Supporting Implementation of Concept-Based Pedagogy by Learning about Faculty use of the AIChE Education Division Concept Warehouse

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Structured Abstract

BACKGROUND

The AIChE Education Division Concept Warehouse (CW) is an online repository and instructional system intended to facilitate use of best practices in engineering pedagogy targeted at conceptual learning readily adoptable by engineering instructors. The CW contains a library of over 2,000 short, conceptually oriented questions called "ConcepTests," a number of validated concept inventories, and multiple instructional tools designed to facilitate effective conceptual learning (e.g., inquiry-based activities and interactive virtual laboratories). The CW both provides the disciplinary course-related content for use with research-based pedagogies such as "peer instruction" developed by Mazur (1997), and a platform for administering a number of these instruments. The CW launched in the summer of 2012 and we have been studying its growth, connecting with users and potential adopters, and refining the tool for the past two years.

PURPOSE

This paper describes an analysis of the usage trends associated with the "ConcepTest" content of the CW. Since the same content can be used online as well as in multiple downloadable formats, it is of interest to the developers of educational tools to better understand the preferences of instructors who use such tools when given multiple options. Additionally, it is of interest to see the impact of the different channels through which adopters become aware of an innovation (e.g., email, web search, or workshops where additional features are demonstrated) and how these channels correspond to how adopters choose to use the tool.

DESIGN/METHOD

The study analysed answers to questions on initial CW faculty applications along with general usage data from the CW to develop correlative relationships between communication channel, prior-experience using concept-based pedagogy, and mode of implementation. The results point to methods to better support current adopters, connect with potential adopters, and further improve the CW tool.

RESULTS

The study results suggest that there is a correlation between hearing about the CW via colleagues and conferences and a higher level of online use. The longer a user has been aware of the resource, the more likely they are to use it in an online mode. Additionally, the greater the user's previous experience with concept-based pedagogy, the higher the level of online activity.

CONCLUSIONS

Based on the initial examination of data from CW, the channel through which a user (instructor) is made aware of an innovation plays a role in the usage mode. More significantly, the level of understanding of an innovation and its underlying principles may impact the decision on how to try to utilize the innovation.

KEYWORDS

concept-based active learning, technology, diffusion of innovations

Introduction & Background

The AIChE Education Division Concept Warehouse (CW) is an online repository and instructional system intended to facilitate use of best practices in engineering pedagogy (Koretsky et. al., 2014). This tool is targeted at promoting conceptual learning and is readily adoptable by engineering instructors. It is of interest to the developers of educational tools like the CW to better understand the preferences of instructors who use such tools when given multiple options. In this paper, we explore instructors' preferences regarding online and offline use. Additionally, it is of interest to see the impact of the different channels through which adopters become aware of an innovation (e.g., email, web search, or workshops where additional features are demonstrated), adopters' prior familiarity with the pedagogical underpinnings of an innovation, and how these factors correspond to how adopters choose to use the tool. We have previously explored how different communication channels correlate to adopter activity level (Gilbuena, Smith, Brooks, Miletic, & Koretsky, 2013) and the growth of our network of users (Gilbuena, Smith, Brooks, & Koretsky, 2014). We extend this work by examining how those communication channels and CW adopters' prior experience with concept-based pedagogy correspond to CW adopters' preferences for online or offline use of the tool. We use the theoretical framework of Diffusion of Innovations (Rogers, 2003) to frame our investigation and interpret our results.

The AIChE Education Division Concept Warehouse

The CW contains a library of over 2,000 short, conceptually oriented questions called "ConcepTests," a number of validated concept inventories, and multiple instructional tools designed to facilitate effective conceptual learning (e.g., inquiry-based activities and interactive virtual laboratories). This tool both provides the disciplinary course-related content for use with research-based pedagogies such as "peer instruction" developed by Mazur (1997), and a platform for administering a number of these instruments and activities. Student and instructor interfaces are available for the community at http://cw.edudiv.org, and university faculty can obtain an account through this site. There are currently over 140 institutions and over 370 accounts registered with the CW. While the tool was initially intended for use by chemical engineering faculty, the CW has expanded to contain content for chemistry, physics, mathematics, and materials science.

This paper describes an analysis of the usage trends associated with the ConcepTest content of the site. ConcepTests can be assigned for students to answer online or downloaded and administered offline. Table 1 provides a summary of these modes of use and they are discussed in more detail below.

Table 1. Description of the Different Modes of Use for CW Users

<table>
<tr><th>Mode of Use</th><th>Description</th></tr>
<tr><td>Offline</td><td>Download questions via Microsoft Word or PowerPoint to use on homework, tests, or with external clicker systems</td></tr>
<tr><td>Online
● Homework

● In-Class with students answering via Laptops, Cell Phones, or Turning Point Clickers</td><td>
ConcepTests are intended to be answers outside of class through student interface

ConcepTests are assigned in class, maybe as part of peer instruction or think-pair-share. The multiple choice questions can be enhanced with short answer explanations and confidence follow-ups. When used with Turning Point clickers, instructors must have appropriate hardware and</td></tr>
</table>

	run a java applet to capture responses.

- ***Offline*** – when faculty use the CW offline, this means they choose to search for ConcepTests (or other concept-based instructional tools) online, and then implement those ConcepTests either in presentation or paper form. In this mode of use, students are not exposed to the online student interface and do not directly interact with the CW. Examples of this mode of use include faculty downloading questions, either as a Microsoft Word document or PowerPoint slides, used on a homework set, test, quiz, or in class with an external clicker system. Instructors already using peer instruction or active learning with concept questions need only make minor changes to current practices in order to incorporate the CW and the tool may save them preparation time.
- ***Online*** - refers to using the web based infrastructure both to find ConcepTests, as well as to administer the ConcepTests. When using the CW in an online mode, instructors have the ability to view results from assignments, which are presented aggregated, tabulated, and archived for later use and are available for download in Microsoft Excel format. Online use is compatible with multiple methods of collecting audience/student responses, including clickers, laptops, and smart phones (either in-class or for homework). If instructors solicit responses via laptops or smartphones, they can also prompt short answer explanations and confidence follow-ups to enhance the multiple choice questions. Such written reflection is perceived by students as helpful (Koretsky & Brooks, 2012). These features require students to interface with the website.

The CW launched in the summer of 2012 and we have been studying its growth, connecting with users and potential adopters, and refining the tool for the past two years. We have previously reported on how the tool was initially designed and tested with early adopters to facilitate usability (Brooks, et. al., 2012). After it was launched and made publicly available we began studying the tool and its propagation, or spread, framing our investigation with the Diffusion of Innovations, which offers a theoretical framework to investigate how and why an innovation spreads from where it was developed throughout a community of individuals. We have studied and reported on how different communication channels have influenced faculty awareness of the tool (Gilbuena, Smith, Brooks, Miletic, & Koretsky, 2013), what the network of users looks like and how that network has grown over time (Gilbuena, Smith, Brooks, & Koretsky, 2014) and what factors contributed to an instructor's decision to use the tool (Gilbuena, Smith, & Koretsky, 2013).

Diffusion of Innovations

We use the framework of Diffusion of Innovations (Rogers, 2003) to investigate the channels used to promote knowledge of an innovation, adopters' prior knowledge, or principles knowledge, of the underlying pedagogy, and how those channels and prior knowledge relate to how the innovation is adopted and implemented. Rogers suggests there are three types of knowledge about an innovation: awareness, how-to, and principles knowledge. Awareness knowledge is defined as "information that an innovation exists." (Rogers, 2003) In our case, awareness that the CW exists would constitute awareness knowledge of the innovation. Borrego, Froyd, & Hall (2010), surveyed department chairs in a variety of engineering disciplines to investigate faculty awareness and identified disciplinary networks and opinion leaders as important for raising awareness of an innovation. They recommend that to facilitate propagation developers should focus on personal interactions rather than "presenting convincing assessment evidence in mass media publications" (p. 202). In another study, Borrego, Cutler, Froyd, Prince, & Henderson (2011) investigated the innovation-decision process in engineering education and highlighted word of mouth, workshops, and literature as the most common diffusion channel to raise awareness. Several communication channels can be used to promote diffusion of innovations. Tront, McMartin, &

Murumatsu (2011) studied the responses of National Science Foundation Program Directors (NSF PDs) and funded Principle Investigators (PIs) to a survey in which the participants rated the success of several NSF recommended dissemination strategies. PIs rated the following as the most effective “traditional” strategies: conference activities (papers, posters, and presentations), publications, workshops, and website postings (of papers and posters). While similar in the top rankings, NSF PDs rated workshops as most effective. Many PIs also noted using a project website. The developers of the CW have attempted to inform potential adopters about the innovation through a multitude of communication channels, including word-of-mouth, conferences, emails, etc. In our previous work, we found that one-on-one, in-person communication channels appeared to be more effective than impersonal emails at attracting users that demonstrated a high level of engagement with the AIChE Concept Warehouse (Gilbuena, Smith, Brooks, Miletic, & Koretsky, 2013).

Workshops and faculty development programs have specifically been a focus of study. For example, Rust (2006) investigated the efficacy of workshops on participants’ teaching practices related to teaching large classes, assessing student-centered courses, and problem-based learning. Rust (2006) found that the workshops affected the practices of most participants, extensively changing the teaching practices of some. Stes, Clement, and Van Petegem (2007) evaluated the effectiveness of a longer term, one-year faculty training program for “novice” faculty members. They followed up with participants two years after participation in the training program via an open-ended questionnaire, finding that the program still had an impact two years later. A study of software engineering innovations investigated the effect of propagation strategies and found that resource intensive formal training increased the speed of adoption over lower resource, ad hoc strategies. These longer, more in-depth workshops and training programs may facilitate helping potential adopters gain how-to knowledge and principles knowledge.

How-to knowledge comes as a second step; it is the information needed for a potential adopter to use an innovation for the intended use. For the CW, this knowledge might consist of knowing how to log in to the website, search for ConcepTests, browse concept inventories and download these items to use offline or assign them to a class in the online mode. Principles knowledge is a deeper understanding of why an innovation is useful. In our case this might include previous experience with concept-based pedagogy or knowledge of the value of concept-based instruction. We use this framework to interpret the relationships between different communication channels that have been used to promote the CW, adopters’ prior experience with concept-based pedagogy (i.e., principles knowledge) and the modes in which adopters use the tool.

Methods

This study utilized answers to a question on initial CW faculty applications and general usage data from the CW including date stamps, number of logins, and number of questions downloaded or assigned online. This data was collected and housed in the CW database. Answers to the question “How did you hear about us?” were analysed using an emergent coding process. Categories representing communication channels were identified in previous work (Gilbuena, Smith, Brooks, & Koretsky, 2014), and used in this study. In addition, responses to the question “Have you previously used concept-based pedagogy in your courses?” were analysed for indications of principles knowledge, with the assumption that if faculty self-identified as previously using concept-based pedagogy that they understood the underlying principles and value in doing so. This data was used to develop correlative relationships between communication channel, prior-experience using concept-based pedagogy, and mode of implementing the CW (online or offline).

Additionally, analysis of direct data regarding ConcepTest usage by mode (online and offline) filtered by unique user gives insight into the distribution of preference of the current instructor population in chemical engineering and other related disciplines supported by the CW. For the purposes of this examination, accounts that showed only login activity and no question downloads or online assignments were excluded. In addition, accounts with less than three downloads or assignments were also excluded because we are interested in levels of activity of adopters and individuals with such low activity, likely have either discontinued use of the tool after an initial introduction, or not had sufficient time to use it in a course. Excluding these accounts resulted in a sample size of N=79. Of these 79, 42 responded yes or no about whether they had previous experience with concept-based pedagogy. This subset of 42 individuals was analysed to identify the correlation between this principles knowledge and the mode of use. Previous results show that there is a subset of CW users that prefer to take screen captures of questions rather than downloading them for offline use; however, the current data do not adequately capture this mode of use. We discuss our use of this information to learn how to better support current adopters, connect with potential adopters, and further improve the tool.

Results and Discussion

Statistically significant outcomes (alpha = 0.05) are discussed below by first summarizing the modes of use. Next, the communication channels are summarized and related to those modes of use. Finally, principles knowledge (i.e., experience with concept-based pedagogy) is summarized and related to modes of use. Principles knowledge ended up being most related to the mode of use.

The CW has been used regularly in both online and offline modes, reinforcing the need for continued support of both modes as the CW matures. Table 2 shows the distribution of the modes of use. Surprisingly, more than half of the users operate in the offline mode exclusively.

Table 2. Distribution of modes of use of CW users included in this study

Only Online	6%
Only Offline	58%
Both Online and Offline	35%

We further examined the data by looking at the communication channels through which these users became aware of the CW and how they related to the modes of use. The primary communication channels include hearing about it from colleagues, at conferences, emails, professional program, websites, and workshops. The data suggest that there is a correlation between learning of the CW via colleagues and conferences and a higher level of online use. However, the individuals who use the CW both online and offline are represented by both colleague and conference channels of communication. In addition, length of time as a user of the CW positively correlates to increased online use. Offline use, however, was much more distributed among communication channels.

We believe that colleagues and conference communication channels are covariates with principles knowledge. Many of the colleagues were experienced with concept-based pedagogies and conferences included conferences with a heavy focus on best practices in education (e.g., the Annual Conference for the American Society of Engineering Education). During initial propagation developers are more likely to diffuse their innovation through communication channels that contain people that are more like them. Because of that focused characteristic of initial propagation, a bias is to be expected. However, the stark difference between modes of use and principles knowledge was not expected.

Table 3 summarizes the users' previous experience with concept-based pedagogy and relates it to average use of online and offline modes. Previous experience is important as it may be an indication of knowledge of the principles behind concept-based pedagogy and value for this type of pedagogy. While there was a moderate difference in total use between faculty that reported prior experience and those that did not, the users with previous experience with concept-based pedagogy were likely to use the CW both online and offline. These users had three times as much online activity on average as those that had no prior experience with concept-based pedagogy. Users with no prior experience appear to be more likely to use the CW offline than online.

Table 3. Average prior experience with concept-based pedagogy related to mode of use

	Offline Average [Downloads/User]	Online Average [Assignments/User]	Total [Activity/User]
No Experience w/Concept	46	16	59
Yes Experience	35	46	80

Finally, we discuss ways we are modifying the CW to further support users in their preferred future modes of use. Faculty face barriers in the form of resistance from students, economics, and technology when considering the online implementation of active learning pedagogies. One of the ways we are improving the tool to help reduce these barriers is by adhering to Learning Tool Interoperability protocol to easily embed CW activities within learning management systems like BlackBoard and Canvas. In this way, students do not need to remember the existence of and credentials for yet another website and are therefore that much less likely to complain to their instructor. We are also integrating features such as accepting SMS text messages. This SMS integration allows student more ways to respond in the online mode, broadening accessibility. This helps faculty who teach in courses where not all students have access to smartphones, tablets, or laptop computers.

Conclusions

Based on the initial examination of data from CW, the communication channel through which a user (instructor) is made aware of an innovation plays a role in the usage mode. Colleagues and conference presentations are significant as opposed to the workshops we originally anticipated. More significantly, the level of understanding of an innovation and its underlying principles (i.e., principles knowledge) may impact the decision on how to try to utilize the innovation. Instructors with prior experience with concept-based pedagogies for example seem more likely to use the CW online. This suggests to developers of educational innovations types of strategies for dissemination that may maximize adoption and increase the extent to which the innovation may be utilized. In the context of application of research-based active learning pedagogies, this can increase the impact of an innovation in engineering education on student preparedness.

References

Borrego, M., Cutler, S., Froyd, J., Prince, M. & Henderson, C.(2011) Developing engineers for social justice: Community involvement, ethics & sustainability. In Australasian Association for Engineering Education Conference 2011

Borrego, M., Froyd, J. E., & Hall, T. S. (2010). Diffusion of engineering education innovations: A survey of awareness and adoption rates in US engineering departments. *Journal of Engineering Education*, *99*(3), 185-207.

Bowen, A., Reid, D., & Koretsky, M. (2014) Development of Interactive Virtual Laboratories to Help Students Learn Difficult Concepts in Thermodynamics. In *American Society for Engineering Education*. American Society for Engineering Education.

Brooks, B. J., Gilbuena, D., Falconer, J. L., Silverstein, D. L., Miller, R. L., & Koretsky, M. (2012). Preliminary Development of the AIChE Concept Warehouse. In *American Society for Engineering Education*. American Society for Engineering Education.

Carter Jr, F. J., Jambulingam, T. , Gupta, V. K., & Melone, N. (2001) Technological innovations: A framework for communicating diffusion effects. *Information & Management*, vol. 38, pp. 277-287.

Gilbuena, D., Smith, C., Brooks, B., Miletic, M., Koretsky, M. (2013). A Preliminary Study of How Communication Channels Affect Awareness and Adoption of the AIChE Concept Warehouse. *Proceedings of the 2013 Research in Engineering Education Symposium, Kuala Lumpur, Malaysia, July 4-6, 2013.*

Gilbuena, D., Smith, C., Brooks, B. & Koretsky, M. (2014). Examining Diffusion Networks and Identifying Opinion Leaders: A Case Study of the AIChE Concept Warehouse. In *American Society for Engineering Education*. American Society for Engineering Education.

Gilbuena, D., Smith, C., Koretsky, M. (2014). Development and Propagation: A Case Study of the AIChE Concept Warehouse. *Accepted to be presented at the 2014 Frontiers in Education Conference, Madrid, Spain, October 22-25, 2014.*

Gilbuena, D., C. Smith, M.D. Koretsky. Examining the Innovation-Decision Process: A Preliminary Study of the AIChE Concept Warehouse. (2013) *Proceedings of the 2013 American Society for Engineering Education Annual Conference & Exposition, Atlanta, Georgia, June 23-26, 2013.*

Koretsky, M., Falconer, J., Brooks, B., Gilbuena, D., Silverstein, D., Smith, C., Miletic, M. (2014). The AIChE Concept Warehouse: A Tool to Promote Conceptual Learning. 4(1) *Advances in Engineering Education.*

Koretsky, M., & Brooks, B. (2012). Student Attitudes in the Transition to an Active Learning Technology. Chemical Engineering Education, 2012, 46, 289-297.

Mazur, E. (1997). *Peer instruction*. Upper Saddle River, NJ: Prentice Hall.

Rogers, E. M, (2003), Diffusion of innovations. New York: Free Press

Rust, C. (2006). The impact of educational development workshops on teachers' practice.

Stes, A., Clement, M., & Petegem, P. V. (2007) The Effectiveness of a faculty training programme: Long - term and institutional impact. 2007.

Streveler, R., Miller, R., Santiago-Roman, A., Nelson, M., Geist, M., & Olds, B. (2011). Rigorous Methodology for Concept Inventory Development: Using the 'Assessment Triangle' to Develop and Test the Thermal and Transport Science Concept Inventory (TTCI). *International Journal of Engineering Education*, 968–984.

Tront, J., McMartin, F. & Muramatsu, B. (2011) Improving the dissemination of CCLI (TUES) educational innovations. *Proceedings from the 41st ASEE/IEEE Frontiers in Education Conference, October, 2011, pp. 12-15.*

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. DUE 1023099, 1022957, 1022875, 1022785. We also acknowledge a supplement to grant DUE 1023099 to participate in the I-Corps for Learning program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

We are grateful for all of the individuals who are using the AIChE Concept Warehouse and those who have provided feedback to improve this tool, particularly those who participated in this study. We would also like to acknowledge the people who supported this work with their time and help.

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