DIGITAL DISSEMINATION PLATFORM OF TRANSPORTATION ENGINEERING EDUCATION MATERIALS

FINAL PROJECT REPORT

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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 we will develop a web-based system that will be used by transportation engineering educators to share curricular materials and methods. A research-based action oriented approach will be taken where we iterate between development and studies of usability and adoptability of the system. The efforts described in this report are the first in two stages and include the development and testing of a pilot system, including research efforts that support the development, and the gathering of existing curricular materials to be uploaded to the system. Diffusion of Innovations (DI) Theory has been used extensively to study and implement the characteristics of a system that will facilitate its broad use by educators. This research and development effort will rely 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 study suggest 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. Next steps in this project include one more sequence of usability and adoptability studies followed by the development and dissemination of PTERC to a broader audience.

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List of Abbreviations

PacTrans: Pacific Northwest Transportation Consortium
PTERC: PacTrans Transportation Education Resource Center
WSDOT: Washington State Department of Transportation

Executive Summary

There is national interest in improving engineering education, particularly focused on engineering learning. While there have been substantial improvements and developments (and supporting research) in teaching strategies and curriculum, there is far less adoption of these strategies. National agencies have called for more widespread adoption of best practices and reduced focus on new development. To facilitate this sharing of practices a web-based system will be developed that will be used by transportation engineering educators to share curricular materials and methods. A research-based action oriented approach will be taken where we iterate between development and studies of usability and adoptability of the system, referred to as PTERC from this point forward. The efforts described in this report are the first in two stages and include the development and testing of a pilot system, including research efforts that support the development, and the gathering of existing curricular materials to be uploaded to the system. Diffusion of Innovations (DI) Theory has been used extensively to study and implement the characteristics of a system that will facilitate its broad use by educators. This research and development effort will rely on DI theory, with a specific focus on characteristics of an innovation known to affect adoption. This report provides insight into existing practices of individuals developing introductory courses in transportation engineering. 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 study suggest 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. Next steps in this project include one more sequence of usability and adoptability studies followed by the development and dissemination of PTERC to a broader audience.

Chapter 1 Introduction

National interest abounds in improving engineering education in the US. This interest stems from low performance on concept inventories (Steif, Dollar, & Dantzler, 2005; Steif & Hansen, 2006) concerns over the role of the US as a national economic leader (The National Academies, 2006), evidence of best practices in curriculum development and pedagogy, and a desire to improve the experiences of engineering students and educators. These concerns led to the development of an abundance of materials and methods, which are based on proven, effective methods of development that positively affect student learning and other important educational outcomes. While progress has been made in improving courses and curriculum, it is greatly hindered by inefficiencies associated with duplicating development efforts. For example, there are approximately 200 introduction to transportation engineering courses taught annually in the US and little evidence of sharing of materials (other than textbooks) in these courses. The National Science Foundation (NSF) spends millions of dollars annually through the Transforming Undergraduate Education (TUES) (NSF, 2012) in STEM program on the development and testing of teaching methods and materials, yet its effect is not evident (as indicated by lack of sharing best practices and materials amongst educators).

More knowledge is needed to gain insight into how and why faculty and teachers adopt curriculum. Where do educators go for resources when developing a new course or revising an old course? How do instructors make adoption decisions when they find curriculum? In what forms can dissemination venues (such as websites) take to optimize adoption? This project will begin to answer these important questions and this knowledge will guide the development of an architecture and sustainable plan for a web-based dissemination repository of best practices and materials.

Chapter 2 Literature Review

The adoption of innovations on an individual basis (i.e. teacher adopting portion of a course) in education has been studied primarily using Diffusion of Innovations Thoery. Using this framework provides the opportunity to learn from prior research, while also contributing to the knowledge base in this area.

2.1 Introduction to Diffusion of Innovations

Diffusion of Innovations (DI) theory provides a broad description of how an innovation is adopted (Rogers, 2003). Rogers defines diffusion by breaking it into four components: "Diffusion is the process by which (1) an *innovation* (2) is *communicated* through certain *channels* (3) over *time* (4) among the members of a *social system*" (2003, p. 11). The component of DI theory that is useful for this study is characteristics of something that affects use and adoption. Rogers identified five characteristics of innovations that have large effects on their adoption: relative advantage, observability, trialability, compatibility, and complexity.

Rogers' definition includes a very broad range of innovations that range from typical technological innovations like computer software or kitchen appliances to abstract ideas and practices. Anything that can be communicated can be considered an innovation. Many innovations fall into Roger's category of "technology," which he defines as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome" (Rogers, 2003, p. 13). Rogers writes, "…a technology has two components: (1) a *hardware* aspect that consists of the tool that embodies the technology in the form of a material or physical object and (2) a *software* aspect that consists of the information base for the tool" (Rogers, 2003, p. 258-259). In Rogers' use, the differences between hardware and software are similar to the differences between computer hardware and software, but the

terms apply to anything that fits into Rogers' definition of technology. The actual attributes of the innovation are not discussed: Rogers only states that the way potential adopters perceive innovation has a strong influence on their decision to adopt. Noting the influence of potential users' perception of an innovation, Rogers' identified five attributes of an innovation that may influence rate of adoption: relative advantage, observability, trialability, compatibility and complexity.

Relative advantage describes how potential adopters expect the innovation to improve their lives. This improvement heavily relies on potential adopters' comparisons between an existing tool, system or idea to the innovation. The actual usefulness of the innovation is not important unless the adopter perceived the innovation as being more useful than the existing alternative. *Observability* is closely related to relative advantage. It describes the degree to which an innovation's benefits are visible to potential adopters. Observability is partly a property of the innovation itself—for example, the positive effects of diet pills are more easily observable by potential adopters than the benefits of heartburn medication—and partly a property of marketing and advertising. It is the visibility of the innovation as well as the visibility of its relative advantage. Observability is sometimes related to *trialability*. Trialability describes how conveniently an innovation can be partially adopted. A movie in the theater, for example, has very low trialability because an individual is required to purchase and consume the product prior to evaluating the product. Often, computer software has high trialability because potential adopters can use it and observe its relative advantages before having to commit to adoption. *Compatibility* describes how well an innovation's purpose and use integrate with a society's values and norms. *Complexity* relates to the perception of the adopter regarding

difficulty of learning to use the innovation. Table 2.1 shows examples of each of these attributes as they relate to the development of the web-based repository:

Table 2.1 Examples of characteristics of the database that may affect adoption

Relative Advantage	Is this an easier way to find curriculum than existing alternative? Which aspects are easier/harder than the alternative?
Observability	Do you hear others talk about how easy the database is to use?
Trialability	Can you use some aspects of the database and not others? Can you try it out without fully utilizing the database?
Compatibility	Is this how I normally look for information related to curriculum development?
Complexity	How hard is it to find the things I want or need? How much training is required for first use?

2.2 Research on Adoption

A large portion of educational research utilizing DI theory examines the diffusion of computer technology or web-based materials amongst various educational contexts. For example, Sahin (2006) collected and reviewed several studies of the adoption of "technology" in education. Sahin used Rogers' definition of technology and distinguishes between hardware (e.g. a textbook) and software (e.g. the knowledge required to use the textbook appropriately in order to support learning). Most DI studies in education, however, focus almost exclusively on the hardware of technology. In Sahin's study, the primary concern was computer use, but similar research has investigated course management systems (Bennett & Bennett, 2003; McQuiggan, 2006) and online teaching materials (Shea, McCall, & Ozdogru, 2006). In general, these studies found that teachers' adoption of online or computer-based curricular materials depended largely on their attitudes toward computers (Blankenship, 1998; Isleem, 2003), and their

confidence in their ability to use them (Zayim, Yildirim, & Saka, 2006). Other broad investigations of the degree to which technology is integrated into education have found correlations between technology adoption and student achievement (Christensen, Griffin, & Knezek, 2001), teaching experience (Less, 2003) and general knowledge of computers (Surendra, 2001). Although no research has been done investigating the use of a web-based storage site for curricular materials, lessons learned from similar research will be used to guide research and development described in this effort.

Many DI studies in education focus on the characteristics of potential adopters and its relationship to resistance to adopt an innovation. In their 2003 study of the diffusion of a course-management system, Bennett and Bennett noted, "In fact, the biggest obstacle to applying technology in the classroom at many institutions is not a lack of funds or technology but a faculty that is unwilling to use the technology made available to them…" (p. 54). Similarly, McQuiggan (2006) and Aboelmaged (2000) argue that studies of diffusion in the educational setting need to incorporate individual adopters' perspectives in order to be useful. Surry (2002) included individual concerns in the development of his of "integrating technology into higher education" model (which was based on surveys of 61 college Deans and suggested perspectives in theoretical literature), but differed significantly from previous work by emphasizing financial and institutional resources.

DI-based research in education tends to over-emphasize the hardware of technology and neglect the software. The studies cited (Bennett & Bennett, 2003; Sahin, 2006; Shea et al., 2006) found relationships and made claims about teachers' use and relationship to computers and particular online resources ("hardware," in Rogers' terms). However - with the exception of Surendra (2001) – the noted literature do not discuss the diffusion of ideas (software) related to

education. Few studies investigate the diffusion of curricular materials, and none found in this review investigate the diffusion of curricular innovations that Rogers would consider software. Due to their inherent differences, especially in terms of trialability and observability, it is likely the hardware and software would diffuse differently: the research currently does not address these differences.

Similarly, the majority of the research founded its analysis on quantitative analysis of unvalidated (and often unexplained) surveys. In the absence of validated, reliable survey instruments, it is unclear how much information is actually gained by such research. Additionally, such research fails to capture adopters' perspective in detail, and cannot uncover the causes of faculty beliefs and actions. In a rare exception, Frank, Zhao and Borman (2004) conducted multiple interviews with teachers in their schools to understand their use of computers. This approach made it possible for them to discuss the teachers' use of computers within the their institutional and social contexts, as well as infer important relationships between computer use and social networking. Finally, most DI studies in education are conducted at a single point in time. As argued by Waarts, van Everdingen and van Hillegersbert (2002), Rogers' theory of diffusion has multiple time-dependent features, including the rate of adoption and communication channels.

Most DI-based studies treat the decision to adopt as a singular event (Waarts et al., 2002). The description of the adoption decision is primitive and simplistic compared to Rogers' way of examining the innovation itself. This perspective also makes is difficult to define what the innovation is. Although technological innovations do not often change during diffusion, curricular materials may change as each individual adopts them. This is discussed in the framework of DI theory, but is not accounted for in the overall model of diffusion.

The majority of DI studies in education are broadly quantitative. This results in generation of findings that indicate the existence or predominance of certain researcher-identified phenomena, rather than identifying causes of actions or experiences that explain participants' behaviors. As Bennett and Bennett have found, however, "…the biggest obstacle to applying technology in the classroom at many institutions is not a lack of funds or technology but a faculty that is unwilling to use the technology made available to them…" (2003, p. 54). This is a quantitative finding – that faculty are unwilling to use technology – that can best be explored using qualitative methods. Any survey that attempted to investigate why faculty are unwilling to change practices would necessarily have to assume a range of possible answers in order to create a survey instrument. Qualitative methods have the advantage of being able to follow unexpected results and honestly explore causal relations without limiting presuppositions.

2.3 Applying the Literature to this Research

In order to develop a web-based repository that effectively addresses' users needs, this research is founded on an action research perspective, while simultaneously utilizing DI theory to understand how and why faculty adopt others curriculum. The research effort will involve qualitative interview methods that provide the opportunity to explore details of faculty adoption processes and decisions, without inhibitive preconceived notions of this phenomenon. The interview questions will be based on DI theory. In addition to the development of several stages of qualitative research, issues arising from faculty in early interviews that do not fit within DI theory, but are valuable to our development of the database, will contribute to the formation of the web-based repository. The following research questions will guide our effort:

1. What methods do faculty use to look for curriculum when developing or refining a course?

2. What characteristics of the curriculum affect adoptions decisions as they relate to expected use (e.g. the size of the adopted material - course vs. one day of material, complexity of material presented, anticipated use of material, etc…)
3. What additional information (if any) is necessary for the adopter to know about the materials to encourage adoption?
4. How can a web-based repository be developed to maximize use and adoption of materials?

Efforts to develop the repository will be based on previous efforts, expertise in database development and word searches, and practical models that work well for other purposes, such as existent transportation curriculum and training websites (e.g. National Research Council, 2012; Department of Transportation, 2012). However, our proposed site differs from these and other existing sites: The two noted sites provide information on training and entire curriculum for training sessions. The web-based repository developed from this research will have smaller pieces of data (e.g. portions of lecture notes, assessment questions, active learning exercises, etc.) that can be found and easily utilized and multiple methods of accessing information via provision of browsing menus and ability to search terms when an individual is building a course.

Another benefit of this research is that interview data will provide insights into faculty approaches to teaching and learning and their use of best practices. For example, if faculty search for active learning exercises for use in the classroom, it can be inferred that faculty use active learning in the classrooms. In the long term, this knowledge adds to the development of the database in a way that provides insights into these best practices, encourages these best practices, and by tracking downloads of materials we can better understand faculty use of best pedagogical practices.

Chapter 3 Project and Research Objectives

The overall goal of this project is to develop a web-based repository in which best practices and materials may be effectively shared amongst transportation engineering educators. The success of the dissemination hinges on the development of the site through consciously addressing perceived attributes of the innovation. This report provides detailed information regarding the process of developing the repository according to findings from two preliminary studies, as well as briefly describe the current state of the website. As noted previously, developing an innovation that effectively addresses issues of adoption and potential users' desires should assess changes over time. As such, this report provides insight into one portion of the project (the initial development of the site). The iterative process of constructing a web-based repository according to the tenets of DI theory, while addressing the issue through an action-oriented perspective, is illustrated in figure 3.1.

Using interviews with individuals who recently developed an introductory class in transportation engineering and an analysis of syllabi for introductory courses in transportation engineering, the characteristics of the materials to include in the repository and potential functional qualities of the site were identified. The four main research questions guided this initial stage of the project:

- What methods do faculty use to look for curriculum when developing or refining a course?
- What characteristics of the curriculum affect adoptions decisions as they relate to expected use (e.g. the size of the adopted material - course vs. one day of material, complexity of material presented, anticipated use of material, etc.)?
- What additional information (if any) is necessary for the adopter to know about the materials to encourage adoption?

- How can a web-based repository be developed to maximize use and adoption of materials?

These questions assess potential issues that may affect adoption of the web-based repository. Rather than only taking into account perceived attributes of innovations (i.e. relative advantage, compatibility, complexity, trialability, and observability) after final construction and dissemination of the repository, the basis of the initial process was proactively addressing DI characteristics of the innovation and the perceptions of potential adopters prior to the dissemination of the repository to the transportation engineering educator community. Through the analysis of this preliminary dataset, the development of a taxonomy and interface provide an initial architecture from which future work may be based.

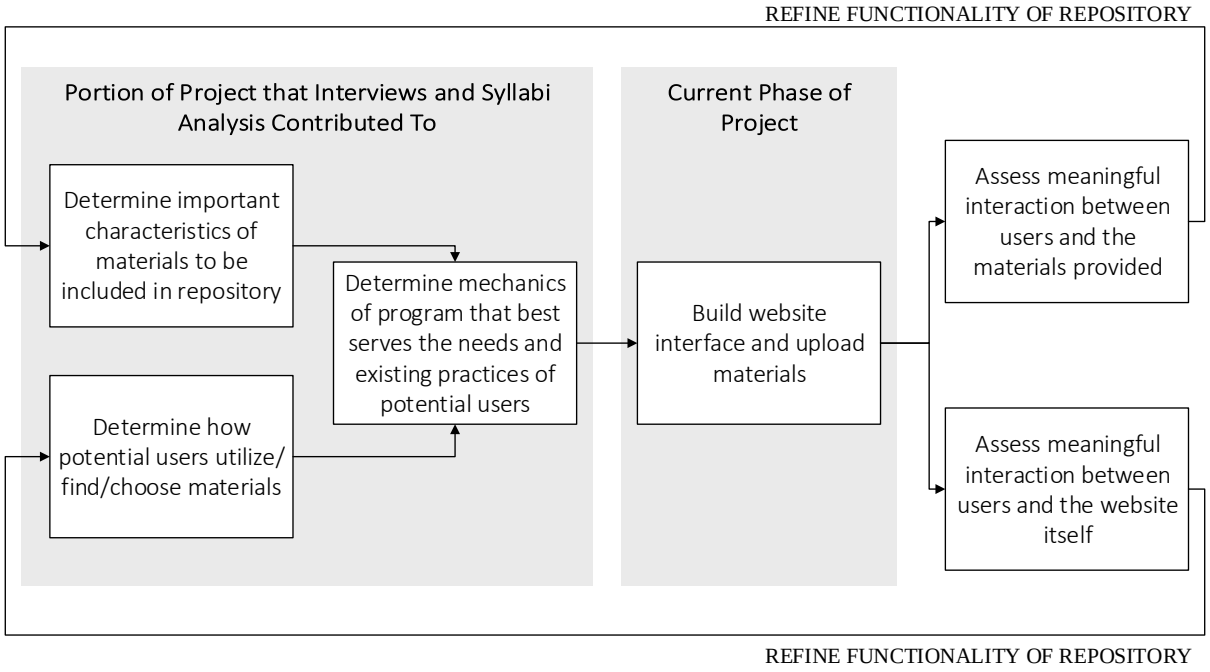

Figure 3.1 Process of project

Chapter 4 Method

A series of semi-structured interviews with four individuals in the process of constructing curriculum for introductory transportation engineering courses was conducted. Themes from the interviews provided insight into sources these individuals utilized to gather materials for their courses, types of materials the participants sought, characteristics of the materials that either encouraged or discouraged adoption into their courses, and functional characteristics of a web-based repository that they perceived to potentially affect their willingness to use the innovation.

Along with the semi-structured interviews and thematic analysis of the data, a document analysis of 24 syllabi from introductory transportation engineering courses taught at various universities within the United States was completed. The analysis of the syllabi provided insight into what types of textual resources were currently utilized by educators, the transportation engineering topics faculty taught in their courses, and types of resources (e.g. textbooks, handouts, film, guest speakers, etc.) faculty included within their courses.

4.1 Interviews

Four individuals, who either were in the process of developing or recently completed developing an introductory course in transportation engineering, were interviewed. All of the participants worked at universities located in the Pacific Northwest. The individuals interviewed were purposefully selected due to their concurrent development of the course relevant to this research. Participants I and II were identified as potential participants based on suggestions from experts within the project team. Miles and Huberman (1994) branded this sampling process as "reputational case selection", in that experts actively recommended individuals to interview based on participants' reputation within the field. Access to the two teaching assistants (TAs) interviewed resulted from snowball sampling: Participants I and II were asked during their

respective interviews to suggest other potential interviewees with insight into the curriculum-construction process for introductory transportation engineering courses (Miles & Huberman, 1994). Participants III and IV were the individuals Participant I suggested for the study. Table 4.1 provides a summary of the courses developed by the participants, tenure status, and responsibilities relating to the development of the course.

Table 4.1 Summary of participants' characteristics and duties

ID	Participant I	Participant II	Participant III	Participant IV
Course Title (Course Standing)	Transportation Engineering (Junior)	Transportation Engineering Fundamentals (Senior) Fundamentals of Transportation Engineering (Junior)	Transportation Engineering (Junior)	Transportation Engineering (Junior) Construction Engineering (no level given)
Tenure/Position	Professor	Instructor	Teaching Assistant (Graduate Student)	Teaching Assistant (Graduate Student)
Duties for class	Did lectures for course	Did lectures and activities during courses	Helped develop activity-based learning portion (lab) of course	Assisted in developing lab portion of course

The interviews comprised of two parts: 1) gaining insight into the interviewees' actual experiences in developing coursework, and 2) accessing participants' opinions and perceptions regarding the development of a web-based repository. In order to access and compare participants' experiences, behaviors, values, and opinions, a standardized open-ended interview approach was utilized in this study (Patton, 2002). The following protocol summarizes the main questions asked during the interviews:

Part 1: Understanding Participants' Experiences and Existing Practices

- In developing the transportation course, what types of materials did you utilize?
- How did you locate these materials? Where did you locate the materials?
- While looking for materials to use, how did you filter what to use and what not to use?
- What were some of the characteristics of the materials that affected your decision to use it in class? What characteristics prevented you from choosing materials?
- What information about the materials did you need to have prior to using it in your course?
- Did you do any internet searches for materials? What sites did you go to? Did you adopt any of these materials?

Part 2: Accessing Participants Opinions and Values regarding a Web-based Repository

- What types of materials would you like to see in a web-based repository?
- Do you have any recommendations or suggestions on how such a repository should work?
- How should the materials be presented or how the site should look?
- How would you design something like this to maximize its use?

In addition to these core questions, a list of probes in association to the main questions were developed in order to provide participants the opportunity to explain their statements in greater detail and clarify their responses (Creswell, 2013). An individual researcher conducted one-on-one telephone interviews with the participants. The researcher recorded data via detailed, written field notes of participants' statements. The length of the interviews ranged between 20 to 55 minutes.

Due to the relatively small sample size of participants, the data was coded by hand rather than using a computer data analysis software (Creswell, 2013). Using an analytical framework approach, examining the data consisted of generating codes grounded in the responses of the participants. Thus, codes utilized in this study were grounded in the dataset rather than presupposed based on existing theory (Patton, 2002). For example, the themes generated from

the first question ("In developing the transportation course, what types of materials did you utilize?") included codes such as "main resource," "lecture notes," "textbooks", "and "websites." For the second main question posed during the interviews ("How did you locate these materials?"), the codes generated from the data included "personal experience," "recommendations of peers," "library website and catalogue," and "general web-based search." Founded on patterns interpreted from such codes - both within responses for individual questions, as well as patterns across responses to various main questions - nine themes emerged across the dataset. The following section presents these themes and underlying supporting codes.

4.2 Syllabi Analysis

In order to determine existing practices and actual materials utilized in contemporary engineering courses, the researchers conducted a document analysis of syllabi utilized in introductory transportation engineering courses. Using a web search of "introduction to engineering syllabi," 24 syllabi relevant to this study were identified and analyzed. Table 4.2 provides a list of the syllabi included in this study.

Markedly, some of the institutions were listed more than once (e.g. University of Washington). This indicates that several syllabi from differing terms were acquired via the online search. Also notable is the inclusion of various syllabi utilized in the spring term of 2009. In the summer of 2009, 20 of these syllabi were collected during the Transportation Engineering Education Conference that took place in Portland, Oregon, and provided as open access documents online (Turochy, 2009).

Table 4.2 Summary of analysis of syllabi

School	Course No.	Jr level	Course Name	Sem/ Qtr.	Year
Arizona	CE 363	x	Transportation Engineering and Pavement Design	Fall	2009
Auburn University	CIVL 3510	x	Transportation Engineering	Spring	2009
Boise State	CE 370	x	Transportation Engineering Fundamentals	Spring	2002
Brigham Young University	CEEn 361	x	Introduction to Transportation Engineering	Winter	2009
Iowa State University	CE 355	x	Principles of Transportation Engineering		2009
Louisiana State University	CE 3600	x	Principles of Highway and Traffic Engineering	Spring	2009
Louisiana State University	CE 3600	x	Principles of Highway and Traffic Engineering	Spring	2009
Marshall University	CE 342	x	Transportation Engineering	Spring	2009
Purdue University	CE 361	x	Transportation Engineering		2009
San Diego State	CIV E 481	x	Transportation Engineering	Spring	2009
Southern Illinois University Edwardsville	CE 376	x	Transportation Engineering	Spring	2010
Tennessee Tech	CE3610	x	Transportation Engineering	Fall	2009
University of Alabama Huntsville	CE 321	x	Introduction to Transportation Engineering	Spring	2009
University of Cincinnati	CEE 351	x	Transportation Engineering	Spring	2009
University of Connecticut	CE 2710	x	Transportation Engineering	Spring	2011
University of Florida	TTE 4004	x	Transportation Engineering		
University of Maryland	ENCE 370	x	Introduction to Transportation Engineering and Planning	Spring	2009
University of Missouri-Columbia	CE 3100	x	Transportation Systems Engineering	Spring	2009
University of	CE 211	x	Transportation Engineering (Lecture)	Spring	2009

Missouri-Rolla					
University of Nebraska	CIVE 361	x	Highway Engineering	Spring	2009
University of Washington	CEE 320	x	Transportation Engineering I	Fall	2006
University of Washington	CEE 320	x	Transportation Engineering I	Fall	2009
University of Wyoming	CE 3500	x	Transportation Engineering	Spring	2011
University of Nevada-Reno	CEE 362	x	Transportation Engineering	Spring	2009

The analysis of the syllabi provided a means to supplement statements made by the interviewees regarding the types of materials from which courses were developed, as well as the relative importance of the resources utilized to develop the courses. The analysis of such documents provides rich information regarding actual material use within contexts of interest (Creswell, 2013; Patton, 2002). Further, the results from the analysis of the syllabi provide suggested actions in addressing DI attributes in the development of the web-based repository.

The specific research questions that guided this portion of the study assessed textbook utilization within classrooms, the topics of focus within introductory courses in transportation engineering, and supplementary materials utilized in lectures:

- What textbooks were utilized in the courses? In what way(s) did the textbooks affect the structure of the course?
- What topics did faculty focus on in their courses?
- What other types of resources were utilized in introductory courses?
- What topics were taught with the supplementary materials?

4.3 Linking DI Theory to Methods Utilized in Study

As noted previously, the exploration and identification of themes in the interview data along with the document analysis of the syllabi provide insight into existing practices of transportation engineering educators. By understanding the relationship between potential adopters' existing perceptions and attributes of the innovation defined by DI theory, factors that influence effective dissemination of best practices and materials mediated by a web-based repository may be better understood. This leads to the development of a repository that positively affect rate of adoption of best practices and curriculum.

Chapter 5 Results

After completing an iterative process of reading and coding the data, identifying themes, providing thick descriptions of emergent patterns, nine themes became apparent across the interview dataset:

- Course developers actively sought materials from other **academically-oriented professionals** within the field. Only one interview participant mentioned seeking information from non-academically-based professionals.
- Course developers seemed to **want to adopt portions of a lecture** (e.g. figures, slides specific to chosen topics, etc.) as opposed to entire course-work (e.g. full lecture). They wanted to **modify the materials according to their needs**.
- The materials chosen for adoption fit into the course developers' already planned outline for their courses.
- The interviewees also mentioned that **greater specificity of materials** was encouraged.
- All of the interviewees noted that they preferred it if they could **search by topic**
- In locating materials, course developers heavily depended on **personal exposure and experiences** with the materials.
- **Interaction with other users was also important** for most of the interviewees. The basis of this importance seemed to be the **ability to rate and provide feedback** on materials.
- The most **popular material mentioned by interviewees was activities** for students to do as part of the class.
    - The issue of **complexity of the materials** itself was also mentioned by various interviewees **as a major filter** in determining whether to adopt the material within the course.

In addition to these themes, the analysis of the syllabi provided insight into the types of materials utilized in classrooms throughout the United States, relative importance of the materials, and the structure of introductory courses in transportation engineering. Examined in this section is the relationship between these findings to the development of a web-based repository that directly addresses DI attributes.

5.1 Understanding Existing Practices

Firstly, our analysis of the syllabi revealed types of supplementary materials faculty actually utilized within introductory transportation engineering courses. Nearly all of the syllabi analyzed indicated the use of textbooks as a resource within the course. In terms of other materials utilized by faculty in their courses, 13 of the syllabi noted using other types of supplementary materials such as handouts, video/film, guest speakers/lecturers, and other sources. Table 5.1 summarizes the number of courses that utilized the noted supplementary materials:

Table 5.1 Types of materials utilized in introductory transportation engineering courses

Supplementary Material Type	Courses that Utilized Supplementary Material Type	
	Number of Courses	Percentage of Courses
Textbooks	22	91.7
Handouts/ Supplementary Notes	8	33.3
Guest Lecturer/Speaker	5	20.8
Film/Video	3	12.5
In-class design problem/examples	2	8.3
Software	2	8.3
Game	1	4.2
Field trip	1	4.2

During the interviews, the interviewees noted five different sources from which they developed their own course materials: lectures from other faculty and colleagues, textbooks, websites, standards (e.g. the Highway Capacity Manual and AASHTO), and guest lecturers. Participants II and III noted that websites developed by faculty specifically for teaching topics in introductory transportation engineering courses were their main resources. Participant III (along with Participant IV) also noted that textbooks served as a main resource in their development of the course.

The sources identified by the interviewees and the actual materials faculty actually utilize within the courses converge, thus providing validity and credibility to the study (Creswell, 2013). The analysis of the syllabi appears to support the notion that textbooks are influential in the development and structuring of courses. As illustrated in table 5.2, 14 of the syllabi indicated that daily lectures related in part to the structure of textbooks, as indicated by the listing of specific textbook chapters and pages in the specified course schedule provided in the syllabi.

This pattern of dependence on textbooks in the courses provides an opportunity to address issues of compatibility in the construction of the search engine for the web-based repository. Tagging individual entities with terminologies commonly utilized in introductory textbooks (e.g. chapter names, sections, index entries, etc.) provides compatible experiences between the innovation (i.e. web-based repository) and potential users' previous experiences with relevant sources (i.e. textbooks).

Table 5.2 Textbooks utilized in introductory transportation engineering courses

Course No.	Textbook Cited in Syllabus	weeks in term (actual course work)	no. of weeks topics taken from textbook	% of weeks topics taken from textbook
CE 363	(Mannering, Kilareski, and Washburn 2009)	14	14	100%
CIVL 3510	(Garber and Hoel 2009)	10	***6.5***	65%
CE 370	(Khisty and Lall 1998)	32	32	100%
CEEn 361	(Fricker and Whitford 2004)	9	7.11	79%
CE 355	(Mannering, Kilareski, and Washburn 2005)	13	9	69%
CIV E 481	(Banks 2001)	34	34	100%
CE 321	(Banks 2001)	13	12	92%
CEE 351	(Hoel, Garber, and Sadek 2007)	9	7	72%
TTE 4004	(Mannering, Kilareski, and Washburn 2009)	14	14	100%
ENCE 370	(Papacostas and Prevedouros 2001)	14	13	93%
CE 3100	(Mannering and Kilareski 2004)	15	14	93%
CE 211	(Garber and Hoel 2009)	16	13	81%
CIVE 361	(Mannering, Kilareski, and Washburn 2005)	15	12	80%
CEE 362	(Garber and Hoel 2002)	14	7	50%

In order to access sources of information (e.g. lectures from other faculty and colleagues, textbooks, etc.) that affected the choice of materials actually utilized in class (e.g. handouts, in class design problems, films/videos, etc.), the interviewees identified three ways in which they were exposed to the materials. The interviews noted that personal experience utilizing the source, recommendations from peers, and individual searches in existent databases (e.g. library catalogue and general web-based searches on Google. These findings provide guidance in addressing the issue of observability during the development of the repository, particularly regarding the provision of recommendations from peers. Providing information reflective of educators' opinions of the materials, such as rankings and number of downloads, affords

potential users the ability to see benefits in using both the materials provided onsite and the web-based repository itself.

The responses from three participants (II, III, and IV) revealed that three methods of accessing materials largely shaped adoption of materials into their courses: previous exposure to the materials, talking to colleagues and gaining their input, and doing an individual search in existing databases. After exposure to potential materials for adoption, the interviewees noted several factors that affected their choice to adopt the material within their course: perception of students' potential to accept and understand the materials, quality of the materials, and the functional characteristics of the materials. The interviewees' perception of students' reactions to the materials heavily influenced their decision to adopt materials into their classrooms. Upon analysis of the interview data, a pattern of agreement across participants' statements indicated that participants' perception of how "interesting" the material would be for students (particularly for activities) was a major filter in their decision-making process. These findings provide an opportunity to address compatibility and trialability of the web-based repository to needs and desires of potential users. The provision of descriptive characteristics of the materials (e.g. a sample picture, short textual description of the material, etc.) affords potential users the opportunity to quickly assess information about the materials that may be relevant to their personal values prior to actually downloading the material.

In terms of filtering the materials based on perceived quality, the participants noted a wide range of influencing factors, such as the applicability of the actual materials to their course, whether the materials addressed students' conceptual understanding, whether the materials have been previously validated, and if the materials were relevant to current, real-world conditions. Participants II, III, and IV noted that the complexity of the materials as an issue of importance.

These participants mentioned not wanting to "overload" and "overwhelm" students. Further, all the participants sought materials that they perceived to be interesting to students. Another filter the participants utilized in choosing materials was whether the material espoused practical application. For example, Participant III noted that one of the activities she developed for the course required that students to collect field data. The form students utilized during the activity was a form utilized in actual practice.

The participants also provided detail about functional issues of the sources that affected their willingness to adopt certain materials into their curriculum. These functional issues included the provision of information regarding the application of the materials (e.g. time required to complete an activity), ease of access in the sources to access specific information (i.e. material organization, size of original source, etc.), opportunity to modify the materials as needed.

One of the overarching themes across the interviewees' statements was negative experiences in searching for specific materials. Participant IV shared his experience of looking for a specific figure to include in the course materials. Rather than having quick access to the specific figure in interest, he searched an entire chapter of a textbook filled with content he perceived to be irrelevant to the course materials he was preparing. While adopting materials for his course, Participant II noted that the originating source – PowerPoint slides he attained from a colleague teaching a similar course at a different university – ranged in sizes between 3 and 11 megabytes. He noted, "That was way too large." Participant II perceived the size of the originating documents to be so overwhelming, that he "felt that the materials were not applicable" to his course during his initial exposure to his colleague's materials. Only after further exploration of the materials did Participant II acknowledge the depth of materials

provided within the PowerPoints. Upon further reflection, Participant II noted, "if the presentation[s] were separated into topics, it would have been more helpful." Statements from the Participants I, III, and IV echo the preference for specificity of the materials and ability to search by topics.

In order to increase relative advantage of using the site comparing to other sources and decreasing complexity associated with locating desired materials, the issues identified in the interviews must be addressed. Potential solutions include enhancing functional characteristics of the web-based repository and the materials included in the site through provision of multiple means of locating material (i.e. browsing, search by topic, etc.), inclusion of relatively small pieces of information (rather than large documents), and providing materials that easy to modify per the needs of the users.

5.2 Accessing Participants Opinions & Values Regarding the Innovation

The second portion of the interviews focused on gaining insight into potential users' opinions and values regarding a web-based repository for sharing best practices and materials with other engineering educators. One of the first questions asked of the participants was what types of materials they desired to be included within a web-based repository. Table 5.3 summarizes the types of materials participants identified. Note differences between tables 5.1 and 5.3: the only type of material common between the two is the inclusion of examples/exercises. This difference hints at a potential to provide types of materials not available (or easily accessible) in other sources. The provision of such materials may provide relative advantage over other means of accessing materials.

Table 5.3 Types of materials suggested by interview participants

Types of Materials Desired	No. of Interview Participants Who Mentioned Type of Material as a Desired Item
Activities	4
Lecture slides	3
Assignments/homework/examples/exercises	2
Labs (including instructions)	2
Quizzes	1

During the interviews, participants were asked how they would design a repository to maximize its use. The participants suggested several functional properties of a repository that they would like to see (table 5.4): the ability to search by topic, the provision of ways to filter through materials quickly and efficiently, ability to interact with other users, and provision of materials that are easily modifiable. The participants also identified potential concerns and problems: issues with updating the material, attribution of works, and complexity of uploading and sharing materials. Table 5.4 provides notes and excerpts from the interviews reflecting participants' suggestions to maximize a web-based repository's use:

Table 5.4 Notes and excerpts summarizing participants' suggestions for repository

Themes	Participant I	Participant II	Participant III	Participant IV
Ability to search by topic	Mentioned importance of specificity of materials	"specificity is important" Table of Contents or summary of available information would be helpful	Suggested searching by topic	Would rather have the ability to search by topic as opposed to having to dig up specific files in large documents
Filtering through material		Provide levels of understanding (e.g. basic vs. advanced) for materials	Suggested filters based on time to complete activity, context information (i.e. how many	

		Separation/ categorization by topics and/or modules Provide measures of performance and assessment of materials included in repository	students needed to complete an activity, group vs. individual) Present table of factors of each material/activity	
Ability to interact with other users		He also noted that there should be a way to rate what was useful and what was not	Interaction with developers and other users is encouraged Mentioned the importance of having material already checked by others, and proven valid Website may serve as inspiration for faculty to include activities within the course Even if faculty do not use the materials provided, it can still serve as "encouragement" for activity-based learning	Noted the following as positives associated with the website repository: Provides an opportunity for multiple people to look at the sources There's potential for materials to be updated and revised by other users
Ability to modify materials as needed	Preferred materials that would not "require detailed questions" to understand and use	Noted that materials presented within the website repository should be "unstylized" (e.g. specific fonts, school tags, etc.) to provide ease of modification		Preferred if materials provided opportunity to be modified as needed, but also desired material (e.g. activities, labs) that was presented as modules and ready-to-use

5.3 Linking DI Characteristics to Results

Taking into account participants' existing practices in developing course materials along with their suggestions for developing a repository, characteristics of the materials that may affect its adoption are identified in relation to DI categories as identified by Rogers (2003) (table 5.5). This linkage between perceived attributes and proposed actions provide a foundation from which a web-based repository may be developed. Currently, implementation of proposed actions have are at various degrees. The following chapter provides an overview of some of the features of the website.

Table 5.5 Links between perceived attributes of innovation and proposed actions

Perceived Attributes of Innovation per DI theory	**Questions posed relating perceived attributes and proposed action**	**Proposed Actions in Developing Web-based Repository**
Relative Advantage (How do potential adopters expect the innovation to improve their lives, compared to existing tools, system, or ideas)	Is this an easier way to find curriculum than an existing alternative? Which aspects are easier/harder than the alternative?	Provision of materials not easily accessible or available in other sources
		Include material that are small in size (e.g. figure vs. entire lectures)
Observability (Describes degree to which innovation's benefits are visible to potential adopters)	Can potential users see/hear others talk about how easy the database is to use?	Provide indicators showing that materials have been previously validated by others in the field (preferably their peers and colleagues)
		Provide opportunity to communicate with peers about the quality of the materials (i.e. rankings, number of downloads, etc.)
Trialability (How convenient an innovation can be partially adopted)	Can some aspects of the database be utilized in part while not having to access and utilize other aspects?	Provide descriptive characteristics of materials (e.g. preview picture, short textual description of material, etc.) so users can quickly assess if material is relevant to their needs

Compatibility (How well an innovation's purpose and use integrate with a society's values and norms)	Is this how educators normally look for information related to curriculum development?	Tagging materials according to terminologies commonly utilized in popular textbooks utilized in academia
Complexity (How hard an innovation is to learn to use)	How hard is it to find the materials desired or needed? How much training is required for first use?	Provide multiple ways of locating material (i.e. browsing, search by topic, etc.)

Chapter 6 Discussion

Two screen shots from the pilot system are shown in figures 6.1 and 6.2 below. The first is the introductory screen. Users will be required to register before accessing materials and will be limited to faculty and instructors. This will alleviate concerns of students getting access to homework and exam problems and solutions by individuals who have shared their materials. Users will be able to browse all materials or search for materials as described above.

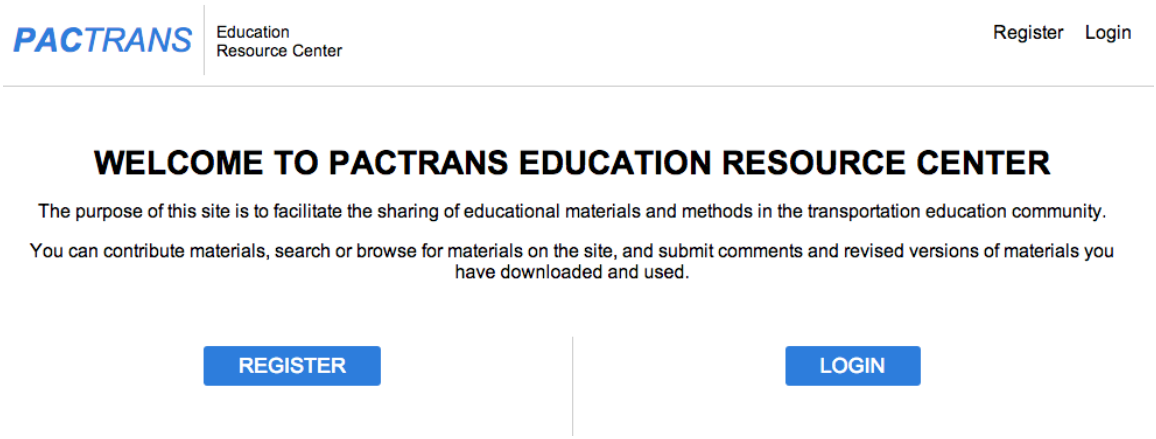

Figure 6.1 Screenshot of registration page of website

Based on data collected from future users we have determined that the materials need to be broken into relatively small pieces to enhance adoption by other faculty. For example, faculty very rarely adopt an entire set of notes, homework assignments and exam questions. Therefore, our approach is to break up the materials according to content area and application, so that faculty can utilize materials from different developers as they put together their materials for a particular content area. For example, a faculty could search for design and homework problems

related to stopping sight distance. Materials that have been collected for this effort are on this relatively small scale.

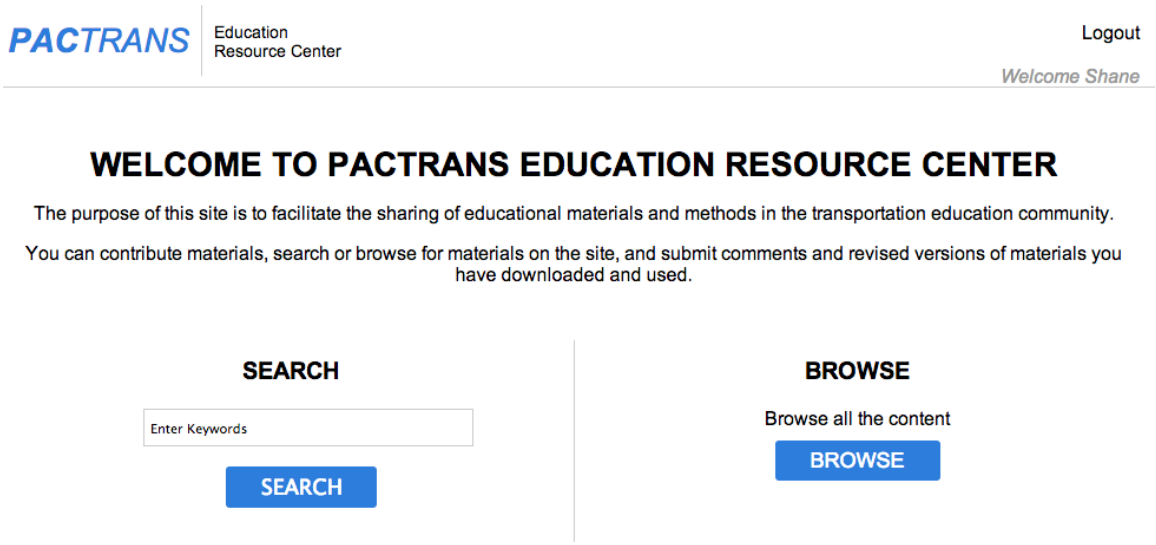

Figure 6.2 Screenshot of the search/browser portion of the site

Chapter 7 Conclusions and Future Work

Substantial progress was made towards the goal of broad usage of a web-based system to facilitate the sharing of education materials amongst transportation engineering educators. Research conducted to date will facilitate the design of PTERC, the size and type of materials that will be uploaded to PTERC, and general user interactions with PTERC.

Next steps will focus on a committed conceptual design of the system, including models of how users will interact with the system, how access privileges will be assigned to users and materials, and how materials will be tagged to be accessible. Two general options are available for tagging, developer-defined and user-defined. The current plan is to have both: a developer-defined hierarchical structure where users can browse materials within this structure, and user-defined keywords where users can search based on these keywords. Once this conceptual design is complete, the system will be developed using the conceptual design and the program architecture from the system that is currently developed and briefly described above.

This project is expected to have a substantial impact on the effectiveness of transportation teaching methods by providing easy access to a diverse set of materials and that it will make the course refinement and development process much more efficient for faculty. The system will be usable by the summer of 2014.

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