

DEVELOPMENT AND USABILITY TESTING OF A STUDENT MOBILE APPLICATION FOR THE AIChE CONCEPT WAREHOUSE

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Abstract

Incorporating user feedback is imperative for the adoption and continued usage of educational innovations in the classroom. We report on the development of an Android-based student mobile application, a user-suggested improvement for the AIChE Concept Warehouse. An Apple-based mobile application is also in development. Our intent is to share the applications' development and improvement process in the hopes that other innovators can benefit from the lessons learned through our experience.

The AIChE Concept Warehouse was developed with the intent of fostering a community of learning within chemical engineering. The Concept Warehouse is a web-enabled database infrastructure that is designed to promote concept-based instruction through the use of concept questions. These concept questions are used in core curriculum courses like Material/Energy Balances, Thermodynamics, Transport Phenomena, Kinetics and Reactor Design, and Materials Science. Availability of high quality concept questions can lower the barrier for faculty to use concept-based instruction and assessment. This software allows the instructor to engage students and evaluate student learning in real-time. The instructor is then able to adjust the pace of lecture in response to student understanding. The Concept Warehouse also allows for reflective assessments such as "the muddiest point."

The student mobile application was developed to make it easier for students to submit answers and written explanations to these assessments using mobile devices. Originally, students

could submit their answers to conceptual questions using clickers, mobile browsers on smartphones, and laptops. Input via smartphones, however, proved cumbersome because it depended on the quality of the student's mobile browser and utilized the full-size webpage interface. The improved mobile student interface facilitates participation by making responses via smartphone more user-friendly.

After the development of the application, we conducted initial usability tests with students who had previously used the web-based options for answer submission. In order to gauge usability, we collected usage statistics from student responses to a usability survey. Survey responses were used to identify student likes and dislikes as well as to compare different available options for answer submission. These results will be used to improve the design of the current application as well as guide our design decisions for the development of the iOS version of the student app.

Introduction

Engineering educators and industry professionals alike have expressed a need for students to have the ability to apply what they learn to novel and challenging problems [1]. Traditional lecture-based courses, however, commonly promote rote memorization over the conceptual understanding needed to apply knowledge to these new situations [2,3]. Instructors need to place a greater emphasis on conceptual understanding in their classrooms in order to adequately prepare students for practice.

The AIChE Concept Warehouse was designed to lower one of the biggest barriers that prevents instructors from using concept-based instruction: access to high quality concept questions. Developing these questions is difficult and time-consuming; these questions must focus on a single important concept, require thought from the student, and be neither too easy nor too difficult to answer [4]. The Concept Warehouse alleviates these barriers by giving instructors access to over 2000 concept questions for core chemical engineering courses and allowing instructors to contribute their own questions. The Concept Warehouse also provides many different methods of delivery for these questions. Instructors can assign these questions as homework or use them in class as part of active learning pedagogies. Students can respond to in-class questions using their clickers, laptops, or smartphones and instructors will receive a distribution of student responses, their written explanations, and summary word clouds in real-time. This feature is useful for determining student understanding of new topics and whether students hold misconceptions about this content.

Many higher education institutions have chosen to adopt clickers into their curriculums. This technology carries with it a set of disadvantages. Clicker limitations include the inability to assess students' ability to answer open-ended questions involving higher level thinking [5], distortion of student responses by providing a set list of answer possibilities, and the inability to simulate situations similar to industry [6]. Most clickers are *not* compatible with the AIChE Concept Warehouse's written explanations feature, which allows students to include an explanation of their answer choice to a multiple-choice question. While laptops allow students to provide these explanations, many students have reported that carrying their laptops from class to class is inconvenient [7]. Thus, mobile devices such as smartphones and tablets are attractive alternatives.

Previously, use of the AIChE Concept Warehouse interface on smartphones proved

cumbersome and inconvenient for students. The webpages were not optimized for mobile devices, and students had to manually resize pages in order to read and answer concept questions. The AIChE Concept Warehouse Student App seeks to improve the student user experience with optimization for small screens and touch-friendly navigation. In this paper, we present a description of the student application. We also provide a detailed description of the design and development process to provide a reference for future design projects. Finally, we report on future plans and activities for the student application.

Related Work

Mobile device applications have been used as teaching and learning aids before. EvaluA+ is an iPad app developed to aid instructors in creating and using rubrics to grade assignments and presentations. It allows instructors to create a rubric, import assignments into that rubric, and then view the rubric and assignment simultaneously for grading in both online and offline modes. Once created, these rubrics can also be shared with students to use as a reference while working on the assignment. The app also has a presentation mode where the instructor can use the rubric to grade a presentation in real-time [8].

Pikme is an iPhone app designed to help the instructor manage class lists to learn student names, randomly select students to participate in class discussion, and rate solicited student responses. The app then stores these ratings so the instructor can use them in assigning grades. Instructors reported that use of the app in class led to increased student motivation, increased participation, improved engagement, and more balanced feedback about course material. Students felt that the random selection for participation in class was fair and provided incentive to prepare outside of class. Some students even reported an increased willingness to volunteer regardless of whether they were chosen by the random selection tool or not [9].

EvaluA+ and Pikme are examples of mobile apps designed to aid the instructor, but mobile apps have also been developed with the intent of providing formative assessment of student understanding in real-time. InkSurvey is free, web-based software that collects student responses to open format questions. Students “ink” their responses with pen-enabled Android devices, iPads, iPhones, or tablet PCs. Students can respond to in-class questions with words, drawings, graphs, or equations. Creating these responses gives an opportunity to interact with the subject material and increase metacognition. The instructor gains real-time feedback about what students are thinking and can address misconceptions and questions [10].

Mobile apps like InkSurvey help promote active learning by encouraging students to reflect on subject material and explain concepts in their own words. Studies of more than 5,000 science and engineering students found that active learning methods double conceptual learning gains [11] and give a 25% higher pass rate than traditional lecture [12]. Active learning methods help place greater emphasis on conceptual understanding. We consider this type of app development a key technology-

based enabler for active engagement and learning.

The Student App Design Process

Develop a Function List for Each Screen

The AIChE Concept Warehouse Student App is designed to have the same functionality as the student version of the web interface. Thus, the app has to be capable of presenting the student with assigned question sets, allowing the student to select an answer, provide a written explanation and confidence follow-up if prompted, and then submit the answer for instructor review and summary reporting. Figure 1 is a graphical representation of the relationship between features for the student app

Create Mock-Ups

Mockups of each screen in the app were created to determine the layout as well as the look and feel. The application is optimized to run on mobile devices, and this was the driving factor in designing the user interface. Screen space is at a premium on smartphones, so the menu is hidden when not needed. When the

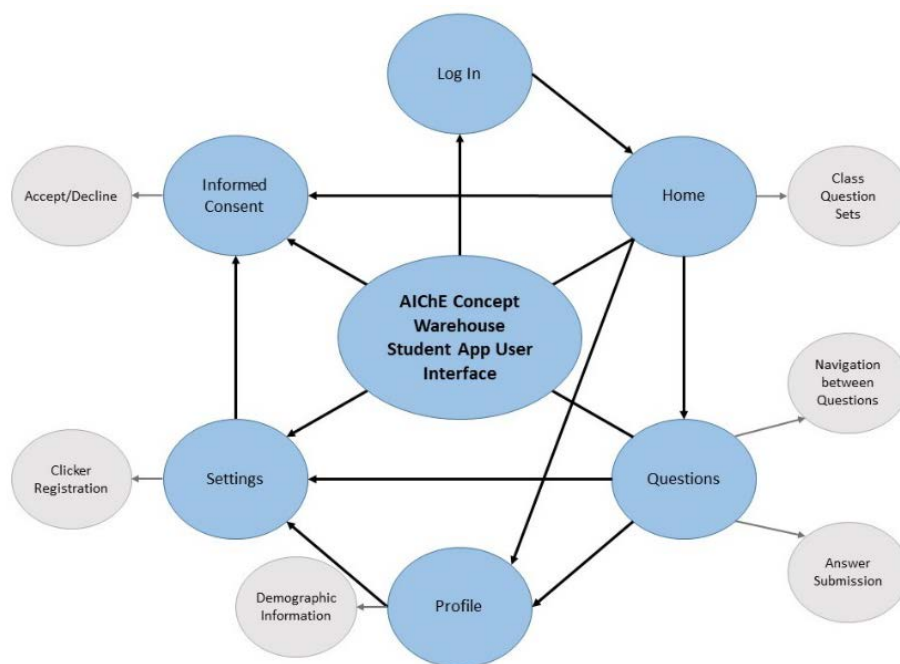


Figure 1: Graphical representation of the elements of the AIChE Concept Warehouse Student App.

student is viewing and answering questions, the question text, image, and answer options are the focus of what is displayed on screen. Menus and navigation were designed for touch input. Figure 2 provides an example of the mock-ups produced when designing the app.

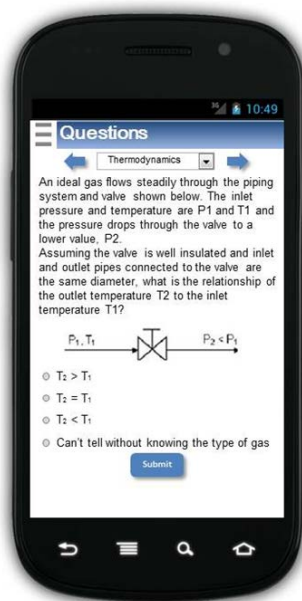


Figure 2: Mock-up of the questions screen interface.

Build a Live Version and Conduct Internal Testing

The AIChE Concept Warehouse Student App was written in Java using the Android Software Development Kit (SDK) and the Eclipse Integrated Development Environment (IDE). Java, the Android SDK, and Eclipse IDE are all available online for no charge. The app was then tested using an Android emulator and developer-enabled phone. These allowed for continued refinement and assurance of stability before releasing the app on a larger scale.

Test Usability in the Classroom

The AIChE Concept Warehouse Student App was tested in a sophomore level energy balances course. Students were encouraged to download the app at the start of their term and answer in-class questions using their smartphones. They

were given a usability survey through the Concept Warehouse to share their experiences and rank which device they preferred to use.

Functionality

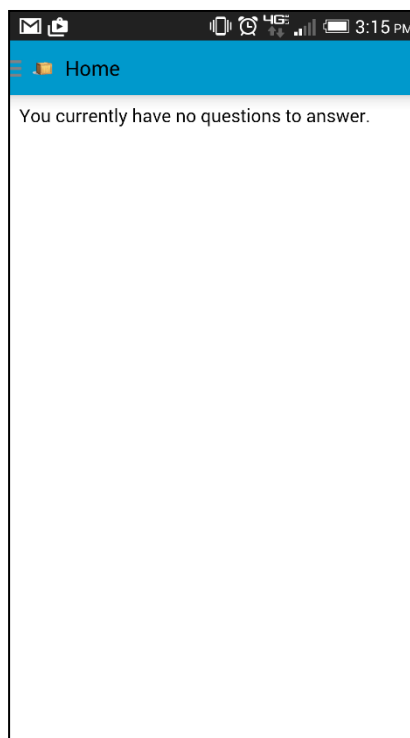
The AIChE Concept Warehouse Student App is intended to mimic the functionality of the webpage student interface [13]. Students must first log in. They begin at the home screen once they have supplied their credentials. If questions have been assigned to the student, these question sets are listed by class with number of questions available to answer (Figure 3a). If no questions have been assigned, a message will appear on the home screen explaining this (Figure 3b). The app supports multiple question types; instructors can assign multiple choice questions, multiple choice questions where students must select all that apply, and questions where answers must be ranked.

The home screen is also the first opportunity students have to use the hidden menu (Figure 4). The menu exists as a small image at the top of the screen to conserve space. Students can either tap the image or swipe from left to right to bring up the menu. This menu serves as the main method of navigation through the app; students have access to their profile, settings, and informed consent information. The profile screen allows students to update their demographic information. This includes birth year, year started at the university, gender, race, and major. The settings screen allows students to register their clickers as a secondary method of submitting answer choices. The informed consent screen provides students with information about the ongoing NSF-Funded AIChE Concept Warehouse Project, *Integration of Conceptual Learning Throughout the Core Chemical Engineering Curriculum* and allows students to opt in.

When questions are assigned, students can navigate to the questions screen (Figure 5) by either clicking on the names of the classes with questions assigned or by clicking the questions



(a)



(b)

Figure 3: The home screen (a) with questions assigned and (b) when no questions have been assigned.

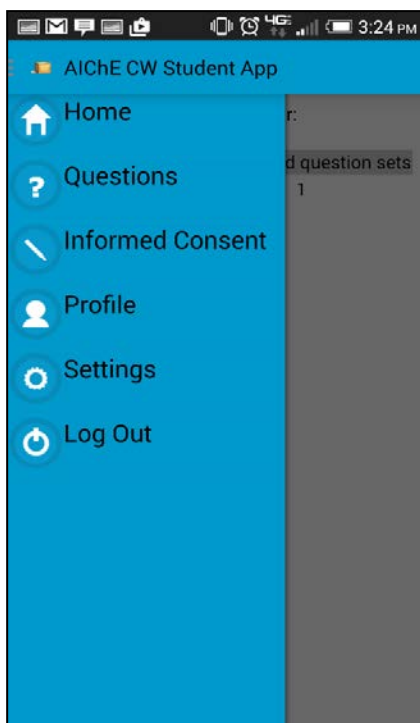


Figure 4: Students can swipe from left to right or tap the button in the upper left hand corner to access the hidden menu.

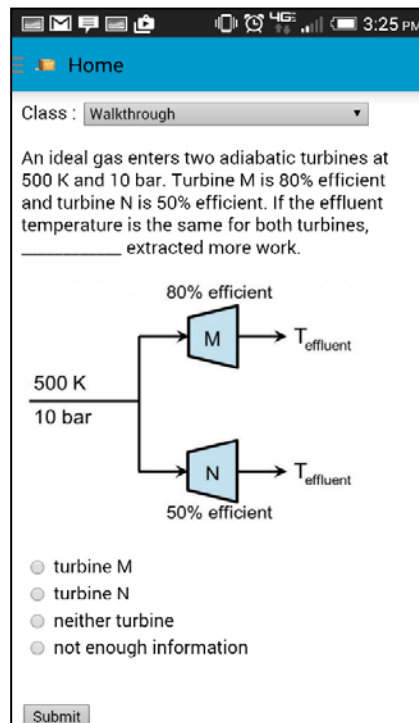


Figure 5: A concept question as it appears on the student's device.

button in the hidden menu. The questions screen presents the question text, associated picture or diagram if applicable, and the answer options. If the instructor has chosen to enable written explanations and/or confidence follow-ups, these text input fields appear as well. Students can use the drop-down menu to navigate between classes that have questions assigned.

Student Usability Feedback

The AICHE Concept Warehouse Student App was tested by students of a sophomore level engineering course. The app was made available on the Google Play Store, and students with Android devices were encouraged to download and test the device in a four week period. Students were then assigned a 12 question survey to answer through the Concept Warehouse about their experiences. Table 1 shows the survey questions.

The survey data includes 178 student responses, though not every student answered every question. This survey was provided to all students in the course, regardless of whether they tested the Student App or not. Students

were allowed to choose the method of answering in-class concept questions using either their laptop, clicker, smartphone/tablet mobile browser, or the Android app on a supported device. Of the 178 students that participated, 156 (88%) indicated that they owned a smartphone. All 178 students ranked the different methods of answer concept questions in the Concept Warehouse in the following manner, from most to least frequently used:

1. Laptops
2. Smartphone mobile browser
3. Tablet mobile browser
4. Using the app on a smartphone
5. Using the app on a tablet
6. Clickers

Nineteen students (11%) mentioned in their survey that they chose not to test the student app. It is likely that the number of students who answered the survey but did not participate in testing is higher given the popularity of iOS devices. Three students mentioned in the open-ended section of the survey that an iOS version of the app would be beneficial. The instructor

Table 1: Survey questions intended to elicit student feedback about the AICHE Concept Warehouse Student App user experience.

Usability Survey Questions	
<u>Question</u>	<u>Question Type</u>
<i>In how many of your courses have you used the AICHE Concept Warehouse?</i>	Multiple Choice
<i>Rank the following methods of using the AICHE Concept Warehouse from most frequently used to least frequently used.</i>	Multiple Choice – Ranking
<i>Do you own a smartphone?</i>	Multiple Choice
<i>How often do you use your smartphone <u>for</u> class?</i>	Likert
<i>In what different ways have you used your smartphone for class?</i>	Open-Ended
<i>Have you ever used a smartphone for educational purposes?</i>	Open-Ended
<i>I will likely continue using this app to answer concept questions through the AICHE Concept Warehouse.</i>	Likert
<i>If I make a mistake in using the app (navigation, inputting information, etc.), I can recover from my mistake easily.</i>	Likert
<i>I would recommend using the app to my friends.</i>	Likert
<i>What additional features would you include in the student mobile app?</i>	Open-Ended
<i>What other aspects of the app would you change?</i>	Open-Ended
<i>Please include any additional comments about the app.</i>	Open-Ended

of the course noted that a large percentage of the class owned iOS devices. An iOS version of the student app is in development to improve student access.

Five of the students provided suggestions for features to add in later versions of the AIChE Concept Warehouse Student App. One student mentioned that they preferred their laptop so that they could have the question window and a reference table open at the same time. Adding multi-window support to the app or allowing students to access important tables of information in the Concept Warehouse is contrary to the intent of the concept questions. Such questions are meant to be computationally simple and conceptually challenging. Two students indicated a desire to be able to change answers after submission; the Concept Warehouse does not support this on the web page or the student app. Two students indicated that the formatting of the question information and answers could be improved. One student mentioned that it was difficult to tell when the confidence follow-up was being used by the instructor, and the other student explained that the formatting of question text (use of bold or italicized characters) did not always function properly. These suggestions are worth further investigation.

Student suggestions indicate that the app effectively allows students to answer conceptual questions in class as well as provide a written explanation of answer selection and an indication of confidence in the selected answer. Based on the rankings from the usability survey, the app has successfully replaced clickers as an answer input method. This app enables features often not provided by clickers, including written explanations and a confidence follow-up. The AIChE Concept Warehouse Student App provides an example of successfully developing and implementing a mobile application in an educational setting.

Future Work

While the app is fully functional and successfully allows students to answer concept questions in-class, some features are missing that could improve the user experience. These features include the ability to save one's username and password, checking network connectivity prior to logging in, and giving the app explicit instructions for operating in a low-power setting.

The usability survey successfully engaged 178 students out of a course of approximately 300, indicating a survey completion rate of about 59%. It would be beneficial to improve the survey for use in later terms. New questions should elicit whether students felt their learning improved as a result of using the app, what features they liked, and what devices (the type of smartphone or tablet) they were using with the app. It might also be beneficial to develop a survey for instructors as well to capture usage trends and other aspects of the class as a whole.

The lack of an iOS version of the app was a major barrier to complete replacement of other devices for answering in-class questions. An iOS version of the AIChE Concept Warehouse Student App is currently in development using the new Swift programming language and Xcode IDE. This version of the app will be available in Summer 2015 pending Apple's approval.

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant No. DUE 1023099. 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.

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Biographical Information

Rachel White is a senior in chemical engineering at Oregon State University. Her interest in engineering education comes from student experience and observing fellow classmates struggling with their studies. She is interested in promoting conceptual understanding in the chemical engineering core curriculum so that students can perform better both in the classroom and beyond.

Bill Brooks is a Postdoctoral Scholar in the School of Chemical, Biological and Environmental Engineering at Oregon State University. As an undergraduate he studied hardware, software, and chemical engineering. He ultimately received his Ph.D. from Oregon State University in Chemical Engineering. He is currently interested in the development of technology to study and promote STEM learning.

Milo Koretsky is a Professor of Chemical Engineering at Oregon State University. He received his B.S. and M.S. degrees from UC San Diego and his Ph.D. from UC Berkeley, all in Chemical Engineering. He currently has research activity in areas related to engineering education and is interested in integrating technology into effective educational practices and in promoting the use of higher-level cognitive skills in engineering problem solving. His research interests particularly focus on what prevents students from being able to integrate and extend the knowledge developed in specific courses in the core curriculum to the more complex, authentic problems and projects they face as professionals. He is one of the founding members of the Center for Lifelong STEM Education Research at OSU.