



Refinement and Dissemination of a Digital Platform for Sharing Transportation Education Materials

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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.¹ 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.

In an effort to improve curriculum sharing, there is currently a two-part study underway for the development and dissemination of a web based repository containing curriculum materials and best practices. These two efforts are in place to understand, facilitate, and encourage sharing of materials and best practices between educators. The first is the development and refinement of the web-based repository for curriculum materials; the second is a study on the curricular decision-making processes of transportation engineering educators.

The overarching goal of these two studies is to develop an effective web-based repository where engineering educators can readily share educational materials and best practices. The development and dissemination of this repository is dependent on two aspects - a successful, usable web-based system, and materials that educators are interested in. If the materials contained within the website are what the educators are looking for, yet the repository does not meet user expectations, it is likely that educators will seek other methods of gathering these materials. Alternatively, a well-designed repository will be of little use if the materials available are not appealing or applicable to the short-term or long-term needs of educators.

Much research has been done in the design and development of technical systems for human use.² 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 can 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.

Literature Review: Diffusion of Innovations

The national interest for improving engineering education in the United States has led to 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.³ 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.⁴

An innovation is anything that can be considered new, such as a technological advancement or idea.⁵ 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.⁶

A technology is a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome.⁷ 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.⁸

Prior educational research involving Diffusion of Innovations (DI) theory has focused on the use of computer technology,⁹ course management systems,^{10,11} and online teaching materials.¹² While these studies have found the adoption of technology in classrooms to be correlated to student achievements¹³ and teaching experience,¹⁴ 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,^{15,16,17} 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.^{18,19} Previous studies have also treated adoption as an isolated incident,²⁰ unlike Rogers' Diffusion of Innovations approach that considers adoption a process that occurs over time.²¹ 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 university²². 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.²³ 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.²⁴

Methods

Background: Project Design

Because there has been no research on a web-based repository of curriculum materials, results from prior studies discussed above are being used to inform the development of the web-based repository and the decision-making research. The project utilizes Rogers' components of adoption in several ways. Relative advantage is addressed through both of the studies. The usability testing allows for potential user feedback on the usefulness of the repository, while the decision-making research gains insight into how educators are currently sharing information with each other. Observability is 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 is not only an effective method for developing a system that potential users find useful, but also increases awareness of such a system amongst transportation engineering educators. Trialability is 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 is development-level material and not a technology that is directly used in the classroom, using the system does not necessarily require individual users to change their teaching practices. Complexity is addressed through usability testing, by allowing potential users to voice their concerns or expectations of the system during the development stages. Compatibility is included in both studies: follow-up questions on why or why not this system would be useful to the potential users are asked during the usability testing, while identifying the materials in the repository that potential users are interested in contributes 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 serves as informational background, while the web-based repository is the physical tool that allows users to access the information sought. Unlike previous studies, perspectives on the system by potential adopters and the quality of the materials provided as judged by the same potential adopters are both taken into consideration, and these considerations are made over time, rather than at one moment in time. By being web-based and dependent on how educators use the system, the repository also has the ability to evolve and change over time.

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 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 1 and Figure 2 as an "X" will be occupied with a preview of the selected document.

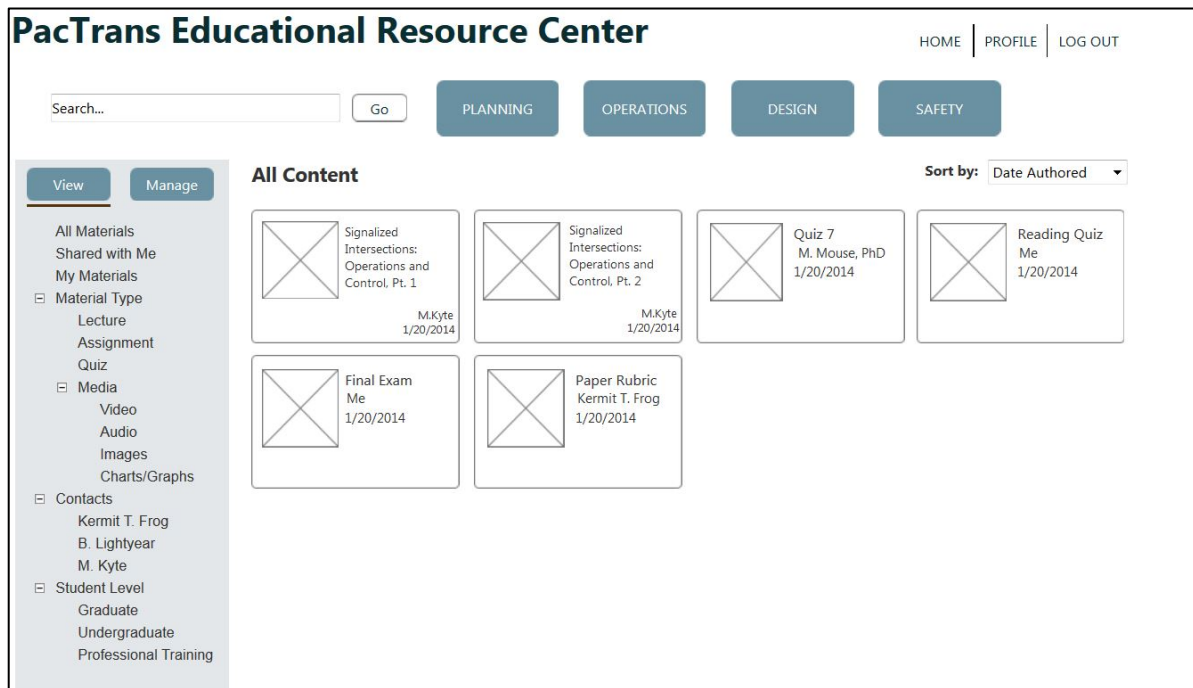


Figure 1: Screenshot of the repository prototype used in round one of usability testing

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 2 shows a screenshot of the repository prototype used in the second round of usability testing.

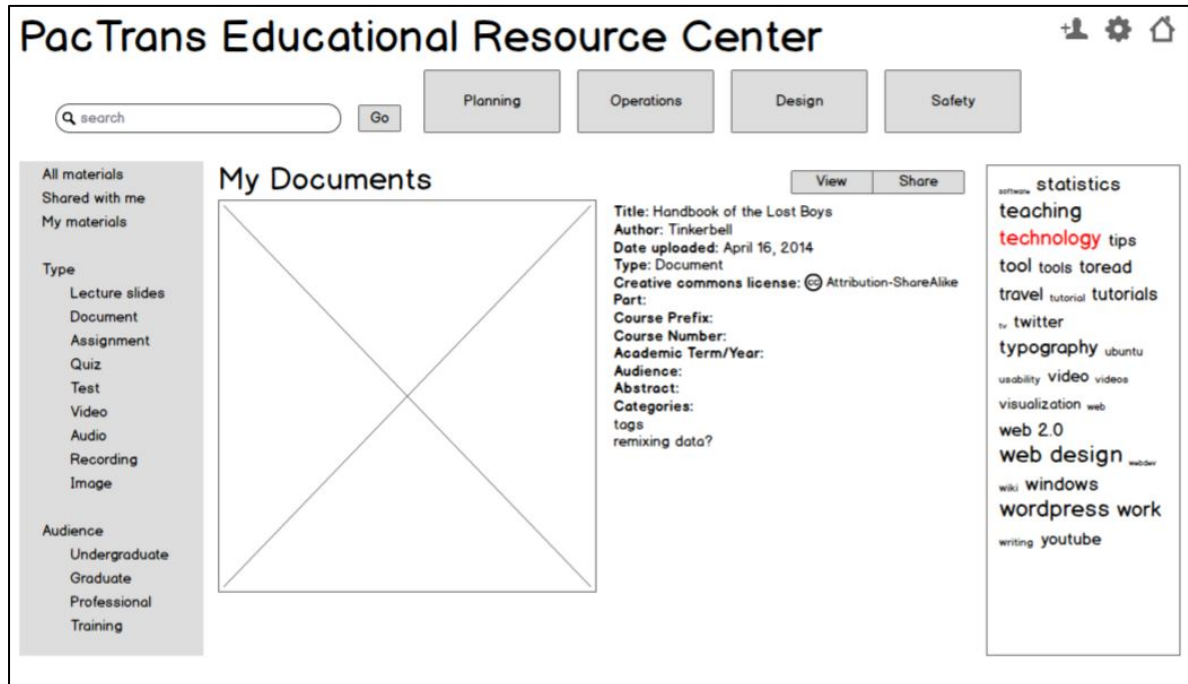


Figure 2: Screenshot of the repository prototypes used in the second round of usability testing

Decision-Making Research

For this study, the twenty-four engineering educators interviewed were instructors who teach transportation engineering or transportation-related courses. They broadly represented eighteen universities from thirteen states across the country. Seventeen of the universities are public research university, and one is a private university. The transportation educators chosen for this study were also identified as potential end users of the web-based repository under development.

The interview protocol was developed over several iterations. The initial protocol was focused mainly on a new course or newer course that the faculty had developed on his or her own. The focus was on newer courses so that the decision-making process was fresher in the minds of the participants. This interview protocol was initially administered to five participants, and the results were analyzed to see what kinds of themes would warrant additional interview questions. It was decided after the first round of interviews that sending the participants the interview protocol beforehand was beneficial. Furthermore, it was decided that asking participants to have a copy of their most recent course syllabus as a reference during the interview could lead to responses more oriented toward their decision-making thought process because it would serve a concrete reminder about choices that were made but were perhaps not given much consideration at the time. 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 taught by the instructor.

The transcribed interviews were coded using the analysis software Dedoose.²⁵ After each interview was transcribed, it was analyzed for any responses that related to faculty decision-

making. Follow-up questions were developed to gain further detail on these responses, and these questions, along with the interview transcriptions, were sent to the participants prior to conducting a follow-up interview.

Results and Discussion

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 3). 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.

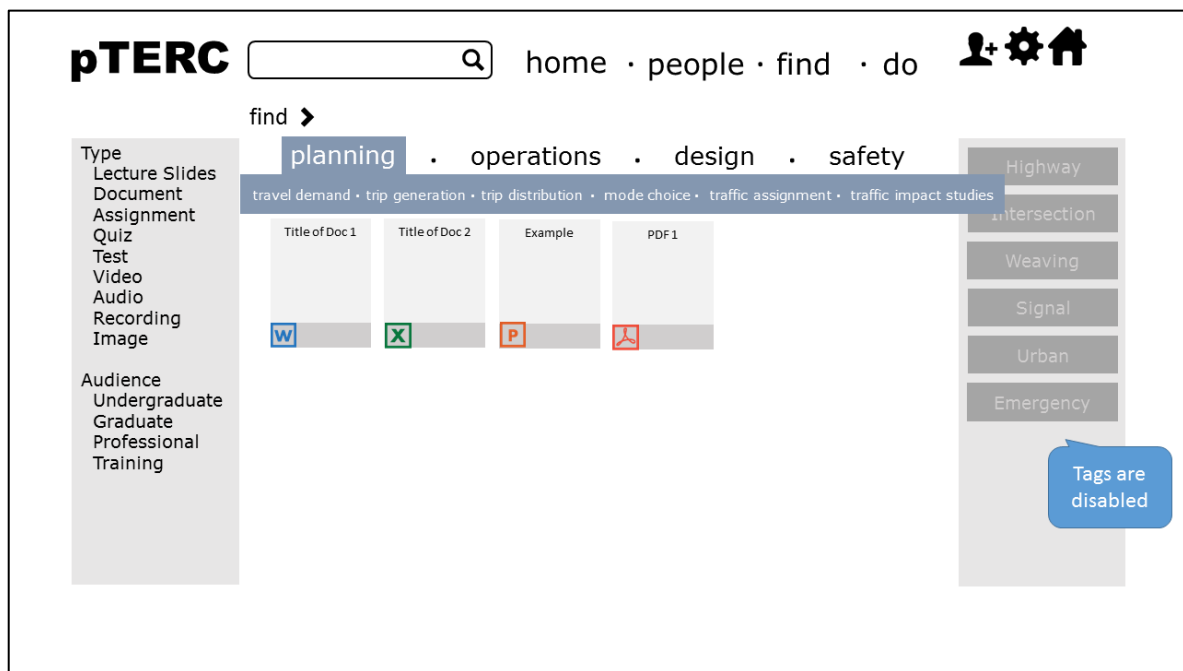


Figure 3. Screenshot of an updated user interface.

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.

Decision-Making Research

The on-going decision-making research has identified several findings that can be used to further refine the web-based repository. First, we found that the type of materials most commonly created and changed are lecture materials, as opposed to homework or exams. *Lecture materials* included slides, notes, and lecture style. Second, we found that there were three major factors that influenced their decisions to use or change lecture materials: 1) active learning, 2) improving the clarity of materials for students, and 3) incorporating real world or contemporary materials. For the purposes of this research, *active learning* entailed explicit use of the term by the participant, moving away from older or more traditional teaching practices, and/or using materials and practices to improve student engagement. Materials were considered *real world* if labeled such by a participant, or if coming from industry or practice. *Contemporary* material was that which was up-to-date, such as current design standards and manuals.

Other preliminary findings include that when faculty members create or change materials, they most often gather materials from colleagues, textbooks, or design manuals and guides. When instructors borrow materials from colleagues they generally do not implement the materials as is, but rather make modifications to the materials or implement only portions of the materials. Educators are also looking for materials that they can include in their already existing materials, such as an individual lesson or activity instead of notes designed for an entire course.

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.

The next step in this project is to complete a third round of usability testing. For this round, the information gathered in rounds one and two will be used to develop a functional website of the 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 will alleviate any potential functionality issues that occur when using an interactive PDF prototype, making the webpage features the main focus of the testing. The functional system will 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 will get us one step closer to a final iteration of the repository.

Another important step is gathering of materials for the repository. The results from the decision-making research will 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.

These two studies are expected to positively influence teaching practices in transportation engineering. Educators will be able to easily access transportation engineering curriculum materials and best practices, which can encourage dissemination, as well as reduce the replication of materials that already exist.

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