REFINEMENT AND DISSEMINATION OF A DIGITAL PLATFORM FOR SHARING TRANSPORTATION EDUCATION MATERIALS

FINAL PROJECT REPORT

by

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16. Abstract National agencies have called for more widespread adoption of best practices in engineering education. To facilitate this sharing of practices a web-based system framework used by transportation engineering educators to share curricular materials and methods was developed. A research-based, action-oriented approach was taken where iteration occurred between the usability and adoptability of the system and the material-sharing and decision-making process of its content providers. The results of this study suggest that managing the size and content of the materials provided in the repository and establishing an effective and efficient means to access the material are of critical importance to the long-term success and sustainability of the system.		
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Table of Contents

List of Figures

List of Tables

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Executive Summary

There are approximately two hundred *Introduction to Transportation Engineering* courses taught annually in the United States but little evidence to suggest that teaching materials (other than textbooks) are being shared between the instructors of these courses. The National Science Foundation (NSF) spends millions of dollars annually through the Transforming Undergraduate Education in STEM (TUES) program on the development and testing of teaching methods and materials (NSF, 2012). Conversations with NSF program managers indicate that they are disappointed with the rate of return on this investment, and would like to see much less development and much more sharing and dissemination of best practices. New NSF programs are emerging specifically on utilizing best practices and understanding the adoption process.

During the initial phase of this project, the research team developed a framework for a prototype website, the PacTrans Transportation Education Resource Center (pTERC), for sharing transportation curriculum and best practices. A research-based action oriented approach was taken where iteration between development and studies of usability and adoptability of the pTERC system occurred and included: the development and testing of a pilot system, research efforts that supported the development, and the gathering of existing curricular materials to be uploaded to the system. Diffusion of Innovations (DI) Theory was used extensively to study and implement the characteristics of a system to facilitate its broad use by educators. This research and development effort relied on DI theory, with a specific focus on characteristics of an innovation known to affect adoption. Understanding potential adopters' experiences, opinions, and values enabled the initial development of the web-based repository's architecture. Interviews with these individuals and a supplementary analysis of syllabi in relevant courses afforded the initial development of the web-based repository according to the tenets afforded by DI theory. The results of this initial study suggested tangible and direct means of addressing potential users' perceptions about the repository and the materials included within it, such as managing the size of materials provided onsite and providing various ways of accessing the materials.

This project extended the efforts from the initial phase to further apply usability and adoptability studies to the development and dissemination of pTERC to a broader audience. There were two parts to this latest study, and included the development and refinement of the web-based repository for curriculum materials and the study of curricular decision-making processes of transportation engineering educators. These two efforts were developed to understand, facilitate, and encourage sharing of materials and best practices between educators.

The overarching goal was to develop an effective web-based repository where engineering educators could readily share educational materials and best practices. The development and dissemination of this repository was dependent on two aspects - a successful, usable web-based system, and materials that educators were interested in. If the materials contained within the website matched educator needs but the functionality of the repository did not, educators would seek other methods of gathering these materials. Alternatively, a well-designed repository would be of little use if the materials available were not appealing or applicable to the short-term or long-term needs of educators.

To provide a usable web-based system, academic- and industry-established user-centered design practices were incorporated in the development of the repository system. This included an in-depth needs assessment phase in which college professors were interviewed about their own educational materials-sharing practices. Iterative prototyping and usability testing was built on the data gathered from the needs assessment phase.

The purpose of this usability testing was to gain knowledge to develop a sustainable plan for a web-based dissemination repository of best practices and materials, as well as determine how that repository could be developed to maximize use and adoption of materials. This was accomplished through determining the methods faculty use to look for curriculum when developing or refining a course, the characteristics of the curriculum that affect adoption decisions, and additional information needed for the adopter to know about materials to encourage adoption.

Many project objectives were achieved and completed as part of this project, though additional testing is recommended before pTERC can be released as a public platform. The success of the repository will ultimately depend on each user's perceived usefulness of the materials available in the repository, the decision-making research focused on identifying characteristics of materials that transportation education faculty members implement in their classrooms, the reasons faculty members have for modifying materials, the resources and materials faculty members draw from when modifying materials, and a formal plan that allows for the sustainable and manageable operations of the repository into the future.

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Chapter 1 Introduction

In an effort to improve engineering education in the United States, the National Science Foundation (NSF) has invested heavily in the Transforming Undergraduate Education in Science, Technology, Engineering, and Mathematics (STEM) program (TUES) by developing an abundance of curricular materials and teaching methods (NSF, 2012). While these materials and methods are evidence-based and shown to positively affect student learning and educational outcomes, they have been slow to be adopted or disseminated.

To improve curriculum sharing, this project examined the development and dissemination of a web-based repository containing curriculum materials and best practices. Two inter-related efforts were developed to understand, facilitate, and encourage sharing of materials and best practices between educators; the first was the development and refinement of the web-based repository for curriculum materials, and the second was a study on the curricular decision-making processes of transportation engineering educators. If the materials contained within the website matched educator needs, yet the repository did not meet user expectations, educators would seek other methods of gathering these materials. Alternatively, a well-designed repository would be of little use if the materials available were not appealing or applicable to the short-term or long-term needs of educators.

Nationally there is a growing interest in the reform and improvement of college curricula generally, and engineering curricula specifically (Lattuca & Stark, 2014; NAE, 2008). In an effort to understand the underlying causes of the lack of streamlined materials and content-sharing, more insight is needed on engineering educators' decision-making processes as they relate to curriculum planning. Examining how and why engineering educators create or change their curriculum will allow for more understanding of why instructors do not change or adopt certain curriculum components.

Within higher education literature, numerous studies have examined factors that influence instructors' teaching-related decisions and curriculum reform (Hagerty & Stark, 2014; Hora & Anderson, 2012; Hora & Ferrare, 2013; Hora, 2012; Kane et al., 2002; Lattuca & Stark, 2009, 2014). Structural, socio-cultural, and individual factors have all been found to play a role in curriculum reform. Structural factors (e.g., type of institution, course characteristics, discipline, instructors' workload and available time, budgets, institutionally implemented pedagogical reform projects, teaching evaluations, accreditations, and institutional policies and support) have a large influence on instructors' curriculum planning and decision making processes (Hagerty & Stark, 2014; Hora & Anderson, 2012; Hora & Ferrare, 2013; Hora, 2012; Lattuca & Stark, 2009; Lowther et al., 1990). Social-cultural factors (e.g., perceived norms from the institution, department, other faculty members, and even students) also have influence on instructors' curriculum planning and decision making process (Brew, 2013; Hagerty & Stark, 2014; Henderson & Dancy, 2007; Hora, 2012; Hora & Anderson, 2012; Lattuca & Stark, 2009, 2014). Individual influences include the instructors' beliefs, knowledge, and goals. Individual beliefs influence which teaching practices instructors find plausible, possible and desirable, and a combination of teaching knowledge, goals and beliefs can shape instructors' practices (Lattuca & Stark, 2009; Schoenfeld, 2000).

This study contributed to that body of literature, as well as that specific to engineering education, which is described in the literature review. Prior studies often conclude that further research is needed on the diffusion, adoption and implementation of curricular innovations, and barriers to curricular change. In particular, the micro-level decision making within specific courses through interviews remain underexplored. By focusing on individual micro-level decisions that instructors are already making, and not asking them about adopting specific materials, this study gains insight into *how* instructors adopt materials, *what* characteristics they are looking for when changing and creating course components, and *why* they make changes to their courses. A micro-level method of interview also mitigates the potential for over-reporting of the use of research-based instructional strategies. In contrast to much other research that focuses on barriers to change, then, our study focuses on understanding the changes faculty *do* make.

Several inter-related goals guided this study. The first goal was to gain insight into engineering educators' decision-making process as they related to curriculum planning. The second goal was to identify characteristics of course components that faculty implement in their classrooms, including what course components faculty do or do not modify when implementing them in their classes. The third goal was to identify what resources instructors use to gather materials from during curriculum planning. Understanding these aspects of faculty decision-making processes can help future curriculum developers create course components that will interest and be more adoptable for engineering educators. To that end, the following research questions guided this analysis:

1. What course components do faculty members adopt and modify when designing their courses?
2. Why do faculty make changes to a course?
3. When making changes to a course, how do faculty members approach the process?
4. When making changes to a course, what resources do faculty members utilize?

Much research has been done in the design and development of technical systems for human use (Gould & Lewis, 1985). In order to provide a usable web-based system, academic- and industry-established user-centered design practices were incorporated in the development of the repository system. This included an in-depth needs assessment phase where system stakeholders (e.g., professors who would use the system) were interviewed about their own educational materials-sharing practices. Iterative prototyping and usability testing was built on the data gathered from the needs assessment phase.

The purpose of this usability testing was to gain knowledge to develop a sustainable plan for a web-based dissemination repository of best practices and materials, as well as determine how that repository could be developed to maximize use and adoption of materials. This was accomplished through determining the methods faculty use to look for curriculum when developing or refining a course, the characteristics of the curriculum that affect adoption decisions, and additional information needed for the adopter to know about materials to encourage adoption.

Recognizing that the success of the repository depends on the potential users' perceived usefulness of the materials available in the repository, the decision-making research focused on identifying characteristics of materials that transportation education faculty members implement in their classrooms, reasons faculty members have for modifying materials, and what resources and materials faculty members draw from when modifying materials.

This report begins with a brief description of Rogers' Diffusion of Innovations and active learning and a review of engineering education research relevant to the adoption of research-based instructional strategies. These topics, which emerged as salient to our data, are discussed in order to provide necessary background to the subsequent sections. A description of the study's methods come after the literature review, and are followed by the presentation and discussion of the research findings. This report concludes with recommendations for those developing curricular materials and those conducting engineering education research around faculty decision-making and information-sharing, along with a description of the current state of the web-based repository.

Chapter 2 Literature Review

2.1 Diffusion of Innovations

There has been widespread interest in improving engineering education in the United States which has led to an abundance of educational materials and methods. While these materials and methods are proven to positively affect student experiences and learning, and to improve courses and curriculum, their sharing and use in practice is limited by the unwillingness of educators to adopt new materials or change their teaching practices (Borrego, et al, 2010). An example of this abundance is the fact that there are over two hundred introductory-level transportation engineering courses offered by faculty at universities across the country, yet there is little evidence to suggest that materials and methods are shared between these educators. Rogers' Diffusion of Innovations Theory can help guide efforts to understand this lack of diffusion and ways to increase diffusion (Rogers, 2003).

An innovation is anything that can be considered new, such as a technological advancement or idea (Rogers, 2003). According to Rogers, the adoption of an innovation relies heavily on the potential user's perception of the following five components: *relative advantage, observability, trialability*, *compatibility* and *complexity*. *Relative advantage* describes the perception of a current innovation being better than the ideas that came before it. A potential user will find an innovation useful to them if they feel it is better than what came before; the actual usefulness of the innovation is not necessarily relevant. *Observability* describes the ability of potential users to see the benefits of an innovation. *Trialability* is the potential user's ability to partially adopt or test out an innovation before having to fully commit to adopting the innovation. *Complexity* is how difficult the use of an innovation is perceived to be. *Compatibility* is how well potential users feel the innovation fits with their values and norms (Rogers, 2003).

A technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome. Rogers' theory considers a technology to have two components: (1) a hardware aspect, consisting of the tool that embodies the technology as a material or physical object, and (2) a software aspect, consisting of the information base for the tool (Rogers, 2003).

Prior educational research involving Diffusion of Innovations (DI) theory has focused on the use of computer technology (Sahin, 2006), course management systems (Bennett & Bennett, 2003; McQuiggins, 2006), and online teaching materials (Shea et al., 2006). While these studies have found the adoption of technology in classrooms to be correlated to student achievements (Christensen et al., 2001) and teaching experience (Less, 2003), the focus tends to be on the hardware components of technologies and neglects the software components. Research on hardware has identified relationships between use of technologies and the characteristics of adopters (Blankenship, 2003; Isleem, 2003; Zayim et al., 2006), but it has not addressed the adopters' perspectives, which have been argued to be necessary to be considered in the development of innovations if they are to be disseminated (Aboelmaged, 2000; McQuiggins, 2006). Previous studies have also treated adoption as an isolated incident (Waarts et al., 2002), unlike Rogers' Diffusion of Innovations approach that considers adoption a process that occurs over time (Rogers, 2003). This could be due to the fact that the technologies in the previous studies were not designed to change over time.

Many academic institutions have considered the use of an institutional repository to share scholarly materials within their university (Dubinsky, 2014). For example, a study at the

University of Oklahoma interviewed professors on their knowledge, concerns, and possible use of an online repository at their institution (Brown & Abbes, 2010). While there is evidence that the use and amount of content within these repositories is growing, the growth appears slow, and there is little evidence of active faculty participation (Dubinsky, 2014).

2.2 Innovations in Teaching and Learning

Active learning is a very general term, and covers a wide variety of research based instructional strategies. Active learning can most simply be defined as any teaching method whose purpose is to get students actively involved, and is often characterized by authentic learning tasks, collaborative learning, and limited direction from instructors (Keyser, 2000; Prince, 2004). Examples of active learning include group work, project-based learning, discussions, fieldwork, case studies, simulations, and peer teaching, among many others (Keyser, 2000; Prince & Felder, 2006; Prince, 2004). When compared to a more traditional lecture-based teaching method, active learning has many benefits, including students that are more engaged in activities and what the instructor is saying, greater emphasis on developing students' skills, and allowing students greater exploration of their own attitudes and values (Keyser, 2000; Ragains, 1995; Williams & Cox, 1992). Critiques of lectures include that students tend not to enjoy them, and they target lower-level learning (Keyser, 2000; Ragains, 1995; Williams & Cox, 1992). Compared to other research-based instructional strategies, active and collaborative learning have the highest percentage of implementation among instructors who are aware of research-based instructional strategies (Prince, 2004). In a study of undergraduate physics faculty, Henderson and Dancy (2007) found that instructors are aware of alternative teaching methods, and were also aware of the issues surrounding traditional teaching methods, yet they continued to teaching their courses in a traditional manner.

To address that lack of change, numerous studies have been conducted with a focus on improving STEM instruction through the dissemination, adoption and implementation of research-based instructional methods and materials. Research within engineering education has found similar barriers to change as those identified in higher education research. For example, Davis (2011) mentions instructor characteristics, the value placed on research over teaching, available faculty time, and funding as barriers to the implementation of engineering education innovations. Similar studies on curriculum planning have also found funding, class characteristics, instructors' available time, and discipline to influence instructors' decision making (Borrego et al., 2013, 2010; Davis, 2011; Seymour, DeWelde, & Fry, 2011). Student attitudes and expectations, pressure from the department and other instructors to cover certain amounts of content, and lack of instructor time, both in curriculum development and in the actual classroom itself have also been identified as barriers (Henderson & Dancy, 2007). This report supports this prior research, but also adds new insight into the changes that faculty members do make.

Of particular significance to the study at hand is the fact that the characteristics of the innovation itself can be influential in adoption rates, including the perceived complexity of the innovation, and whether the innovation could be easily implemented by a single instructor, or required collaboration between departments (Borrego et al., 2013, 2010; Henderson & Dancy, 2007). Relatedly, a disconnect between developers and instructors has been identified as a key barrier. Henderson and Dancy (2007) interviewed physics instructors who made changes to their courses that were influenced by educational research. They found several differences in expectations between instructors and researchers, and that these differences were barriers to dissemination of educational innovations (Henderson & Dancy, 2007). Instructors felt researchers were expecting them to adopt their innovations with little or no changes, instead of working with instructors to apply research methods to their classrooms. They also discussed the needs for researchers to address possible difficulties instructors may face, and how to overcome these obstacles, instead of telling instructors how easy a change would be (Henderson & Dancy, 2007; Henderson, 2006). Instructors are looking for materials that are easy to modify and customize and often feel researchers do not provide easily modifiable materials (Henderson & Dancy, 2007). The project described herein addresses those issues because it was designed to support alignment between instructors' expectations, curriculum materials created, and mechanisms for dissemination of those materials.

Chapter 3 Methodology

3.1 Project Design

Because there has been no definitive research on a web-based repository of curriculum materials, results from prior studies were used to inform the development of the web-based repository and the decision-making research. The project utilized Rogers' components of adoption in several ways. Relative advantage was addressed through both of the studies. The usability testing allowed for potential user feedback on the usefulness of the repository, while the decision-making research gained insight into how educators shared information with each other. Observability was included in this repository by providing users with information on the quality of the materials, such as user ratings or number of downloads. The usability testing was not only an effective method for developing a system that potential users found useful, but also increased awareness of such a system amongst transportation engineering educators. Trialability was included in the system by allowing users to view excerpts or previews of materials before they chose to adopt the material into their classroom. Since this was development-level material and not a technology directly used in the classroom, using the system did not necessarily require individual users to change their teaching practices. Complexity was addressed through usability testing, by allowing potential users to voice their concerns or expectations of the system during the development stages. Compatibility was included in both studies; follow-up questions on why or why not this system would be useful to the potential users were asked during the usability testing, while identifying the materials in the repository that potential users were interested in contributed to the decision-making research.

The two studies can be seen as the hardware and software components of a technology that Rogers describes. The decision-making research served as informational background, while the web-based repository was the physical tool that allowed users to access the information sought. Unlike previous studies, perspectives on the system by potential adopters and the quality of the materials provided was judged by the same potential adopters and both taken into consideration, and these considerations were made over time, rather than at one moment in time. By being web-based and dependent on how educators used the system, the repository had the ability to evolve and change over time.

The adoption of best practices and materials in the repository system can be understood as a push or pull model. In a ‘push’ model developers try to make others aware of their innovation and subsequently adopt it. In a ‘pull’ model the focus is how people become aware of something (other than from the developers) and how they learn more about it and decide if they will use the innovation. The developed site allowed for simultaneous push and pull activities; faculty could ‘push’ their materials to the site and make announcements about their newly shared materials. Faculty could also ‘pull’ materials from the site. Several key aspects of the site are discussed below.

- Register – Users must register for use of the site. Access will be provided to faculty and instructors, but not to students. All users will be verified by the research team. This was done to allow faculty to feel comfortable with sharing their materials and potentially solutions knowing that students would not have (direct) access to the materials.
- Tags – All items have multiple tags associated with them. The two categories of tags are transportation content area and application. All materials are categorized in three

transportation concept tiers, 1 - Concept Categories (Operations, Safety, Design and Planning), 2 - Concept Subcategories, and 3 - Concepts. There are two application categories, Active and Passive, and several applications within each category. Active refers to items where students would be doing something other than observing, and passive items are where students would just be observing, such as videos and lecture notes.

- Search – Users can search for items using keywords, or tags, related to content and use. For example, one could search for 'sight distance' and 'learning activity' and would get all items tagged with these descriptors. The user can click on the title and then would be taken to a page with further information about the activity and a link to download the activity.
- Browse – This feature allows users to browse, filter and sort by different criteria. For example a user could sort by categories first and then by applications.
- Upload – Curriculum developers can send materials via e-mail or through the pTERC. The materials will be reviewed and uploaded by the research team. We believe this is the only way to achieve reasonable consistency and quality of the materials available on pTERC.

3.2 Usability Testing

In order to refine the design of this digital repository, educators participated in two rounds of usability testing. This allowed the designers to see how potential end users interact with the repository, as well as get user feedback on these interactions. The first round of usability testing consisted of four engineering educators from a public research university. Participants in this round of testing all teach a transportation engineering or related course. Two instructors are tenured faculty, and two teach part time while working in industry. For this round of testing, researchers traveled to the participants' institution to carry out the tests. Users were given an interactive PDF prototype of the repository and asked to perform certain tasks. While interacting with the repository, users were asked to state each step out loud: what they were expecting, the reasoning behind their choices, and when their expectations were not met. This round of testing was centered on file uploading, adding contacts, sharing materials with contacts, browsing for contacts, and downloading files. Figure 3.1 shows a screenshot of the repository prototype used in the first round of testing. In the live version of the web based repository, the spaces shown in Figure 3.1 and Figure 3.2 as an "X" will be occupied with a preview of the selected document.

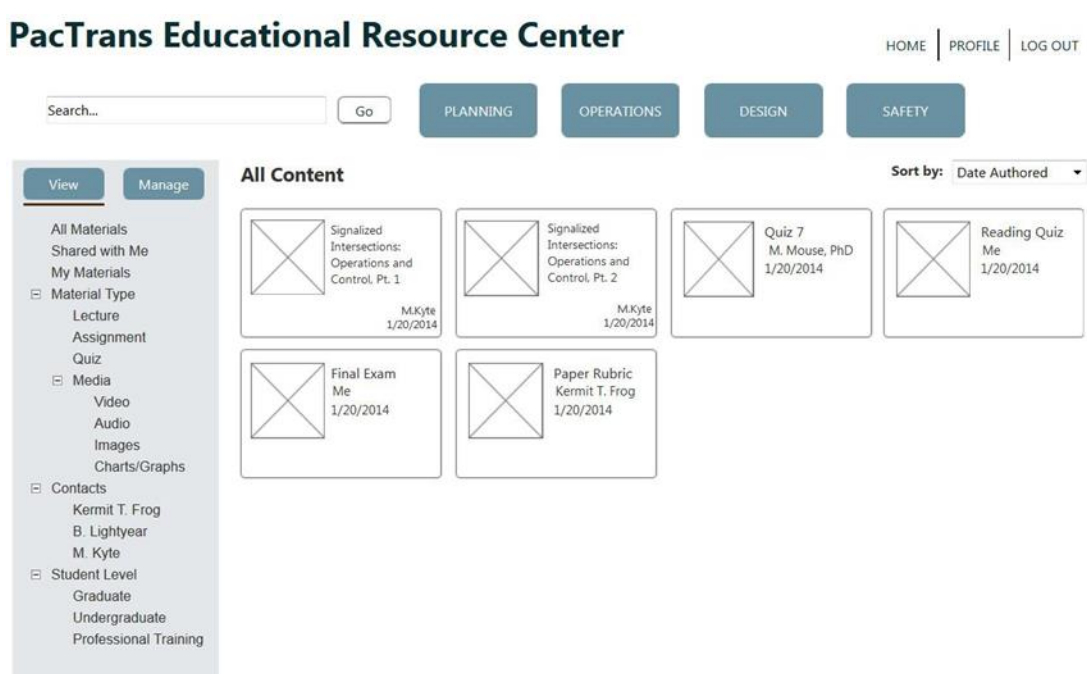

Figure 3.1 Screenshot of the repository prototype used in round one of usability testing

Using the results from the first round of testing, the prototype of the repository was refined and a second round of tests were administered. Improvements included refining the levels of categories used to organize materials to simplify content navigation and improve the user experience. The second round of usability testing involved two tenure track transportation engineering educators, as well as four graduate students who plan on entering into academic careers. This round of testing also occurred at a public research university. Again the researchers traveled to the instructors' institution to carry out the tests. This test was administered in the same way as the first round, but this time the tasks focused on inviting contacts, requesting connections, adding members to groups, and sharing content. Figure 3.2 shows a screenshot of the repository prototype used in the second round of usability testing.

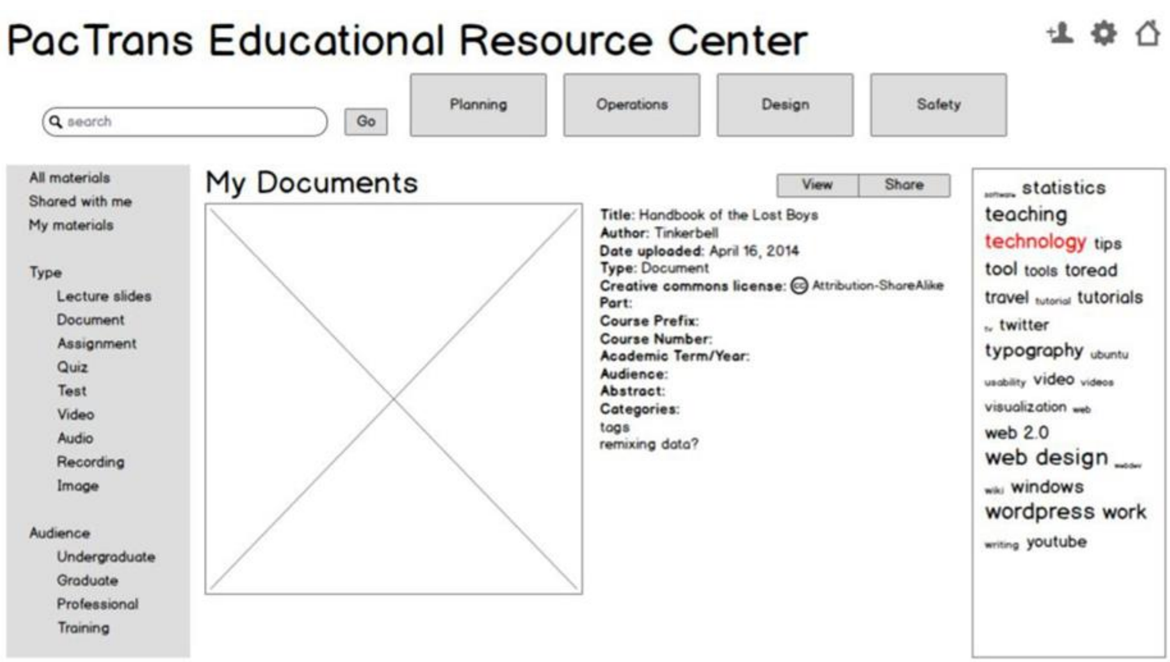

Figure 3.2 Screenshot of the repository prototypes used in the second round of usability testing

3.3 Decision-Making Research

3.3.1 Participants and Recruitment

This study consisted of interviews with twenty-four engineering educators from eighteen universities across the United States. The participants were college instructors who teach transportation engineering or transportation related courses. Fifty-two potential participants were contacted, giving a 46% response rate. Of the twenty-four participants, twenty were tenure track instructors and twenty-two came from research institutions. There was a wide range of levels of teaching experience represented, with the number of years of teaching ranging from two to twenty-eight, and the number of times teaching the course in question ranging from two to thirty times.

The participants were first identified through a sample of convenience through existing ties with three potential participants. Once those instructors agreed to participate in our study, they were asked to identify potential participants that they had connections with. This snowball sampling continued will all instructors who agreed to participate until we had a large enough sample size. All contact was made via email.

3.3.2 Data Collection

The interview protocol was developed over several iterations. An original protocol was developed with the research goals in mind, and focused mainly on a new course or newer course that the respondents had developed on their own. This interview protocol was used with five participants, and the results were analyzed to determine if themes emerged and if certain areas of curriculum planning would warrant more interview questions.

It was decided after the first round of interviews that sending the participants the interview protocol beforehand, and asking the participants to have a copy of their most recent course syllabus as a reference during the interview could lead to responses more oriented toward the thought processes behind the decisions made. It was believed that many of these decisions are automatic when developing courses, and are not often thought about consciously; therefore, allowing respondents more time to reflect on the process would allow for responses more in line with the research goals. It was also noted that many instructors do not develop courses completely from scratch, so the protocol was changed to include any transportation related course that the instructor teaches, versus a course they recently developed.

3.3.3. Data Analysis

Each interview was recorded and saved as an audio file, then transcribed into a text document. After each interview was transcribed, it was analyzed for any responses that related to the research goals. If there was a response that related to the research questions, the response would be coded in the transcription. The transcribed interviews were coded using the analysis software Dedoose (2014). The initial rounds of coding were for respondent and class characteristics, such as course level, required course, etc. This allowed for course and instructor characteristics to be easily extracted from the data. The transcriptions were then coded to organize responses based on the interview questions asked. The next step was to identify any time when a respondent made a specific decision to change or develop something in their course. Each decision was then broken down into what course component was changed or developed, why it was changed, how it was changed, and what material was used to make that change or develop that course component. If the respondent did not mention one or more of these details, it was addressed in a follow up interview. Follow up questions were developed based on this coding to gain further detail on responses related to the research goals. Follow up questions and the interview transcriptions were sent to the participants and a follow-up interview was conducted.

Chapter 4 Results

4.1 Usability Testing

The first round of user testing found that the initial version of the categorizing system for the materials did not meet the needs and expectations of the users. Results from this round of testing highlighted points of interaction that were difficult for users, including navigating complex engineering materials. As a result, the category hierarchy was changed and a set of filters was added that could be used in combination with the categories to allow users to further refine search results (see Figure 4.1). Some educators also had concerns over the security of their materials once they were uploaded to a repository like this one. This led to the development of user accounts with different levels of privacy for materials, such as an option to share materials with any user of the repository, or being able to choose specific users to share materials with.

The second round of usability testing found that the contact and group management features met potential users' expectations. The security features that were included after the concerns that arose in the first round of testing yielded mixed reviews from the users in the second round. While most appreciated the increased security, there were concerns about the added complexity being a barrier to use and sharing. Some users also found symbols and links to be misleading or difficult to navigate. A possible solution for this would be labeling all links with words as opposed to symbols or pictures.

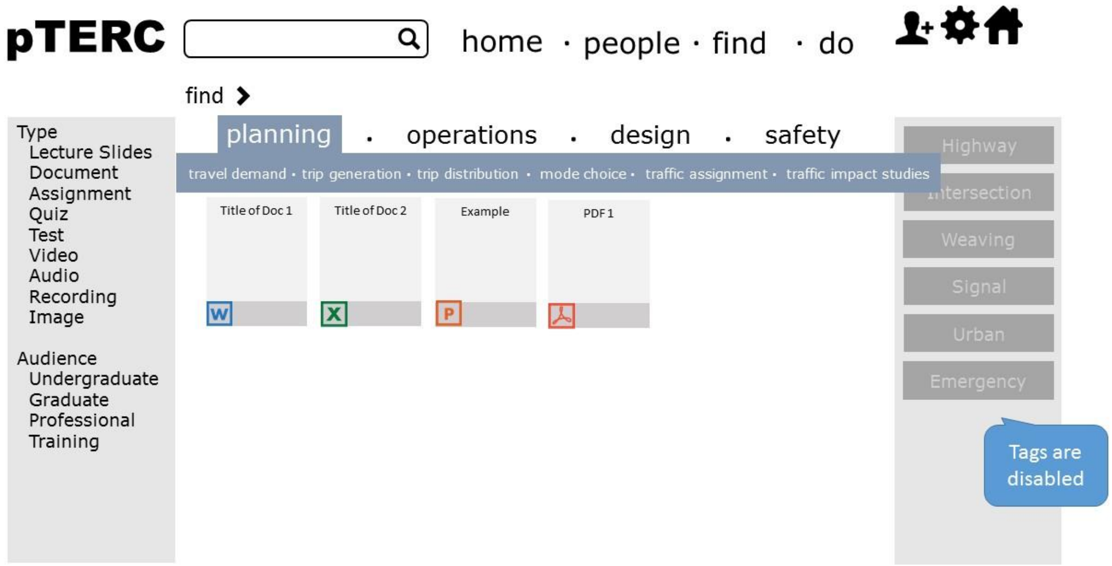

Figure 4.1 Screenshot of an updated user interface

4.2 Decision-Making Research

Our findings were organized into four categories aligning with the research questions: 1) what types of course components instructors tend to change or adopt, 2) why instructors change or adopt these course components, 3) how instructors go about making these changes and adopting these course components, and 4) where instructors get course components from when making changes to their courses.

What course components do faculty change?

The types of course components changed are summarized in Table 4.1.

Table 4.1 Prevalence of course components changed

Course Component	# of Participants
Lecture	23
In-class activities	16
Homework	8
Exams	7
Labs	5

When transportation engineering faculty members were asked about creating and changing course components in their classes, they talked most about lecture components, with twenty-three respondents mentioning developing or changing lecture components. Lecture course components include lecture slides, notes, and lecture style. Lecture notes were either developed from scratch when the respondent first taught the class, or they received course notes from a colleague who taught the course before them.

The next most common component that respondents changed was in class activities, with sixteen respondents mentioning creating or changing them. In class activities that were mentioned by respondents included group discussions, in class problems and group activities. A specific example from a respondent was taking a break in lecture, splitting students up into groups, giving the students a problem, and then having the students work them out on their own and share their findings and opinions with the class. Another example mentioned was having students read a current news article relating to the course, and then having a course discussion on the article. Less commonly mentioned changes to course components included exams, homework, and labs, mentioned by seven, eight, and five respondents, respectively.

Why do they change course components?

When asked about changing course components, or what course components they adopted into their courses, respondents mentioned three reasons for making changes, which are summarized in Table 4.2.

Table 4.2 Reasons for making changes

Reason	# of Participants
Incorporate active learning	17
Incorporate real world and contemporary material	16
Increase clarity	13

The most commonly mentioned reason for change was including active learning elements into their courses. Of the twenty-four interviewees, seventeen mentioned implementing active learning activities in their classroom, or modifying course components to include more active learning. For the purposes of this research, the term active learning was considered as when a respondent explicitly mentioned the term active learning, mentioned moving away from older or more traditional teaching practices, or using course components and practices to improve student engagement.

Another common reason for changing or adopting course components into classrooms was the incorporation of real world and contemporary course components. This reasoning was the second most commonly reported, with sixteen of the twenty-four respondents mentioning the incorporation of these types of course components. Course components were considered real world if a respondent mentioned the material being real world, from industry, or used in practice. A contemporary course component is considered material that is up-to-date, such as current design standards and manuals. For example, one participant described the incorporation of real world examples into his lectures:

> *So what I try to do with the lectures is I have one main concept per lecture, so we'll go through the theory behind it and then we'll do some example problems, we'll talk about how it's applied in real life and then we'll do a design problem they'll actually get to use the concepts in the field somewhere (Tenure track professor, public research university, six years teaching experience, six times teaching this course).*

The third most common reason stated for changing or adopting course components was to increase clarity for the students. Thirteen of the twenty-four participants mentioned clarity as a factor in their decision-making processes. Lack of clarity in materials was attributed to several causes. One reason was what the material they had did not go into enough depth on the subject being covered. Another was that the material they had was overly complex and needed to be simplified in order to be presented to students at the correct level. Many participants also mentioned that if students struggle on a certain topic or give them feedback that an aspect of the course is confusing, they would go back and attempt to make the information clearer.

How do faculty change their courses?

When participants were asked how they go about changing course components, there were three main paths that were mentioned: they are summarized in Table 4.3.

Table 4.3 Paths to change

Path	# of Participants
Begin with component to change	18
Begin with desired source	10
Begin with component to adopt	9

With eighteen of the twenty-four participants mentioning changing course components in this manner, the most common path to change was for respondents to want to change aspects of a course component they were already using in their class. Participants would identify gaps in of the components they wanted to make changes to, then go out and look for a material to fill these gaps. These gaps could be additional information on a specific topic, or information on a topic that was not included in their course that they felt should be. A common example of this path to change was adjusting the presentation of course components they received from colleagues, as described by one participant:

> *I had somebody else's notes. They got changed quite a bit but that was nice to have as a starting point. I changed order of presentation on certain things, the logic that one person sees in how you explain a concept to someone is not the same way that you see it or feel comfortable explaining it, so it was never a factual change, you just change what gets presented when, or what order you go through the textbook (Tenure track professor, public research university, twenty-four years teaching experience, twenty times teaching this course).*

The next most common path to change, with ten of the twenty-four participants changing materials in this way, was for respondents to have a source of course components in mind, look into that source, and then decide to adopt those course components into their classroom. These sources of course components ranged from textbooks and design manuals, to course components from colleagues who teach or have taught a similar course.

Lastly, nine participants mentioned seeing a course component and then deciding to use that course component in their class. There were two ways faculty discovered these course components, they either found the course components on their own, or had the course components presented to them. A common example of respondents discovering a course component on their own was finding either a news story or journal article, and then bringing those course components into their classroom. These components were then used for lectures, homework, or in class activities. When course components were presented to participants, it occurred in two ways; either a colleague presented the course component to them, or they attended a professional development event. For example, one participant explained:

> *I've attended a couple of teaching workshops over the last few years, mainly active learning based workshops. I like that pedagogy, I try to work elements of that into my classes and students seem to respond well to that (Tenure track professor, public research university, five years teaching experience, three times teaching this course).*

When respondents mention adopting a course component into their classroom, often they do not use the component in their class exactly how they receive it. It was common for respondents to use pieces of components they receive, or to modify a course component to fit into their own lecture.

What sources do faculty use when changing or developing their courses?

As summarized in Table 4.4, participants described multiple sources they used to modify their courses.

Table 4.4 Sources for change

Source	# of Participants
Colleague	21
Design standards and manuals	20
Textbooks	18
Research-based materials	9

When talking specifically about a time they changed or developed a course component, instructors borrowing course components from a colleague was mentioned twenty-one times. When instructors borrowed from a colleague, lecture components were mentioned sixteen times, in class activities were mentioned three times, labs were mentioned twice. Following course components from a colleague, the next most commonly used resource was design standards and manuals. Twenty participants mentioned the use of design standards and manuals, materials that are used in industry by practicing engineers. Textbooks were another common resource for course components, with eighteen participants mentioning this source. Often, these were different textbooks than those students were required to have for the course. Finally, nine participants mentioned using research-based material, including materials from scholarly journals and conferences, as well as the instructors' own research project, or research projects conducted by colleagues.

Chapter 5 Discussion

5.1 Usability Testing

The current pTERC site has substantial functionality and course materials have been uploaded. However, a series of presentation and functionality issues remain unresolved. The presentation of the user interface needs to be improved, and the tagging and searching features need improvement to make them more robust and reliable. The following refinements to the site will make the site sufficiently functional to be operational:

1. Continue strategic action-research to optimize the adoptability of the site both before and after launch to the transportation engineering community.

2. Continue uploading transportation learning activities to the site prior to launch.

3. Develop a sustainability plan for the site to ensure that it is used broadly for years to come.

4. Integrate an application like Google analytics on the site so that usage can be appropriately quantified.

5. Examine how instructors adopt the non-traditional modes of offering academic education in transportation engineering; develop course materials suitable for various modes; learn how different instructors use the non-traditional modes and how their adaptation can be improved.

The intended benefits include the following:

1. The site will act as a clearinghouse of the best transportation educational materials that have been developed at institutions across the Pacific Northwest. By compiling and making available these resources the introduction to transportation experience will be improved for all undergraduate students in the region.

2. The site will serve as a prototype that can ultimately serve as a clearinghouse for all UTC developed curricular materials, and eventually as the national site for storing and sharing peer reviewed, high quality educational materials for transportation instruction.

3. The adoption research will contribute to improving the dissemination and adoption practices across the country by making practical and theoretical advances in DI theory related to web-based curriculum repositories.

4. Employers of engineers, especially state transportation agencies, note the lack of comprehensive undergraduate training in specialty areas. A variety of post-graduate education programs, such as the traditional MS, work for a few students; however most students need education modalities that fit with a work schedule that often involves summer overtime and travel. The time demands of the education must conform to the students' life style, which also values "work- life balance." Delivering this specialty education with techniques that are convenient for the working engineer would benefit engineers, employers, and, ultimately, the public. This research contributes to the implementation of new methods in postgraduate education, where there is a deficiency, and perhaps leads to implementation of these technologies as an improvement in undergraduate education, either in general, or in some niche situations.

5.2 Decision-Making Research

Our interviews with transportation engineering instructors revealed that: 1) transportation engineering instructors most commonly change lecture components, including lecture slides, lecture style, lecture notes and in class activities, 2) the most common reasons for changing course components were to include active learning elements, improve clarity of materials for students, and incorporate real world and contemporary components into their classrooms, 3) when transportation engineering faculty change their course components, they have three main paths to change; considering the component they want to change first, considering the source of component they want to incorporate first, or seeing a material and then deciding to adapt it into their course, and 4) the most commonly used resources for changing curriculum components were materials from a colleague, design manuals and standards, textbooks, and research materials. Transportation engineering instructors do not adopt materials whole. Rather, they adopt individual pieces of the materials they borrow, such as an in class activity, or a piece of information for a lecture slide. Instructors also tend to make modifications to materials they adopt into their classrooms.

The focus on lectures, in contrast to other course components they could have discussed, suggests that instructors consider lectures the most important course components. However, as discussed in the Literature Review, lectures may not be the most effective means of teaching, and students do not particularly enjoy or pay attention during lectures (Keyser, 2000). If instructors are focusing mostly on lectures, yet lectures are not particularly effective, they are potentially using time that could be spent on the use of research-based instructional strategies on pedagogies that are less effective for student learning. Instructors may also consider lectures the most important course component due to the fact that most of their time in the classroom is spent lecturing. If a large portion of in class time is dedicated to lecturing, then developing and preparing for lectures would naturally take up a significant amount of time.

Despite the focus on lectures however, there was also demonstrated interest in active learning. These results are in line with Prince's (2004) results that found active and collaborative learning are well known research based instructional strategies, and commonly implemented amongst engineering instructors. These results also align with evidence from higher education literature that university instructors have an awareness of research based instructional methods, and are also aware of the benefits of using these methods over traditional lectures (Henderson & Dancy, 2007; Henderson, 2006). While our participants do continue to use lectures in their courses, they wanted to move away from the traditional lecture style, and add more active learning elements into their classrooms. These results suggest that instructors are aware of the fact that traditional lectures are perhaps not the most successful way to teach a course.

These results can be useful for the development and dissemination of curricular materials in several ways. The first way these results can be used to improve dissemination of materials is for future researchers to consider the development of research based instructional methods that are of a small enough size where they can be easily incorporated into existing lectures. The instructors in this study wanted to add more active learning elements into their classrooms, but were not looking to change their entire course, just add course components in places in their existing courses where they felt they needed them; therefore, an instructional method that requires a complete redesign of a course is unlikely to be adopted by these respondents. Active learning materials that allow instructors to easily incorporate their own course content are more likely to be adopted. These results represent an opportunity for change within engineering education. Instructors are seeking active learning elements in an effort to move away from traditional lectures, and if researchers can provide materials that will fill these gaps, engineering education can begin to move away from less effective traditional lecture style, and towards more engaging and innovative teaching styles.

In contrast to the heavy focus on lectures, and incorporating active learning therein, participants did not often discuss changing exams, homework, or lab activities, suggesting that these are seen as either more difficult to change or not as important to change. If these components are more difficult and time consuming to develop, instructors are not likely to change them often once they are developed to their liking. Changing or developing a homework, lab assignment or exam problem requires not only a change of the problem, but developing a solution, as well as determining the amount of time the problem will take students to complete. Lectures, on the other hand, can be easily modified by adjusting a few slides, and can even be adjusted during class time if need be. If instructors are not actively changing these course components, research efforts that focus on the development of these components may not be disseminated as widely course components that instructors are looking to change, such as lectures. Researchers attempting to develop these types of course components could include measures of effectiveness of their components on student learning in order to increase awareness of the importance and effectiveness of these course components, while also providing evidence of the effectiveness of the methods and materials they are developing, which could in turn increase adoption rates.

Chapter 6 Conclusions and Future Work

Usability testing combined with decision-making research has led to considerable progress towards the development of a successful web-based repository of curriculum materials and best practices. This research has aided in the design of the system, the end-users' expectations of this kind of system, and the characteristics of materials that should be included in this system.

Based on the results of this research we can make several recommendations for developers of instructional materials and engineering education researchers. First, those creating research-based instructional strategies should focus on developing course components that can be easily adapted into already existing classes, easily modified, and can be easily transferred to different subjects. Because we found that instructors modify course components they adopt, addressing this factor in the development of research-based instructional methods can improve adoptability of developed curricular materials. Second, researchers should focus on developing research-based instructional strategies that instructors can incorporate into lectures. Because lectures are the most common course components instructors make changes to, there is a greater chance of instructors adopting a course component if it can be incorporated into a lecture. Third, researchers developing research-based course components should focus on including active learning elements. We found that 77% of participants were looking to change their course components to include more active learning elements, so it is apparent that instructors are aware of active learning, and they are in search of methods to incorporate that into their existing materials. These recommendations are being used to inform the development of a web-based repository for sharing of transportation curriculum materials.

In addition to these recommendations for developers of curricular materials, our findings also suggest several lines of inquiry for future research. Engineering education researchers should focus on comparing course components that instructors consider the most influential on student learning within the classroom, and what course components actually have an effect on student learning. Additionally, future research should look at not only barriers to change, but also address methods to overcome these barriers. Additionally, it is possible that the act of conducting interviews itself can be used to raise awareness of research-based instructional strategies. Greater awareness of others' curriculum planning processes and decision-making is useful in raising consciousness of one's own planning decisions (Stark, 2000). If interviews were used to raise awareness of which course components are the most influential on student learning, perhaps the focus of curriculum planning could shift to developing and refining the more influential components.

As discussed, there is no lack of research-based curricular materials. What are needed now, are ways to improve dissemination and adoption of those materials. The findings presented in this report, and the recommendations based upon them, can help developers of research based instructional methods to improve adoptability of the materials and methods that they develop, which can increase the likelihood that they will lead to change within engineering education. Improving the adoptability of research-based instructional methods through an understanding of faculty decision-making processes can improve the state of engineering education through increased dissemination of methods that are proven to have a positive impact on student learning.

The next step in this project is to complete a third round of usability testing. For this round, the information gathered in the initial rounds would be used to determine the functionality of the website and repository. While the static prototypes were useful during the early rounds of testing, they limited some user functionality, such as typing in search bars and text boxes. A functional webpage would alleviate any potential functionality issues that occurred when using an interactive PDF prototype, making the webpage features the main focus of the testing. The functional system would also contain actual transportation course materials, as compared to the simulated materials that acted as placeholders to test the functionality of the system. This next round would get us one step closer to a final iteration of the repository.

Another important step is the continued gathering of materials for the repository. The results from the decision-making research would be used to determine materials of value to educators. As discussed, these materials should include active learning elements, real world materials, and materials that are small enough to be included into an existing course, such as an individual lesson plan or lecture.

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