not just regurgitate." These responses indicate that survey respondents interpreted this set of questions in reasonable alignment with our proposed definitions of active learning as "students doing something other than listening and taking notes in the classroom" and conceptual exercise as focused on the concepts and not requiring calculations.

Figures 4 through 6 show participant responses to the six belief questions. Generally, participants strongly agreed (range of 41% to 65%) or agreed (range of 35% to 46%) with the idea that active learning and conceptual assessment exercises are an important part of lecture (Figure 4).

A similar pattern was observed in that participants strongly agreed (50% to 67%) or agreed (30% to 44%) with the idea that active learning and conceptual assessment exercises improve student learning (Figure 5).

Of the six belief questions, the extent of agreement with the notion that all instructors should implement active learning and conceptual exercises was the least consistent (Figure 6). The majority of respondents again stated that they agreed or strongly agreed however, compared to the other questions, a larger percentage of participants were neutral or even disagreed, particularly in the 6-month post survey.

The educational beliefs survey responses using the 5-point Likert Scale were transformed into numerical values with "Strongly Agree" responses given a value of 5 and "Strongly Disagree" given a value of 1. For the 57 participants who responded to one of the three surveys, 41 individuals completed the pre- and post-surveys, 31 the pre- and follow-up surveys, and 24 completed all three surveys. Response rates provide meaningful evidence; however the representativeness of the sample is more critical as we are interested in observing the responses across time. Even at our lowest response rate of 40%, we are confident that the sample reflects the population of participants.

Simple means and standard deviations for the paired and unpaired observations are shown in Table 2. Most of the participants strongly agreed with the statements in both the pre- and post-surveys. Question 1 scored the highest in both pre- and post-surveys; for the follow-up survey, the question on whether active learning improves student understanding scored slightly higher.

When comparing the results of the pre- and post-surveys, in all cases except question 6, which asked whether conceptual exercises should be implemented by all instructors, the responses were higher (i.e. more favorable) in the post–survey when compared to the pre-survey. For question 6, the average was slightly lower when all observations were included and slightly higher when only the paired observations were analyzed. The standard deviations were lower for questions 1 (active learning importance), 3 (active learning implementation), 4 (conceptual exercises importance), and 6 (conceptual learning implementation) indicating more consensuses among the participants. There were very minor increases in standard deviation for questions 2 and 5.

We found different results, however, when comparing the pre- and follow-up surveys. For all six questions the numerical results were lower. For questions 1 (active learning importance), 2 (active learning improves learning), and 5 (conceptual exercise improves learning) the differences were slight. Questions 3 and 4 showed larger differences for both questions.

To determine whether the differences shown in Table 2 are statistically significant, we performed both a Chi-Squared test and a paired t test; Table 3 shows the resulting p-values. The chi-square test analyzed whether there was a significant difference between the observed frequencies in the pre- and post- survey and pre- and follow-up survey using the 24 observations where all three surveys were completed. Question 5 (conceptual exercises) was the only question found to have a significant difference between the pre- and post-surveys using the Chi-Squared statistical test. When comparing the pre- and follow-up survey, question 5 again was found to be significant along with question 6 (conceptual exercise implementation).

A second analysis was performed using the paired pre- and post- observations and a t-test statistic. For the pre- vs. post- analysis, differences in responses to question 3 (active learning implementation) were found to be statistically significant and question 1 (active learning importance) was very close to the significance level of $\alpha=0.05$ ($p=0.057$). For the pre- vs. follow-up survey, question 3 again was significant along with question 6 (conceptual exercise implementation).

The survey questions as a whole were intended to measure participants' beliefs about the educational value of active and conceptual learning exercises. To determine whether sets of questions constitute a scale (the questions are not independent, and in fact different ways of asking the same question) the Cronbach Alpha Reliability Coefficient was calculated for the three active learning questions, the three conceptual exercise questions, and all questions together for each of the three survey implementations, pre-, post-, and follow-up. Resulting values are shown in Table 4 and generally indicate that each set of three questions and the six questions constitute a scale, considering all values are greater than 0.7 (Kline, 1999). A new variable was calculated as an individual's average response to all six questions (table 4, column four), representing the scale of the educational value of active learning and conceptual exercises.

Paired t-tests were conducted for three combinations using the new variable, pre- and post-, pre- and follow-up and post- and follow-up. Resulting p-values are 0.011, 0.013, and 0.0022, indicating that that there is a statistically significant difference in post- and follow-up survey results. P-values of slightly greater than 0.010 for pre- and post- and pre- and follow-up surveys show that the differences were nearly statistically significant at the 0.01 significance level.

Curriculum Development Networks

To better understand the impact of the TEEW on participants currently employed as faculty members, we performed social network analysis. Each participant was asked in the pre-survey and in the follow-up survey about sharing of curricular materials with other TEEW participants. UCINET 6, a software package for the analysis of social network data (Borgatti et. al., 2002), was used to develop a pre-existing network figure based on 36 responses and a 6 month network figure based on 27 responses (Figure 7). Each node in the figure represents an individual participant. The gender of the participant is documented as a square node (male) or a circular node (female). The rank of the participant is documented by three colors red (assistant professor), blue (associate professor), and green (full professor). The links represent a sharing of curriculum materials: an arrow pointing away from a node means materials were provided by that participant, while an arrow pointing towards a node means that participant received materials.

Two widely accepted quantitative measures, inclusiveness and network density, were used to further describe the change over time in the overall networks (Scott, 2010). For our purposes, inclusiveness refers to the number of points that are included within the various connected parts of the network. This value can be calculated as the total number of nodes minus the number of isolated nodes (Equation 1) (Wasserman and Faust, 2009).

$$inclusiveness = \frac{(total\ number\ of\ nodes - numer\ of\ isolated\ nodes)}{total\ number\ of\ nodes} \quad (1)$$

The network density describes the general level of linkage among the points in a graph. The more points that are connected to one another, the denser the graph. For a directed network graph, where the data is asymmetrical, the network density calculation can be expressed as a proportion of the maximum number of lines possible (Equation 2) (Wasserman and Faust, 2009).

$$density = \frac{l}{n(n-1)} \quad (2)$$

Where:

l – Number of lines

n – Number of nodes

By calculating the inclusiveness and density of networks from the pre-and follow-up surveys and measuring the delta between the two we can quantify whether a shift has occurred in the professional network (Table 5). The values in Table 5 correspond to a 24.0% increase in network inclusiveness and a 280.0% increase in network density.

Beyond the overall network analysis, the performance of an individual node, a professor, can also be considered. This was accomplished though calculating the indegree (the number of professors giving a particular professor materials) and the outdegree (the number of professors that a particular professor provided materials to) for each node in the before and after network. The sum of the indegree and outdegree measures for each individual node ranges from 0 to 23 in both the before and after network. The highest observed vales in the before network were and indegree of 11 and an outdegree of 12. In the after network, the highest indegree was 7 and the highest outdegree was 16. The sum of the indegree and the outdegree were calculated for each node. 35.1% of the nodes in the before network and 40.7% in the after network had sums greater than 5.

Value and Influence of Workshop

Participant responses to the question from the Follow-up Survey "What were the 3 most valuable aspects of the conference?" were coded and tabulated and are shown in Table 6. The first two categories, representing about 55% of participants, relate to improved knowledge of active learning and conceptual exercises and having the opportunity to develop activities and ranking tasks during the workshop. The last two categories relate to interacting with others during the conference, developing networks to facilitate sharing of materials that extend beyond the duration of the workshop. Collectively, these responses suggest that the goals of the conference were met in the eyes of the participants; they learned more about both the value and mechanics of developing active conceptual exercises, and they established professional networks to continue the development and sharing process beyond the TEEW conference.

In the follow up survey, participants also were asked to describe the most influential aspect of the conference. Ninety percent of responses related to the influence on changing their teaching practices, including “Providing the motivation to take the time to put more conceptual exercises in my classes”, “given more inspiration to consider making radical changes to my course design,” “I hope to implement ranking tasks in my classes,” and “I am conscious of how little active learning I have in my lectures…my goal is to try and add either one more active learning or conceptual exercise to each lecture.”

Additionally, in the follow-up survey faculty members were asked if they used and/or designed active and conceptual learning exercises. 67% said they both designed new active learning exercises and used them. 52% said they designed new conceptual learning exercises and 65% said they used conceptual learning exercises. Considered together, the quantitative and qualitative responses strongly indicate that participants are either in the process of or have already changed their teaching practices as a result of participating in the conference.

SUMMARY AND CONCLUSIONS

This research effort sought to determine whether facilitating collaborative development of active learning activities and conceptual assessment exercises through a thoughtfully designed workshop could positively influence beliefs about the importance of active and conceptual learning and sharing of curricular materials within a curriculum development network. The TEEW attracted 60 participants, including faculty members, Ph.D. students, and public sector employees. Meaningful shifts were identified across time in participant beliefs and the curriculum development network. More specifically:

- Most participants indicated a belief in the importance of active and conceptual learning in the classroom in both the pre-, post-, and follow-up surveys. It is not surprising that the largely self-selected participants were pre-disposed to value active and conceptual learning, and it is encouraging that, approximately two thirds of participants reported that they both designed and implemented new learning activities, and implemented new conceptual exercises. This suggests that participants' enthusiasm for active and conceptual learning was strengthened, making them more likely to expend the energy to implement such activities in the classroom.
- Participant beliefs that all instructors should implement active and conceptual learning activities in the classroom first increased (from immediately before to immediately after the workshop), then decreased (from immediately after to 6-months post). This could reflect both the recognition that implementing these techniques in the real world is significantly more challenging than developing them in a supportive environment, and that this is something with which those who have not been trained may struggle. This also provides indirect evidence for the value of the curriculum development network. It suggests that participants have developed a more nuanced understanding of the requirements for implementing such activities effectively.
- The six belief questions combined constitute a scale of questions measuring the educational value of active learning and conceptual exercises. Testing of this scale confirmed a statistically significant difference in post- and follow-up survey results

and a nearly statistically significant difference in pre- and post- survey results and pre- and follow-up survey results, indicating that when taken in the aggregate the questions posed in the surveys did demonstrate shifts in beliefs. The self-selection of participants may have led to higher than average pre-survey results, and the challenges associated with implementing new techniques in engineering classrooms may have depressed the follow-up survey results.

- The inclusiveness and density of the curriculum development network increased by 24% and 280%, respectively. This suggests that participants substantially widened their networks of engineering education colleagues through the workshop.
- Conference participants reported that they learned more about the importance and development of active conceptual exercises and developed network ties to facilitate future development and implementation. Almost 70% of respondents indicated they had already designed and implemented active and conceptual exercises in their classrooms as a result of the conference. These open-ended and quantitative responses suggest that the workshop had the desired outcome of effecting change in transportation engineering classrooms.

These data and the associated analysis should help to inform current efforts to coordinate professional development workshops for engineering faculty and to encourage the implementation of active learning and conceptual exercises in the classroom. Although direct causal links are not established between the workshop and the desired result of faculty adopting educational innovation in their classrooms, strong preliminary evidence is presented to suggest that the professional development workshop model described in this research effort did contribute to positive improvements in faculty beliefs, curriculum development networks, and classroom practice.

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FIGURE CAPTION LIST

TABLE CAPTION LIST

Table 1. Categories of Questions Included on Each Participant Survey

Categories / Number of Questions Asked	Survey Type / Number of Respondents		
	Pre- / 50	Post- / 43	Follow-up / 37
Beliefs about active learning and conceptual assessment exercises / 6	X	X	X
1. Active learning is an important part of a lecture period. 2. Conceptual exercises are an important part of a lecture period. 3. Active learning improves student understanding. 4. Conceptual exercises improve student understanding. 5. All instructors should implement active learning in their lecture. 6. All instructors should implement conceptual exercises in their lecture.			
Engagement in curriculum development networks / 2	X		X
Value of workshop / 2			X
1. What were the three most valuable aspects of the conference? 2. What was the most influential aspect of the conference?			

Table 2. Descriptive Statistics of Pre- and Post-Surveys

Type:	Descriptive Statistic (sample size):	Question: 1[A]	2[B]	3[C]	4[D]	5[E]	6[F]
Pre-Survey	Average (all observations, n=50)	4.560	4.540	4.080	4.480	4.540	4.380
	Std Deviation (all observations, n=50)	0.571	0.573	0.868	0.671	0.537	0.629
	Average (Pre/Post paired obs., n=41)	4.512	4.512	3.927	4.439	4.512	4.317
	Std Deviation (Pre/Post paired obs., n=41)	0.589	0.546	0.866	0.700	0.546	0.642
	Average (Pre/6 Month paired obs., n=31)	4.613	4.548	4.226	4.516	4.613	4.452
	Std Deviation (Pre/6 Month paired obs., n=31)	0.549	0.559	0.750	0.561	0.487	0.559
Post-Survey	Average (all observations, n=43)	4.651	4.628	4.279	4.581	4.558	4.349
	Std Deviation (all observations, n=43)	0.477	0.611	0.726	0.493	0.541	0.566
	Average (Pre/Post paired obs.,n=41)	4.659	4.634	4.268	4.561	4.561	4.341
	Std Deviation (Pre/Post paired obs., n=41)	0.474	0.615	0.733	0.496	0.543	0.568
Follow-up Survey	Average (all observations, n=37)	4.432	4.486	3.973	4.216	4.389	3.811
	Std Deviation (all observations, n=37)	0.755	0.642	0.885	0.843	0.792	0.896
	Average (Pre/6 Month paired obs., n=31)	4.360	4.440	3.800	4.120	4.400	3.680
	Std Deviation (Pre/6 Month paired obs., n=31)	0.686	0.637	0.894	0.909	0.566	0.882

[A] Active learning exercises are an important part of lecture
[B] Active learning exercises improve student understanding
[C] Active learning exercises should be implemented by all instructors
[D] Conceptual exercises are an important part of lecture
[E] Conceptual exercises improves student understanding
[F] Conceptual exercises should be implemented by all instructors

Table 3. Results of Statistical Analyses

Comparison of:	Statistical Tests:	Question: 1[A]	2[B]	3[C]	4[D]	5[E]	6[F]
Pre- and Post-Survey	**Chi-Square**	0.195	0.147	0.152	0.396	**0.041**	0.168
	Paired t-test (p-values)	0.057	0.133	**0.005**	0.281	0.599	0.838
Pre- and Follow-up Survey	**Chi-Square**	0.335	0.352	0.491	0.412	**0.002**	**0.020**
	Paired t-test (p-values)	0.134	0.845	**0.023**	0.086	0.169	**0.003**

[A] Active learning exercises are an important part of lecture
[B] Active learning exercises improve student understanding
[C] Active learning exercises should be implemented by all instructors
[D] Conceptual exercises are an important part of lecture
[E] Conceptual exercises improve student understanding
[F] Conceptual exercises should be implemented by all instructors

Table 4. Cronbach Alpha Values for Survey Questions

Survey:	3 Active Learning Questions:	3 Conceptual Exercise Questions:	All 6 Questions:
Pre-	0.70	0.80	0.75
Post-	0.71	0.85	0.82
Follow-up	0.70	0.71	0.84

Table 5. Change in Network Density and Connectivity

Measures	Pre-Survey	Follow-up Survey	Delta
Inclusiveness	0.76	1.0	0.24
Density	0.05	0.19	0.14

Table 6. Value of Participating in the TEEW

Category:	Example Quote:	Percentage:
Learning about active learning and conceptual exercises	“Learning how to develop / implement these types of exercises.”	35
Developing material	“Working on ranking tasks”	20
Discussions and idea exchanges	“Hearing the approaches that others have taken in their classroom teaching”	20
Networking	“Networking, contacts with other similar thinking teachers”	25