# ADOPTION OF TECHNOLOGICAL INNOVATIONS:

# A CASE STUDY OF THE ASSESS WEBSITE

By

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A thesis submitted in partial fulfillment of
the requirements for the degree of

MASTERS OF SCIENCE IN CIVIL ENGINEERING

WASHINGTON STATE UNIVERSITY
Department of Civil and Environmental Engineering

MAY 2013

To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation/thesis of SARAH JEANNE BROOKS find it satisfactory and recommend that it be accepted.

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## ACKNOWLEGEMENTS

This research was supported through the National Science Foundation, grant number DUE 1065486. Assistance in writing the enclosed manuscript was provided by Shane Brown and Denny Davis. Narration for the videos referenced throughout this document was completed by Gregory Gould.

ADOPTION OF TECHNOLOGICAL INNOVATIONS:

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Abstract

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May 2013

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In engineering education, assessment instruments are often developed to evaluate programs and projects. Unfortunately, these innovations are not always adopted by intended audiences. Rogers' Diffusion of Innovations (DI) Theory provides a framework to analyze characteristics of an innovation that will effect adoption. The Appraisal System for Superior Engineering Education Evaluation-instrument Sharing and Scholarship (ASSESS) is a user-driven, web-based catalogue of assessment instrument information. The purpose of this study is to develop an understanding of ASSESS' adoptability as well as to characterize lessons learned and how to apply them to other technical innovations. Interviews with potential users were used to explore user perspectives of ASSESS. It was found that the innovation's *Use as an Alternative* and its *Functionality of Design* were the primary categories important for adoption. These categories relate to the *Relative Advantage*, *Complexity*, and *Compatibility* DI characteristics. Focusing on these categories and DI characteristics is recommended for developers of engineering education technological innovations.

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# CHAPTER ONE

## INTRODUCTION

This research studies the diffusion of innovations theory as applied to the adoption of the Appraisal System for Superior Engineering Education Evaluation-instrument Sharing and Scholarship (ASSESS) website. This chapter provides information about the submitted publication for this research as well as previous work in this area.

The Chapter Two was submitted to *Advances for Engineering Education: A Journal of Engineering Education Applications* (AEE) as a manuscript for publication. An online journal, AEE strives to diffuse innovations to the engineering education community. Innovations focused on in the journal include: "*course and curriculum design, teaching, and assessment both within and outside of the classroom that have led to improved student learning*" (American Society for Engineering Education, 2012). The journal is specifically interested in presenting innovations through the use of multimedia. As such, five videos were submitted to be published with the following manuscript. Once published, these videos would be accessible by clicking on the figures in the journal article. For this document, the videos can be viewed using the links provided under each figure.

The journal manuscript details the adoptability of ASSESS. The purpose of ASSESS is to provide users with information on quality assessment instruments for use in engineering education, specifically higher education settings. Quality assessment instruments are a current growing need in engineering education, as well as other disciplines. As such, ASSESS is not unique in making resources available for the engineering education community. Previous efforts include: The Field-tested Learning Assessment Guide (FLAG) website, The National Science Digital Library (NSDL), The Buros Center for Testing, The National Engineering Education Delivery System (NEEDS), and the Engineering Pathway website. The main advantages of ASSESS are as follows:

- Efficiency in finding appropriate, quality assessment instruments
- Standards-based comparisons for more objective selection of quality assessment instruments
- Information on instrument assumptions, applicability, and limitations to guide proper use
- User contributed knowledge, experiences, and reviews adding to evidence for instrument validity and appropriate use
- Reviews from experts to help developers advance their instruments toward superior status
- Feedback from users to help developers make ongoing improvements to instruments in ASSESS
- Continual updates on superior instruments to keep the community informed on instrument status

# CHAPTER TWO

# JOURNAL SUBMISSION

## Introduction

Educational innovations to improve and assess engineering education are often developed, but not commonly adopted by the intended users. An abundance of assessment instruments, such as concept inventories and self-efficacy instruments, have been developed for engineering education. However, these instruments are not broadly adopted. Rogers, who developed the diffusion of innovations theory (DI), notes that even innovations with obvious advantages are slow to be adopted in educational institutions (Rogers 2003).

Adoptability studies are usually performed after the development process and typically study how an innovation is adopted (Rogers 2003, pg. 219). One issue with studying adoptability by looking at the adopters is that at this point it is too late to make significant improvements or changes to the innovation to aid its adoption. Studying the characteristics of an innovation can be done before the innovation is released for adoption, allowing for improvements to be made. This study will investigate potential adopters' views of a web-based database developed to house information on engineering assessment instruments, during the development process of the database, allowing for insights into adoptability of technological innovations as they are developed and feedback to the developers that can be used to improve adoption.

## Literature Review

When new innovations are created, developers may be interested in how they will diffuse to their intended audience. This raises the question of how to determine the adoptability of the innovation. This information is important when defining the success of the innovation (Procaccino et al. 2005). One common method for understanding the adoptability of an innovative technology, especially in an educational setting, is Rogers' theory of diffusion of innovations (Martins et al. 2004, Kebritchi 2010). Kebritchi notes that "*Rogers' theory has been widely used in a variety of settings, ranging from diffusion of rural technology among farmers to the adoption of innovations in educational settings. This theory is useful for instructional technologists to explain, predict and account for the factors that impede or facilitate the diffusion of their products*" (Kebritchi 2010).

Rogers' theory follows the diffusion of an innovation, looking at characteristics of an innovation, the social system in which it is diffused, the type of innovation decision, the types of communication channels used, and any promotional efforts used by change agents (Rogers 2003, pg. 11). Most of these variables occur after an innovation is released for adoption. The DI characteristics of the innovation itself can be addressed during the development phase of the innovation. Because this research is focused on the development phase, this paper will use DI characteristics to examine adoptability.

Diffusion of innovations theory suggests that five characteristics relate to the adoptability of an innovation, as summarized in Table 1 below (Rogers 2003, pg. 15-16). The diffusion of innovations theory states that "*The characteristics of innovations, as perceived by individuals, help to explain their different rates of adoption*" (Rogers 2003, pg. 15). The "individuals" mentioned are potential adopters, not the developers of the innovation. Most adoption studies neglect the perspective of the developer all together. Developers often have little or no awareness of what potential users are looking for in an innovation (Vonk et al. 2007). Ravitz and Hoadley point out that "*One gap [in communication] is between technology users and technology developers, making it more difficult for developers to seek and obtain feedback from users*"

(Ravitz and Hoadley 2005). This study is unique in that developers will be immediately aware of potential users' views of the adoptability of the innovation.

**Table 1: DI Characteristics**

| Characteristic | Definition |
|---|---|
| **Relative Advantage** | The degree to which an innovation is better than an existing method/practice/idea. |
| **Compatibility** | The degree to which an innovation matches the needs, experiences and views of the adopter. |
| **Complexity** | The degree to which an innovation is perceived as difficult to use or understand. |
| **Trialability** | The degree to which the innovation may be experimented with before committing to adoption. |
| **Observability** | The degree to which the results of an innovation are visible to others. |

There is disagreement in DI literature about which of Rogers' characteristics are the most important for the adoption of technological innovations (Kebritchi 2010, Martins et al. 2004, Samarwickrema and Stacey 2007). Literature about adoption studies for technological innovations in education helped determine what DI characteristics would be important for this study. Studies that operationalized the five DI characteristics for use as interview questions were specifically explored and the resulting three studies are described below:

Kebritchi studied the adoption of a mathematical computer game (2010) targeted to middle school teachers to help their students learn Algebra. The DI characteristics that were the most important were *Relative Advantage*, *Compatibility*, *Complexity* and *Trialability*. *Relative Advantage* was the most important factor, because the game had to be more effective at teaching

Algebra than other options available to the teachers. *Compatibility* was also highly important because teachers needed the game to fit well into their schedules and curricula. If the game could not be adjusted to their requirements, it would not be helpful. *Complexity* was important for teachers in respect to how the game challenged their students. They did not want a game that was too easy, but if it was too challenging it would not be useful. It also had to be simple enough for the teachers to help their students if they ran into difficulty. Finally, teachers wanted opportunities to test the game before they committed to adopting it. Without at least minimal *Trialability*, few teachers were willing to implement the game. *Observability* was not important because teachers wanted to base adoption on their own experiences.

In researching the adoption of Internet resources for teaching foreign language in schools, Martins et al. found that *Trialability* and *Observability* were the most significant DI characteristics (2004). Their study showed that participants who received more training on using the Internet for this purpose adopted this resource in their classroom. They found that when the applications were observable, diffusion was more likely to occur. The other DI characteristics were not perceived as equally important as these two.  It was mentioned that, during training, the advantages of using the innovation and the ease of use were demonstrated. Thus, *Relative Advantage* and *Complexity* could play a role in adoption, but were actually initially part of *Trialability*.

Another adoption study was focused on web-based learning and teaching in higher education (Samarwickrema and Stacey 2007). *Relative Advantage* was discovered to be the most influential DI characteristic followed by *Compatibility*. The features of the web-based approaches, such as communication options, were often cited as reasons for adoption. Adopters previously did not use web-based learning, so the adoption of these methods was an alternative to classroom education. The study found that when the participants' social systems encouraged them to adopt, they were more likely to do so. Because the systems were compatible with their values and those of their social network, they were comfortable with adoption. *Trialability*, *Observability*, and *Complexity* did not affect adoption as much. This could be because most adopters were adopting based on the end goal (web-based learning) instead of based on the learning management system being recommended. If the instructor wanted to provide a web-based class (or was asked to do so by administration), then these three DI characteristics became less important for adoption to occur. The advantages of the system and whether they are compatible with the educational environment are important. Whether or not the adopter's colleagues had used the system, the system was simple, or a free trial was offered, were found to be less important for adoption.

The significance of the various DI characteristics on the adoptability of an innovation appears to be distinct for each innovation. Rogers himself stated that *Relative Advantage* is one of the strongest predictors of an innovation's rate of adoption, but not all literature is in agreement (Rogers 2003, pg. 233). Thus, developers are not able to select a DI characteristic for focus prior to initiating an adoptability study on their innovation.

Previous research generally supports Roger's assertion that *Relative Advantage* is more important than the other DI characteristics for adoptability. If there are no advantages to using an innovation there is no reason to use the innovation even if the other DI characteristics have high levels. *Trialability* is also important for technological innovations if they involve unfamiliar features. Individuals need to be reassured that they are able to use an innovation for their intended purpose before actually adopting it. Finally, *Compatibility* is important because this innovation is intended to be adopted in higher education. If the innovation is not compatible with the institutions' values or requirements, the educator is not likely to adopt it. While *Observability* and *Complexity* should be considered, they are likely not as important. Many practices, tools, and ideas are complex and challenging in higher education, so this should not be an inhibiting factor for adopters. Although *Observability* of results is preferable, in this situation it may not be necessary. Adopters will more likely be concerned with whether the innovation will work for themselves as opposed to others, as in Kebritchi's research.

By performing the adoptability study during the development phase, the researchers believe that the innovation will be more adjusted to user's needs and expectations. An adoptability study during development will allow users to express more possibilities without being limited to what is already finished. For example, if participants are presented with a blank page instead of a fully developed page, they are more likely to express what they were expecting to find there or what they really want to find there. If a page is fully developed already, the participants are more likely to express what they like and dislike about the current page, instead of discussing what they were hoping to find.

If the results from this study prove to be reliable, the researchers believe that adoptability studies during development are superior to those conducted after development. An adoptability study during development allows the development team to make changes as feedback is acquired, as opposed to waiting for the next version or edition to be released. These changes can be immediately tested with another group of potential users to determine how well they worked. Users are free to express their expectations of the innovation and developers are able to use these expectations to adapt their innovation to best meet the needs of its intended audience.

Using the DI theory as a framework for a development phase adoptability study is beneficial for developers. Responses are grouped by DI characteristic, which allows the researchers and developers to focus on areas of concern. With each new set of changes and corresponding interviews, the response ratings for each DI characteristic change, allowing the researchers to evaluate which changes were improvements. Without using a theory or framework, researchers would be more challenged to investigate improvements made by the developers.

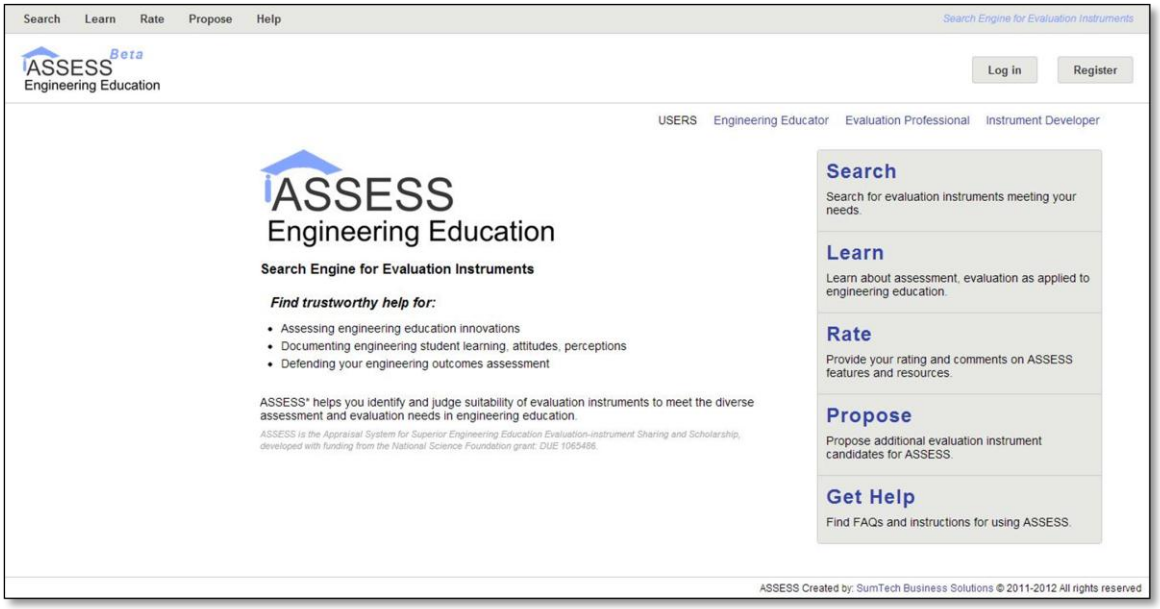
**ASSESS**

Advancing engineering education requires development and use of high quality educational evaluation instruments as well as a community of engineering educators prepared to properly implement these instruments. Many of the research questions addressed by engineering education development projects require both qualitative and quantitative methods of assessment to determine project impacts on performance, perceptions, and academic intentions of people being studied. Project investigators often struggle to find an appropriate evaluation instrument, so they develop their own. This often results in use of less proven evaluation instruments or wasted effort as instruments are needlessly reinvented. Many investigators also lack the knowledge needed to select the best evaluation instruments, administer them as intended by the developer, and interpret evaluation results properly for the instrument and the conditions of its use. The final result is project evaluation that is inadequate for fully documenting the outcomes, guiding project implementation for maximum benefit, and determining real impacts of a given engineering education development project.

At a time when improvement of engineering education is crucial to the well-being of the nation, high quality evaluation instruments must be readily available and also empower project investigators to select and utilize them effectively. The National Science Foundation is also calling for evaluation capacity building (ECB) for personnel working on NSF projects (Katzenmeyer and Lawrenz 2006). A national workshop convened by the authors of this paper also produced recommendations calling for a well-developed clearinghouse for high-quality evaluation instruments to support engineering education (Davis et al. 2009). The national imperative is that high quality evaluation instruments be developed, made available, and used properly in engineering education development projects to support vital advancement of engineering education.

This study will examine the adoptability of the Appraisal System for Superior Engineering Education Evaluation-instrument Sharing and Scholarship (ASSESS), a user-driven, web-based database of evaluation instrument characteristics. For each assessment instrument, ASSESS provides descriptions, uses in engineering education, reliability and validity evidence, as well as both expert and user reviews. An introductory video describing ASSESS is available by clicking on Figure 1.

In considering the purpose and functionality of ASSESS and the literature related to the most important characteristics for adoption of comparable innovations, it appears that *Relative Advantage*, *Trialability*, and *Compatibility* will be the most important characteristics related to adoptability of ASSESS. This innovation is different from those in the literature review in that it is specifically intended for engineering education, as opposed to education in general. ASSESS allows for user input, a function the reviewed innovations did not have. Additionally, ASSESS serves as a database of information with search functions and additional opportunities for learning. However, all the innovations are technological in nature and are used in education. One of the goals of this study is to compare the predicted and actual importance of these characteristics.




- ASSESS is a tool for the engineering education community to increase its ability to evaluate student learning and other impacts from educational practices and innovations.
- The purpose of ASSESS is to help users identify and judge the suitability of different assessment instruments for their specific needs in engineering education.

**Figure 1: Introduction to ASSESS**
http://youtu.be/uAW2Qv5VGdc

The goals of the ASSESS project are to assist engineering educators in identifying assessment instruments suitable for use in specific education or research endeavors. The project also seeks to assist engineering educators in disseminating and refining assessment instruments that have been developed through research projects. ASSESS users are able to submit instruments for consideration for inclusion through the ASSESS interface.

ASSESS will potentially be used by teachers, program assessors and individuals writing grants and looking for information on assessment instruments. The development of ASSESS was chosen because it fills the need in engineering education for a source of information about assessment instruments and has a high probability of being adopted by large numbers of engineering educators. Finally, ASSESS takes the form of a database, which could be translated to areas in education that store other materials, such as curricular materials or assessment questions. Thus, the results of this study may be helpful to an audience much broader than those interested in the specific content area of ASSESS.

**Research Goals**

Literature shows much disagreement on what DI characteristics are most important for the adoption of an innovation, a challenge for developers who would like to collect feedback on their innovation to improve adoptability. Adoptability studies need to be performed during the development process to allow developers to make adjustments to their innovations.

The purpose of this study is to demonstrate the perspectives of potential users of ASSESS gathered using the DI theory as a framework. The following research sub-goals will accomplish the overall research goal.

- Capture multiple perspectives of the innovation during the development phase to develop and refine ASSESS.
- Determine the relative importance of DI characteristics in technological educational innovations.

**Methodology**

Participant Selection

The participants were chosen based on their likelihood to adopt ASSESS in a similar fashion to Guido Vonk in his study of planning support systems (Vonk, Geertman, & Schot, 2007). The first group, Participant Group (PG) One, is individuals who participated two years earlier in a workshop focusing on defining the need for and content of a database for engineering evaluation instruments. Everyone who participated in the workshop was invited to participate in this study. Of the 29 invited to participate nine agreed to be interviewed. PG One had already been exposed to the idea of ASSESS, but not the website itself. Since this group had chosen to attend the workshop and were engaged in engineering education and assessment, they were deemed likely potential adopters of ASSESS. PGs Two and Three were selected from the Educational Research and Methods (ERM) Division of ASEE. PG Two included 10 individuals and PG Three included 4 individuals. ERM members consist of educators and researchers, both users to whom ASSESS is focused. Many ERM members attend educational conferences where ASSESS has been and will again be presented. Their potential increased exposure to the ASSESS project from these conferences and the fact that they are interested in educational research made this group more likely to adopt the final innovation. Additional information about the ASEE ERM division can be found at: http://erm.asee.org/.

The three groups of participants were interviewed throughout the development process of ASSESS to develop a complete perspective on adoptability. The interviews occurred after the initial prototyped site was completed, but before the website was in its completed stage. For PG One, ASSESS had basic functionalities and about 10 instruments with information. For PG two, ASSESS had the same amount of instruments with information, more search features, and outlines of additional pages (learn, rate, etc.). For PG three, some additional instrument information had been added, the additional pages had some information, and improvements had been made in the search features’ functionality. Having the interviews staged at different times enabled the researchers to gather perspectives on changes made during the development process, allowing the development team to see what improved or what still needed to be worked on.

Data from PG Three did not reveal substantial new information beyond the previous interviews, known as data saturation. During analysis, 37 codes were used for PG Two, 36 of these were also used in PG Three. No new codes were added in analyzing PG 3. Krathwohl defines data saturation as the point "*when new observations cease to add much to previous ones*" (Krathwohl 1998, pg. 260). Therefore, no additional interviews were conducted after PG Three, because no new observations were being added.

Interview Protocol

Interview questions were developed using the five DI characteristics as guidelines. Each of the DI characteristics had multiple questions associated with it, as shown in Table 3. In addition to these questions, general questions were used to determine the interviewee's background with assessment instruments. The interview questions were developed, in part, based on previous studies that had operationalized the DI characteristics (Martins et al. 2004, White 2010, Kebritchi 2010, Samarawickrema 2007, Hill and Lee 2010, Liberatore and Breem 1997, Di Benedetto et al. 2003, Heri and Mosler 2008). However, Rogers discourages reusing other studies' questions as "*The specific ways in which the five attributes are expressed differs in each study, and so the measures of these attributes should be uniquely created afresh in each investigation*" (Rogers 2003, pg. 225). For each interview, the participants were also given the definitions of the five DI characteristics and were asked to describe their perspective of ASSESS demonstrating each of the DI characteristics. The wording of some of the interview questions was slightly modified after completing the initial group of interviews to increase clarity and optimize data collection from participants' interviews. Table 2 provides a summary of the questions asked for the participant interviews and the DI characteristic they illustrate.

Interview Methodology

The goal of the interviews was to develop an understanding of the participants' views of ASSESS' adoptability using the DI framework. Interviews were semi-structured (Krathwohl 1998, pg. 287) with open-ended questions (Patton 2002, pg. 20-21). A semi-structured interview style was selected based on the complexity of responses from individuals. The ability to individualize the interviews to collect the participants' unique perspectives is critical when it is expected that aspects of each participant's perspective will be unique. The researchers did not want to assume that they could get all the information they needed from using a fixed set of questions, as would be the case in a closed-ended interview. Thus, the protocol for the interviews had a question set to allow for consistency, but still allowed participants to expand their answers and to delve with greater detail into areas they felt were important.

Participants were asked the questions presented in Table 2 and were encouraged to elaborate on their answers. Follow up questions (shown italicized in Table 2) were asked as necessary for clarification. The interviews were conducted over the telephone and lasted between 10 and 20 minutes.

**Table 2: Participant Interview Questions**

| | |
|---|---|
| **Background Questions** | • **What current methods do you use to access assessment instruments?**<br>• **What do you like/dislike about your current methods?**<br>• **What do you think of the ASSESS database?** ***What was your first impression of the database? Does it meet your expectations or not? How so?*** |
| **Relative Advantage** | • What advantages or disadvantages does this database have over your existing methods for finding assessment tools?<br>• In what ways would this database positively or negatively affect your assessment capabilities?<br>• How would your assessment practices change if you were using this tool? Would you consider this change an improvement or a regression?<br>• How would your productivity change due to the use of this tool? |
| **Compatibility** | • How do you envision ASSESS fitting into your daily work activities?<br>• Why would you want to tell your colleagues about this? *What would you tell them?*<br>• In what ways could this be used in your department?<br>• In what ways could you envision your colleagues in your department using this tool? |
| **Complexity** | • When looking at the ASSESS database, what items, if any, do you not understand?<br>• How hard would it be for you to learn to use this tool?<br>• How long would it take you to become comfortable using ASSESS?<br>• How easily would you be able to get what you want out of it in an efficient manner? |
| **Trialability** | • What do you think the upsides/downsides to trying this tool are?<br>• What are you giving up/gaining from trying ASSESS? |
| **Observability** | • What other databases, similar in educational content to ASSESS, do you know of? *What do you know about them and where did you hear about them?*<br>• How would others know if you were using this tool? |

Analysis Methods

The interviews were recorded, transcribed, and analyzed using Atlas TI (Scientific Software Development 1999). Although the three sets of interviews were conducted at different times during the development of ASSESS, there were not dramatic differences in participants' responses across the three groups. Therefore, the data from all three groups was analyzed together. Data analysis was done with increasing depth as described by Krathwohl (1998, pg. 308). The transcriptions were first read to obtain an understanding of the overall responses. An initial coding step was then completed, which is referred to as descriptive coding to "*see what is there*" (Krathwohl 1998, pg. 308). The data was coded for participant responses that mapped to one of the five DI characteristics. The next step of coding was to "*recode this same material at an interpretive level*" (Krathwohl 1998, pg. 308). The responses were then coded as they related to the DI characteristic – good or bad. The final step for analysis consisted of "*a still deeper level of analysis….code patterns of activities, themes, causal link…*" (Krathwohl 1998, pg. 308).

The responses were then categorized further with individual tags for the reasoning behind the categorization. For example, a participant's response that said they liked the database because they found it self-explanatory and easy to use would be coded as "Complexity – Good – Simple" because it demonstrated good (low) levels of *Complexity* because of how simple it is to use the interface. The dataset was then recoded according to descriptions of the site that are more in terms of the interviewees' language, both for interpretive value and to facilitate transferring findings to the developers. For example, responses were coded as "Additional Features" or "Suggested Changes" to help with the development process. The data was analyzed iteratively to connect the interviewees' descriptions with the DI characteristics. For example, the description of available information is related to DI characteristics *Relative Advantage*, *Compatibility*, and *Complexity*. Finally, for each category of overlap between interviewees' descriptions and DI characteristics the approximate frequency of this occurrence was determined and characterized as high, medium, or low and as either positive or negative. If less than 25% of participants mentioned one of these overlap areas a “low” ranking was assigned, between 25% and 75% received a “medium” ranking, and 75% received a “high” ranking.

## Results and Discussion

The results are presented in terms of six categories that were identified in terms of interviewees’ language: *Expectations of Instrument Inclusion*, *Available Information*, *Community Features*, *Use as an Alternative*, *Searchability*, and *Functionality of Design*. This allows for a more reader friendly presentation because it is expected that readers will more likely understand these categories than the DI characteristics. Also, this choice provides a more reader friendly presentation of videos embedded into the article based on the six categories. These six categories, and the DI characteristics they relate to, are shown in Table 3 below, with a + or – sign indicating if overall responses were positive or negative. If no responses related to a DI characteristic for one of the six categories, this space was left empty in Table 3. The discussion will focus first on each category and then on how each DI characteristic related to that category. Videos are also included to provide an overview of the functionality of ASSESS and features that resulted from or were already aligned with feedback from interviewees.

**Table 3: Ratings for DI Characteristics**

| | Relative Advantage | Compatibility | Complexity | Trialability | Observability |
|---|---|---|---|---|---|
| **Expectations of Instrument Inclusion** | - High | - Low | | | |
| **Available Information** | + Med | + Med | - High | | |
| **Community Features** | + Med | + Low | | | + Low |
| **Use as an Alternative** | + High | + Med | | + High | + High |
| **Searchability** | | + Med | + Low | - Low | |
| **Functionality of Design** | + Med | - Low | + Med | + Low | - Med |

<u>Expectations of Instrument Inclusion</u>

The first category is "*Expectations of Instrument Inclusion*" and is related to expectations of interviewees to find information on specific instruments. This category includes aspects of the *Relative Advantage* and *Compatibility* DI characteristics, as shown in Table 3.

*Relative Advantage* - Participants expressed concern about the database being comprehensive: "*Downsides, like with all repositories, it's only as good as the effort to be inclusive of getting things into it*," "*there's also kind of a concern about would it be updated over time*," and "*The other thing is I tend to not only look at instruments that have only been done in engineering because I like looking at a wide variety of fields*." This concern is especially understandable considering the low number of instruments that had information available in the database at the time of the interviews.

While the *Relative Advantage* DI characteristic did receive a high negative rating for *Expectations of Instrument Inclusion*, not all of the responses were negative. Some participants looked beyond the current size of the database and considered the end result: "*I think the advantage is that it [ASSESS] is engineering focused and we are an engineering school so it filters out…things that I don't want*."

*Compatibility* - Participants were concerned that the database might not include information on the types of instruments they would be interested in: "*I think there would need to be more focus on concept inventories and things of that nature, you know, specific skill-based as opposed to attitude and things of that nature*," and "*I guess for me the really emphatic point here is I'd like to see more qualitative instruments such as open ended surveys and guided survey questions and how to conduct a focus group*."

In an effort to alleviate the concerns found in this category, the development team requested instrument suggestions from interview participants and has begun requesting them from conference attendees where the ASSESS website is being presented. The ASSESS website, once fully developed, will also have a feature that will allow users to suggest or submit instrument information to be included in the database. Thus, the database should evolve to be a highly inclusive set of instrument information providing for each user's individual needs.

<u>Available Information</u>

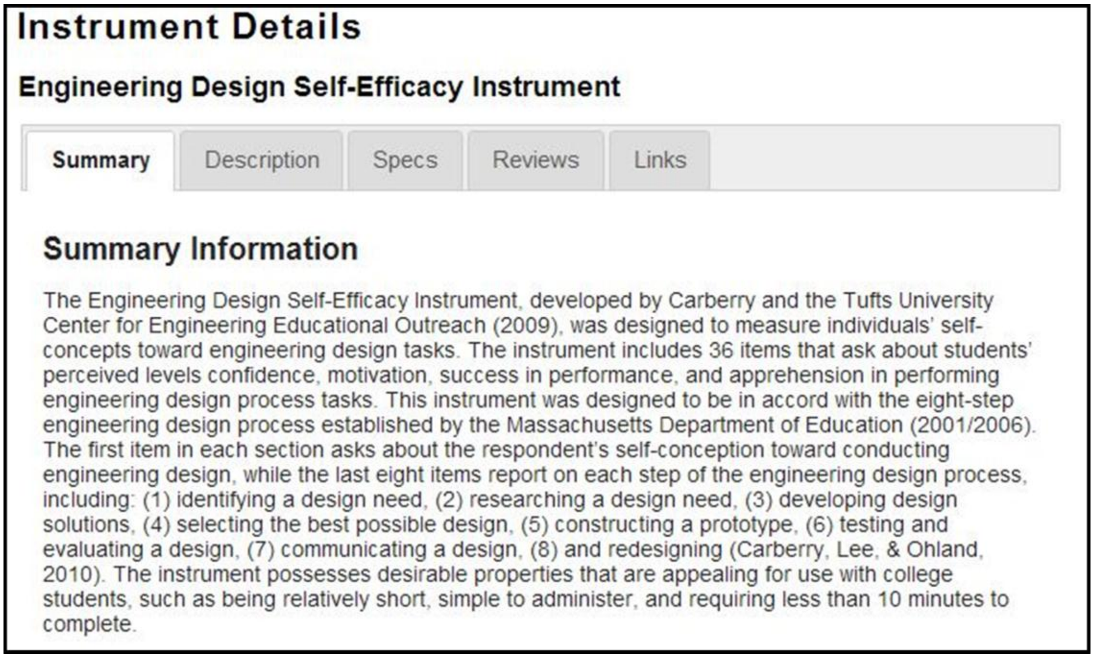
*Available Information* includes the participant perspectives of the information available on the ASSESS website. Examples of information are: specifications about instruments, information about how to use ASSESS, and information about assessment instruments in general. These responses relate to the *Relative Advantage*, *Compatibility*, and *Complexity* DI characteristics. Table 4 shows that *Relative Advantage* and *Compatibility* received medium positive ratings and that *Complexity* received a high negative rating.

*Relative Advantage* - Participants overall were pleased with the amount of information available: "*Despite the fact that I need it or don't need it you have more details on the instrument. You have summary, description, you have the reference…where it was published, reliability and validity, you will have those links*." Additionally, participants thought that they would be able to learn from the information on ASSESS. These two areas increased the overall *Relative Advantage* for potential users.

*Compatibility* – Participants' views of the available information were generally positive. Again, the amount of information available was the most significant topic of responses: "*And if I dive into one in particular it's nice, you get the description, you get all the specifications of the material. You can link things, I can probably download things*." One concern for this DI characteristic was that novice users might still be confused and that there needed to be more information to guide these users: "*In my experience, a lot of faculty members really don't even understand what assessment is. I mean they have so little knowledge where their glossary isn't going to be sufficient for them, at least that's been my experience. Now, maybe people going into this website already know something about assessments, but I wouldn't count on it*."

*Complexity* – The main area of concern was that the information available on ASSESS was too confusing. Symbols and terminology used throughout the website were misunderstood and questioned by participants: "*Utility standards of program evaluation; I don't even know what that means*." Another issue was that the amount of information provided was overwhelming for some participants, "*It might just be 'We're putting all this information out there for you to use,' but I'm just wondering if it could be filtered down first so I can click and go into more details, try to find in the areas that I'm more interested in, whatever it may be in those particular areas*."

In order to minimize confusion, the development team reviewed the terminology used on the website. Some symbols and terms were altered and a glossary was added to assist with the remaining terminology. Additionally, a "learn" tab was added to the website. This tab includes information about the website, about assessment instruments, methods, practices and results, and the glossary of terms. While some participants had mentioned that the amount of information was troubling, the additional information will be sorted into smaller chunks. Therefore, the information would presumably not be overwhelming. Another feature that has been added to minimize confusion is a question mark icon available above potentially confusing sections of text. If this icon is hovered over using a mouse, a pop-up window opens with additional explanatory information. These changes should make the information on the ASSESS website more applicable for all users. A video detailing information available on ASSESS can be accessed by clicking Figure 2. The video highlights the areas that participants noted as positive as well as the areas of improvement.



Instrument Details

Engineering Design Self-Efficacy Instrument

Summary | Description | Specs | Reviews | Links

Summary Information

The Engineering Design Self-Efficacy Instrument, developed by Carberry and the Tufts University Center for Engineering Educational Outreach (2009), was designed to measure individuals' self-concepts toward engineering design tasks. The instrument includes 36 items that ask about students' perceived levels confidence, motivation, success in performance, and apprehension in performing engineering design process tasks. This instrument was designed to be in accord with the eight-step engineering design process established by the Massachusetts Department of Education (2001/2006). The first item in each section asks about the respondent's self-conception toward conducting engineering design, while the last eight items report on each step of the engineering design process, including: (1) identifying a design need, (2) researching a design need, (3) developing design solutions, (4) selecting the best possible design, (5) constructing a prototype, (6) testing and evaluating a design, (7) communicating a design, (8) and redesigning (Carberry, Lee, & Ohland, 2010). The instrument possesses desirable properties that are appealing for use with college students, such as being relatively short, simple to administer, and requiring less than 10 minutes to complete.

- Each instrument includes tabs of information. The summary tab gives the user an overview of the instrument including recommendations for use and how it has been used in engineering education.
- General information about assessment instruments and terminology is also available.

**Figure 2: Available Information in ASSESS**

http://youtu.be/r3gDcS5E8GA

Community Features

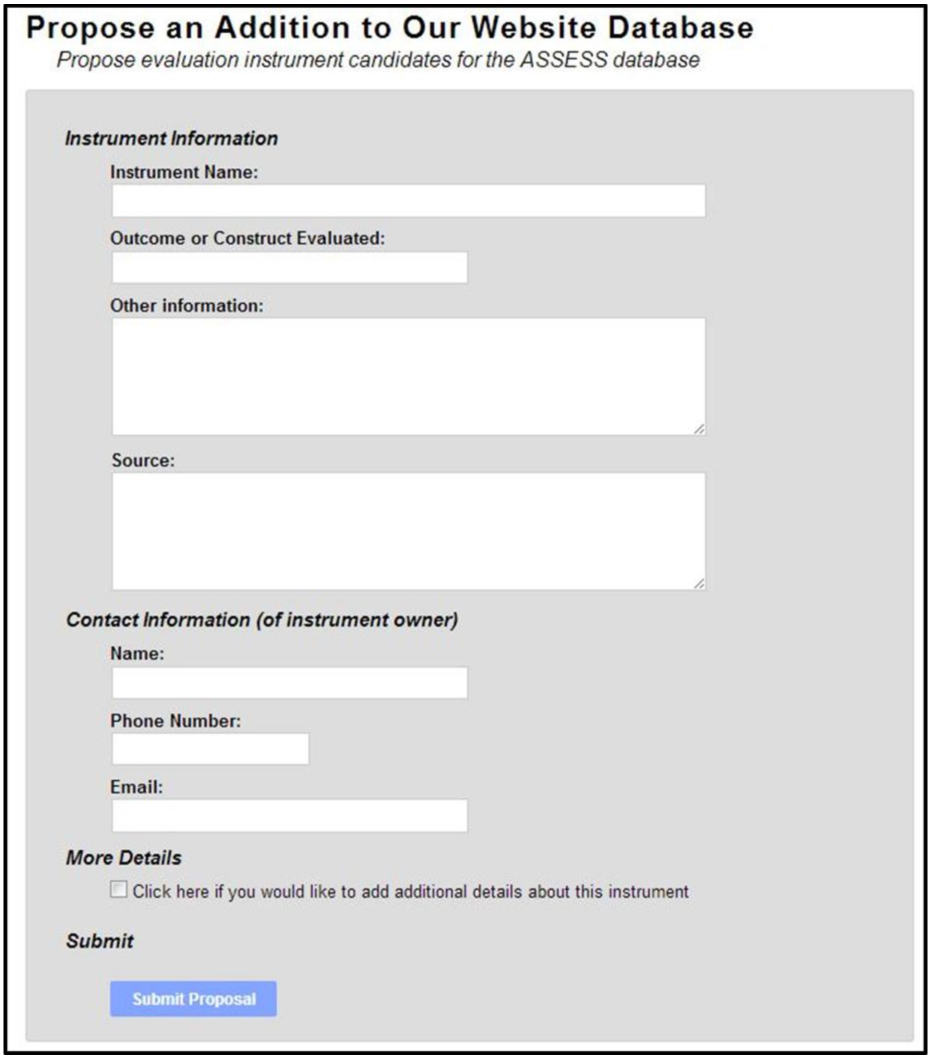
This category is focused on the interactive aspects of the website, including user ratings of assessment instruments and users' ability to submit information about assessment instruments. *Relative Advantage* has a medium positive rating while *Compatibility* and *Observability* are low positive ratings, as shown in Table 3.

*Relative Advantage* - Including interactive possibilities on ASSESS increases the *Relative Advantage* over alternative ways of researching assessment instruments. Participants felt that these features would be beneficial: "*It becomes a very useful way for me to follow what others* *are doing*" and "*Once it gets more reviews and commentary from the community, I think you're gaining collective knowledge, gaining access to collective knowledge*."

*Compatibility* - Participants provided positive comments about the *Community Features*, because it gave them some control over the database. It was evident that participants wanted to have the ability to give input on the database: "*The ability to have input on things by either offering reviews or submitting instruments yourself is good, that way it can grow, but grow in a way where there's some control with reviews, maybe some control in quality*."

*Observability* - The *Community Features* also provide participants with greater confidence in using ASSESS. As one user stated, "*If I see a bunch of user comments then that tells me right away people are using this website*." Participants expressed greater likelihood to use ASSESS if they knew other people were successfully using this resource. The *Community Features* demonstrate the number of users on ASSESS to potential users.

Originally the development team was uncertain as to whether to include user or expert reviews of assessment instruments on ASSESS. The feedback in the *Community Features* category convinced the developers that user reviews are a valuable feature to include in ASSESS. At this point, the ASSESS database includes only the functionality for user reviews, but expert reviews functionality may be added as well. Figure 3 provides access to a video about the *Community Features* in ASSESS. The video shows how users can rate instruments, the website itself, as well as proposing instruments for inclusion.




- ASSESS is a user-driven database and there are opportunities for users to provide input on ASSESS.
- Users are able to review instruments, propose instruments for inclusion, and propose instruments for development.

**Figure 3: Community Features in ASSESS**

http://youtu.be/G5g8E2odu9g

Use as an Alternative

This area was of particular interest, as the developers' priority was to ensure that the database would be a superior alternative to other methods for locating information about engineering education assessment instruments.

Because of its significance, many interview questions were targeted to specifically address this area. Questions such as “What current methods do you use to access assessment instruments?” and “What advantages or disadvantages does this database have over your existing methods for finding assessment tools?” were used to develop an understanding of participants’ perspectives. Responses related to this category were found related to all DI characteristics except for *Complexity*, as shown in Table 3.

*Relative Advantage* – The most significant advantage over other methods was that ASSESS is a centralized location for information about assessment instruments. Many participants were frustrated with looking for information in a multitude of places and were looking for one inclusive resource: “*Its relative advantage if it is completed as I think it’s envisioned is it would be a single spot to collect data from a lot of different sources, and it would reside in one spot*.”

*Compatibility* – Participants felt that ASSESS would meet their expectations for finding information about assessment instruments. It was also evident that participants felt that ASSESS would be the first resource of its type: “*I’m intrigued with this concept in general because I think that this is something that we really need to have in the community*.” Participants also agreed that ASSESS would assist them in identifying what assessment instrument they should use, “*If you’re looking for tools you shouldn’t have to create them yourself like I do right now*.”

*Trialability* – Users reported that this DI characteristic was high, because it is a feasible alternative and requires no commitment to use. Participants were pleased that to use ASSESS there is no required login information and that it was free. The *Trialability* of ASSESS as compared to alternatives is excellent: “*I mean as long as it’s free there’s no commitment. So, it* *makes it incredibly easy to commit to use it*," and "*I certainly get the sense that with ASSESS I can find the things I need and look at it without having to commit to it*."

*Observability* – Participants recognized how easy it is to refer others to ASSESS. Multiple participants mentioned that other methods of looking up information are not conducive for referring other people to, especially in the case of novices. However, in ASSESS, participants felt that the set up and collectiveness of the information made it easy to refer others to, including novices and students. For some participants, they were most excited about this potential advantage, "*And so, I definitely can see referring people to this website*."

The overwhelmingly positive responses in the *Use as an Alternative* category were very promising for the overall adoptability of ASSESS. If the ASSESS website is useful compared to existing alternatives for potential users, adoption should increase. All four DI characteristics that received responses for this category demonstrated that participants did find ASSESS useful as an alternative means of finding assessment instrument information. Because they were all positive, the development team made no changes based on this category of responses. A video highlighting the uses of ASSESS as an alternative is available by clicking on Figure 4. The main features identified by potential users as beneficial over alternatives is the focus of the video.

| Instrument | Amount of Evidence | | | User Rating | |
|---|---|---|---|---|---|
| | Uses in Engineering | Reliability | Validity | Rating | # |
| Achievement Motivation Inventory | | | | Rate | (0) |
| Affiliation Motivation Inventory | | | | Rate | (0) |
| An Example Instrument | | | | Rate | (0) |
| Assessing Critical Thinking Skills | | Little | Little | Rate | (0) |
| Assessing Women and Men in Engineering STEM Assessment Tools | | | | Rate | (3) |
| Attitude Toward Chemistry Lessons Scale | | Little | | Rate | (0) |
| Attitudes and Beliefs about the Nature of and the Teaching of Mathematics and Science | | More | | Rate | (0) |
| Attitudes Toward Science Inventory | | | | Rate | (0) |
| Behaviorally Anchored Scale | | More | More | Rate | (0) |
| Biology Attitude Scale | | | | Rate | (0) |

- ASSESS is a single collection of information for engineering education assessment instruments.
- All the information is in the same format and easily sorted and compared.

**Figure 4: Use of ASSESS as an Alternative**

http://youtu.be/zbG5CMEfOSg

Searchability

*Searchability* is related to how easily and efficiently participants were able to use the search features in the database. These features include the key word search and the search categories available for narrowing a search.

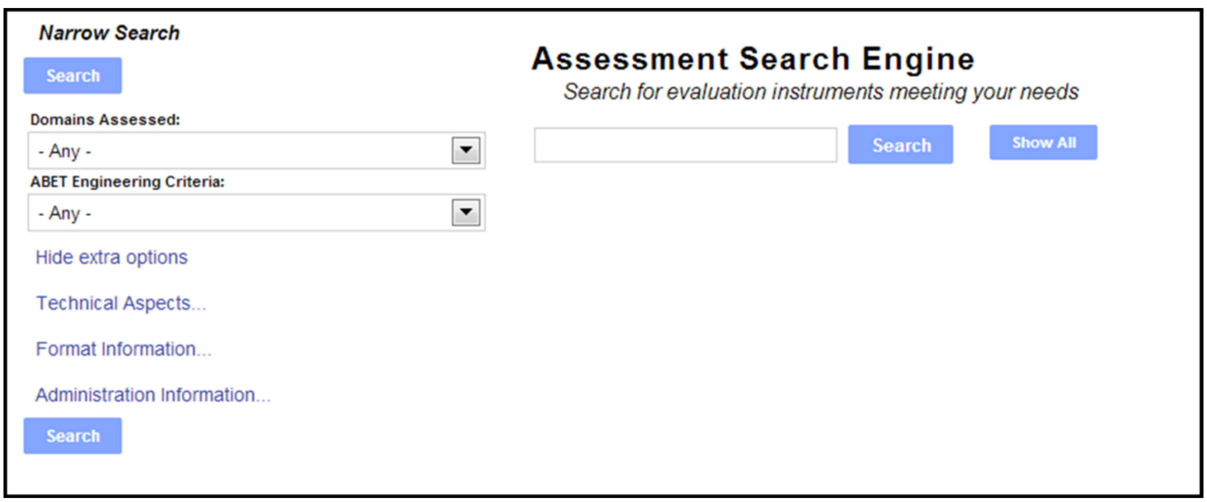
The ability to search the database is a necessary feature for potential users to effectively use the database. Participant responses on searchability are related to the *Compatibility*, *Complexity*, and *Trialability* DI characteristics. *Compatibility* received a medium positive rating, *Complexity* a low positive rating, and *Trialability* a low negative rating, as shown in Table 3.

*Compatibility* – Participants found the database to be compatible for this category. They mentioned that most users should have experience using online search features and that ASSESS was similar to what they were used to. Being able to narrow their search using the side bar of options was also compatible with their experiences and expectations, "*I thought the search terms were fabulous*." The one concern for *Compatibility* in the *Searchability* category was with the engineering fields in the search limiting options. Some participants did not find their specific type of engineering in this field and thus were concerned that they would not be able to find information that would be helpful to them.

*Complexity* – For the most part participants believed that the search features were not complex to use: "*It seemed pretty straightforward as far as searching on the different fields*." A few participants had issues modifying the search fields after their initial modification. While a system was in use to modify the search, some participants did not understand how to use it. An additional source of confusion for some participants was the amount of narrowing terms available. Users can narrow their search by format, administration options, and technical aspects. Some participants mentioned that there were too many choices and that it was hard to know what they should use to narrow their search.

*Trialability* – While this DI characteristic did receive a negative rating, *Trialability* did not have many responses addressing *Searchability*. The only concern was over how the *Searchability* would change with the addition of instruments. Some participants felt that *Searchability* could change, specifically that it would decline, once the amount of instruments was larger.

In order to improve ASSESS' *Searchability*, the developers made a few adjustments to the search page and functions. To minimize confusion, the narrowing options are now accessed by clicking "Advanced Search." Once this is clicked, two limiting options are fully visible and three others are shown by headings that expand to show more options. The fields are also grouped by type, making it easier to find the correct field to narrow a search. An additional method of modifying search terms was added to address issues found by some participants: a "Show All" button was added to the search page. This button allows users to browse the available information without performing a search, aiding those users who do not want to limit instruments they see. These improvements should assist in increasing *Searchability* for potential users. An explanatory video of the searchability features in ASSESS is available by clicking on Figure 5. The changes made based on participant feedback are presented in the video.




- ASSESS provides an efficient way to search for information.
- Users can search utilizing a keyword search, a "show all" feature, and the advanced search fields.

**Figure 5: Searchability in ASSESS**

http://youtu.be/ebliRDt2FuI

Functionality of Design

*Functionality of Design* includes perceptions of the functionality of the website. The focus is on how well ASSESS works as a database and as a website. Perceptions of the information and the usefulness of the database are not included.

The *Functionality of Design* received varied responses from participants, but responses relating to this category were found in all five DI characteristics. Table 3 shows that *Relative Advantage* and *Complexity* received medium positive ratings, *Compatibility* received a low negative rating, *Trialability* a low positive rating, and *Observability* a medium negative rating.

*Relative Advantage*, *Complexity*, and *Trialability* – The responses for these DI characteristics were all similar in nature. Participants felt that the website and database followed conventions with which they were familiar: "*It is very simple to use and I think it would be easy to go back to and somebody wouldn't walk away going, 'Okay, I'm never doing that again'*." For the *Relative Advantage* DI characteristic participants felt that the website was especially effective compared to alternative methods: "*Then a definite upside is being able to find some of the best practices, the best tools with very little effort*."

*Observability* – Participants were concerned that people might not be able to find the website: "*I don't know how else people would find it other than I got an email from you*." The main source of dissatisfaction for the *Compatibility* DI characteristic was that it was unclear how to get to the assessment instruments. While ASSESS's purpose is only to house information about the instruments and not the instruments themselves, some participants were expecting to see at least part of the instrument on the website. Because the instruments will not be available directly on the website, this means that users will have to use the available information to find the instrument. For some participants this was frustrating, while others had expected this.

Because some participants felt that the website was not going to be easy to find, the development team has worked on a publicity plan for ASSESS. In these efforts to spread the word about ASSESS, an emphasis on the purpose of the website will be made. Emphasizing that instruments will not be included in the website should ensure that potential users can develop correct expectations of ASSESS.

Diffusion of Innovations Characteristics

Table 3 shows that the *Relative Advantage* and *Complexity* were the only DI characteristics to receive high negative ratings in any category. Also noticeable is that *Compatibility* was the only DI characteristic that had responses in all six categories. Therefore, these three DI characteristics were considered the most important to focus on during development. *Trialability* and *Observability* overall did not have very many responses. While they each received one category with a high rating, this rating was achieved from an overall lower number of responses than the other three DI characteristics received. Very few responses dealt with the *Trialability* and *Observability* DI characteristics. Thus, *Observability* and *Trialability* were not deemed important.

## Lessons Learned on Adoption Characteristics

In a review of literature dealing with the adoption of technological innovations for use in education, predictions were that the DI characteristics most important for ASSESS were *Relative Advantage*, *Trialability*, and *Compatibility* (Kebritchi 2010, Martins et al. 2004, Samarwickrema and Stacey 2007). Most innovations, especially technical innovations, have *Relative Advantage* as a significant factor effecting their adoption. "*Diffusion scholars have found relative advantage to be one of the strongest predictors of an innovation's rate of adoption*" (Rogers 2003, pg. 233). *Trialability* was also predicted to be a significant DI characteristic. Technological innovations often involve unfamiliar features or functions, and individuals tend to need a testing phase with the innovation before they are willing to fully adopt. Lastly, *Compatibility* was identified as likely to be an important DI characteristic. The researchers believed that in order for an individual to adopt ASSESS, it would need to meet their expectations and work with their previous experiences. Also, if ASSESS did not fit the values or requirements of the individual's institution, they would be less likely to adopt.

As expected, *Relative Advantage* and *Compatibility* were both found to be important DI characteristics for ASSESS. ASSESS has consistent information for assessment instruments, is searchable, and allows for user input. These features contribute to the *Relative Advantage* of ASSESS over alternatives. At the same time, these features are *Compatible* with users' expectations, needs, and experiences: "*It's very tailored to engineering education which is a fairly relatively speaking a new field, an emerging field. So that's fantastic*."

*Observability* was not expected to be important for the adoption of ASSESS. This prediction was correct. This DI characteristic did not receive very many responses. Many participants did not give it much importance: "*And then the Observability I'd say is still kind of unclear since it's still in the development process*," and "*Just because it's so new that it hasn't had the opportunity to be visible. I'm not sure you'll know the visibility also until it gets launched*."

While *Trialability* was expected to be important, there were not very many responses that dealt with this DI characteristic. ASSESS is currently free and does not require registration to search for instrument information. As such, *Trialability* is fairly high: "*I mean that seems like it's a high degree of trialability because it doesn't seem like too much effort to go in there and find something that might be useful and learn a little bit about it and figure out whether it's going to be what you need or not*." There may not have been very many responses about *Trialability*, because it is obviously high for ASSESS.

*Complexity* was determined to be an important DI characteristic, but had not been expected to be important. Many participants were concerned that novice users of assessment instruments would be confused by the information in ASSESS: "*I'm thinking about my friends who, they're interested in incorporating engineering education kinds of things into their regular grants or what they're trying to do in their classrooms or things like that but wouldn't be able to distinguish between … a more appropriate or a less appropriate instrument for what they want*." The ASSESS developers reviewed and adjusted terminology and formatting to decrease *Complexity*.

The researchers believe that these results can be applied to other adoptability studies looking at technical innovations in engineering education. While ASSESS is specifically designed to house information for assessment instruments, the function of this innovation could be changed and still have the same general implications in regards to DI characteristics and adoptability.  Innovations meant to share curricula or exam questions between engineering educators would be expected to have similar results. Innovations that allow for user input are web based, and serve as collections of information would be ideal applications for these results, regardless of the type of information involved. The literature review showed that past studies have been in disagreement about which characteristics are most important for the adoption of innovations. Rogers states that each innovation will have different results as to what DI characteristics are most important for adoption (2003, pg. 225). Thus, these results are more likely to be applicable to innovations that have more of the same features and traits of ASSESS.

**Conclusion**

The six categories identified during the analysis can be applied to the development of other online innovations as well. In looking at the responses in each category, *Use as an Alternative* and *Functionality of Design* seemed to have received the most attention from participants. In other research efforts, developers could consider focusing their efforts with potential adopters towards these two categories. High ratings in *Use as an Alternative* are necessary for adoption, if the innovation cannot be satisfactorily used instead of other methods, it will most likely not be adopted. Similarly, high ratings in *Functionality of Design* are also important. If an innovation does not function acceptably for potential adopters, they are not likely to adopt.

*Relative Advantage*, *Complexity*, and *Compatibility* were chosen as the most important DI characteristics from the diffusion of innovations theory. *Relative Advantage* is very much related to the *Use as an Alternative* category. If the innovation offers no advantages, whether economic, social, efficiency, or other, then individuals have no reason to adopt ASSESS or other technological innovations. *Compatibility* and *Complexity* relate to *Functionality of Design*. The innovation cannot be difficult for adopters to use and it must be based on what is already familiar. Innovations are less likely to be adopted when they are too confusing or against the experiences of the user.

Development of ASSESS continues to prepare this tool for release to the engineering education community in 2013. The development team is refining website appearance and functionality to address issues of search effectiveness, information accuracy, and ease of use. The team continues to enter information for instruments already catalogued and to catalogue additional instruments as they are identified. Adoption research continues to guide the development effort so that at the time of release, ASSESS will receive positive ratings on diffusion of innovations characteristics important for broad adoption. By fall of 2013, the ASSESS website should be supporting enhanced evaluation capacity of the engineering education community at: http://assess.tidee.org.

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