
AC 2011-1584: TECHNOLOGY ADOPTION BEHAVIORS IN A FIRST YEAR ENGINEERING CLASSROOM

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Technology Adoption Behaviors in a First Year Engineering Classroom

Abstract

Advancing personalized learning is recognized as one of the grand challenges facing engineers in the next century. Technology has provided advancements in instruction which were not previously available, but there is often resistance to adoption of new technologies. Our research group introduced the use of tablet computers in a first year engineering fundamentals course initially as part of a study of students' problem-solving strategies, a key skill for students to master and succeed in engineering. A custom tablet computer software application called MuseInk© was utilized to capture problem solving procedures in a manner that emulates handwritten solutions, but uses digital ink to record the solutions. This technology permits different classroom activities beyond the use of hand written solutions typical of traditional courses where assignments are completed with pencil and paper, and adds valuable information beyond the final solution. As with any new implementation of technology, there is a period of resistance and a mixture of feelings toward adoption of the technology that must be overcome to get benefit from the technology. As educators work to make instruction more personalized, effective, and interactive, research on the adoption of new technology is imperative to understand what drives these adoption behaviors to better mitigate resistance to technology implementation. Our research group surveyed students on their attitudes and behaviors toward the use of tablet computers and the MuseInk software technology introduced into the classroom. Diffusion theory is used as a framework to examine the technology adoption behaviors. Overall, the attitudes and behaviors associated with the introduction of tablet computers and MuseInk software followed adoption patterns typically seen with typical diffusion of innovations.

Introduction

Technology has changed the way that business is conducted and therefore has changed skill requirements of new hires, especially in engineering positions. Employers are looking for recent college graduates to be the front-runners of technology driven initiatives more so now than ever before. Technology has also provided opportunity for advancement in personalized learning¹ that was not possible before, but in order for benefits of technology to be realized, it must be successfully adopted. It is an assumption that members of the millennial generation are more comfortable with technology than former generations, which is true on average². However, there are still students entering college without prior experience with technology, which may hinder their success in the classroom and on the job market unless they obtain a level of comfort with technology throughout their college experience. As the level of education has doubled since 1970, with 31% of people age 25-29 holding at least a college degree compared to 16% in 1970, it is important for students to develop technical skills to set them apart from their peers with equivalent educational achievements³.

While many universities have instituted a laptop or tablet computer mandate for undergraduate and graduate engineering programs, many others do not require computers or laptops. While our institution has a laptop mandate, our research group introduced the use of tablet computers in a first year engineering fundamentals course. Primarily this technology was used for research purposes, as part of a larger project called "CU Thinking" (NSF Award # EEC-0935163) which

focuses on students' problem-solving strategies and their relation to prior knowledge⁴. This is an important skill for engineers, but a very difficult concept to personalize given the varied levels of academic preparation of incoming students. Also, problem-solving paradigms such as Polya's method⁵ lack flexibility in terms of the processes that students must adhere to. However, we recognized the added benefit of increasing student exposure to pen-based technology. A custom tablet computer software application called MuseInk was utilized to capture problem-solving procedures in a manner that emulates handwritten solutions, but uses digital ink to record the solutions⁶. This approach introduces different assessment and instructional capabilities beyond the use of hand written solutions typical of traditional courses where assignments are completed with pencil and paper. Other tablet PC applications like DyKnow⁷ and Classroom Presenter⁸ allow instructors to incorporate rapid pen-based feedback on select student work live in class, but do not have the capability of capturing, archiving and annotating student Ink and audio commentary in a way that allows detailed analysis of cognitive processes and error types that was needed for our research.

The digital Ink software (MuseInk ©) has a playback function that allows students to replay their entire problem solution which facilitates review of and reflection on their work. It is believed that this functionality will help students become more aware of mistakes they made in the process, the strategies they used, and how they organize their work in order to identify areas for improvement. There is also a means for identifying important features within the work by associating tags at specific points in the solution. This can be used for communication from instructor to student such as identifying errors or incorrect assumptions. Audio tags can also be added post-hoc to the Inked solution. This can be used by the students to add reflections on their strategies and approaches, an important practice with respect to students' professional and intellectual development⁹. It can also be used by instructors to identify specific skills, concepts or errors that the student needs to attend to. Students can leave notes to inform instructors of problems they are having completing work or for themselves to use while studying. Still frame images of the solution can be exported, which students use as they find appropriate such as adding images to an electronic notebook or presentation. Overall, this has the potential to be a powerful pedagogical tool.

However, with every technological intervention, as with any new product implementation, there are varying levels of acceptance from users. While getting acquainted with a new product, users encounter a hierarchy of effects: 1) awareness, 2) interest, 3) evaluation, 4) trial, 5) adoption, 6) confirmation¹⁰. Users progress through the adoption process at different rates. Rogers's theory of diffusion of innovations describes how some users will adopt a product right away due to seeing high value or meeting an immediate need (innovators, early adopters)¹¹. Others follow to adoption later, often after addressing initial concerns or being swayed by additional information about the product or adoption of other people (early majority, late majority). Still others will not adopt the product until the end of the life cycle, possibly too late to experience all the benefits (laggards)¹¹. The speed of the adoption process can be influenced by 1) communicability, or how well the value of the product is communicated, 2) triability, or how easy it is to try the product, and 3) relative advantage, or how the product is more beneficial than other similar products¹¹.

In order to assess the success of a new product, it is useful to determine how many users have adopted the product, and how far users have progressed through the adoption process. Products can fail at any stage of the adoption process: at the awareness phase due to selective perceptions, at the interest phase by selective retention, at the evaluation phase by low perceived rewards, at the trial phase due to failure to match needs, and the adoption phase by final decision that the product is not a good value¹². Post adoption during the confirmation stage, users decide whether or not to continue use based on how well the product continues to meet their needs¹⁰.

Research Objectives

The goals of this research initiative were to assess the adoption behaviors and attitudes of the class in response to using of the MuseInk software in the classroom and the progression of attitudes in response to changes in software usage in the classroom across two semesters. Ideally, the whole class will achieve adoption of the software quickly, but to adopt the software, students must reach their own conclusions on the value of the software and its ability to meet their educational needs so adoption of the software cannot be forced. At the end of each semester, a survey was distributed to the class to determine how well the software was adopted by students and determine if adoption rates could be increased through behaviors by the educators, serving a promotional role.

Methods

Participants and Environment: Students enrolled in a tablet section of a first year engineering course at Clemson University, "Engineering Disciplines and Skills," participated in this research. Tablet computers were made available in the classroom for the students to use on a regular basis (approximately 10 times during the semester) to complete and submit assignments using the MuseInk software in lieu of paper submissions. Students self-selected their course section, and although participation in the research was voluntary, use of the tablets and MuseInk in the classroom was required. Thirty-six students were enrolled in the spring 2010 section and sixty-one students were enrolled in the fall 2010 section.

During the spring 2010 semester, students were only shown how to complete their work on the software. They were not shown how to replay their work, they were not required to install MuseInk on their own computer, and were not required to utilize the image snapshot features, although they were informed of the features. They were only graded on the correctness of solutions, not on their work with MuseInk explicitly. They completed all problem solutions on MuseInk using tablet computers in class only.

During the fall 2010 semester, students were shown how to complete their work in MuseInk and were shown a PowerPoint presentation detailing how to replay their work. They were also asked to use additional features of the software including the image snapshot feature by placing an image drawn in MuseInk onto a poster created in PowerPoint. Instructor's solutions with playback and audio commentary were made available for selected problems, which encouraged use of the playback feature. Students were not required to download MuseInk onto their personal computers. Grading was still based solely on the correctness of solutions, not on their work with MuseInk explicitly. They also completed all problem solutions on MuseInk using school tablet computers in class only. Some students used Wacom® pads connected to their own computers due to limited availability of tablet computers.

Survey: At the end of each semester, the students who used MuseInk were given an anonymous survey to complete about their experience using the survey. The survey had 10 multiple choice questions with choices of “agree”, “undecided” or “disagree”. The 10 questions were as follows:

1. MuseInk is easy to use.
2. I downloaded and installed MuseInk on my own computer.
3. I know how to replay work I completed in MuseInk.
4. I have replayed work at home that I completed in MuseInk to solve a similar problem.
5. I have replayed work at home that I completed in MuseInk to study for a quiz or exam.
6. Replaying my work made me more aware of mistakes I’m making compared to looking at work completed on paper.
7. Replaying my work made me more aware of my problem solving strategies compared to looking at work completed on paper.
8. Replaying my work made me more aware of how I organize/arrange my work.
9. If my instructor provided solutions in MuseInk, I would replay the instructor’s work to see how they solved a problem.
10. I wish we did more work in class using MuseInk.

Pearson’s chi square tests were conducted to determine any significant differences in survey results between spring and fall 2010. This test was chosen to determine differences in question responses within and between semesters due to the ordinal nature of survey responses which distinguish between positive, neutral, and negative reactions but the strength of each reaction is not necessarily evenly dispersed across participants or questions.

Results

Survey Results

Spring 2010 Results: Results from the Spring 2010 survey (n=36) showed that the majority of students felt like MuseInk was easy to use (94.4%), could replay their work (55.9%), would replay teacher solutions if made available (61.1%), and wished they had used MuseInk in class more (69.4%). Twenty eight percent of students installed MuseInk on their computers, even though it was not required. However, only 13.9% of students replayed work at home either to study for an exam or to help on a similar problem. While most students were undecided (40%) or disagreed (40%) that MuseInk helped them be more aware of problem solving strategies, making mistakes, and organizing their work, it was believed that the low positive response to these benefits of MuseInk were due to low usage of the replay feature.

Fall 2010 Results: Similar results were found for the results from the Fall 2010 survey (n=61), which showed that the majority of students felt like MuseInk was easy to use (88.5%), could replay their work (77.0%), would replay teacher solutions if made available (63.9%), and wished they had used MuseInk in class more (52.5%). In addition, a majority of students downloaded MuseInk to their own computers (68.9%), even though it was not required. More students replayed their work at home either to study for an exam or to help on a similar problem (27% compared to 14%). More students realized the benefits of MuseInk helping them be more aware of problem solving strategies, making mistakes, and organizing their work (40% agreed compared to 20%). It was believed that the increase in positive response to these benefits of

MuseInk were due to an increase in usage of the replay feature. Complete survey results comparing responses for spring and fall are shown in Figure 1.

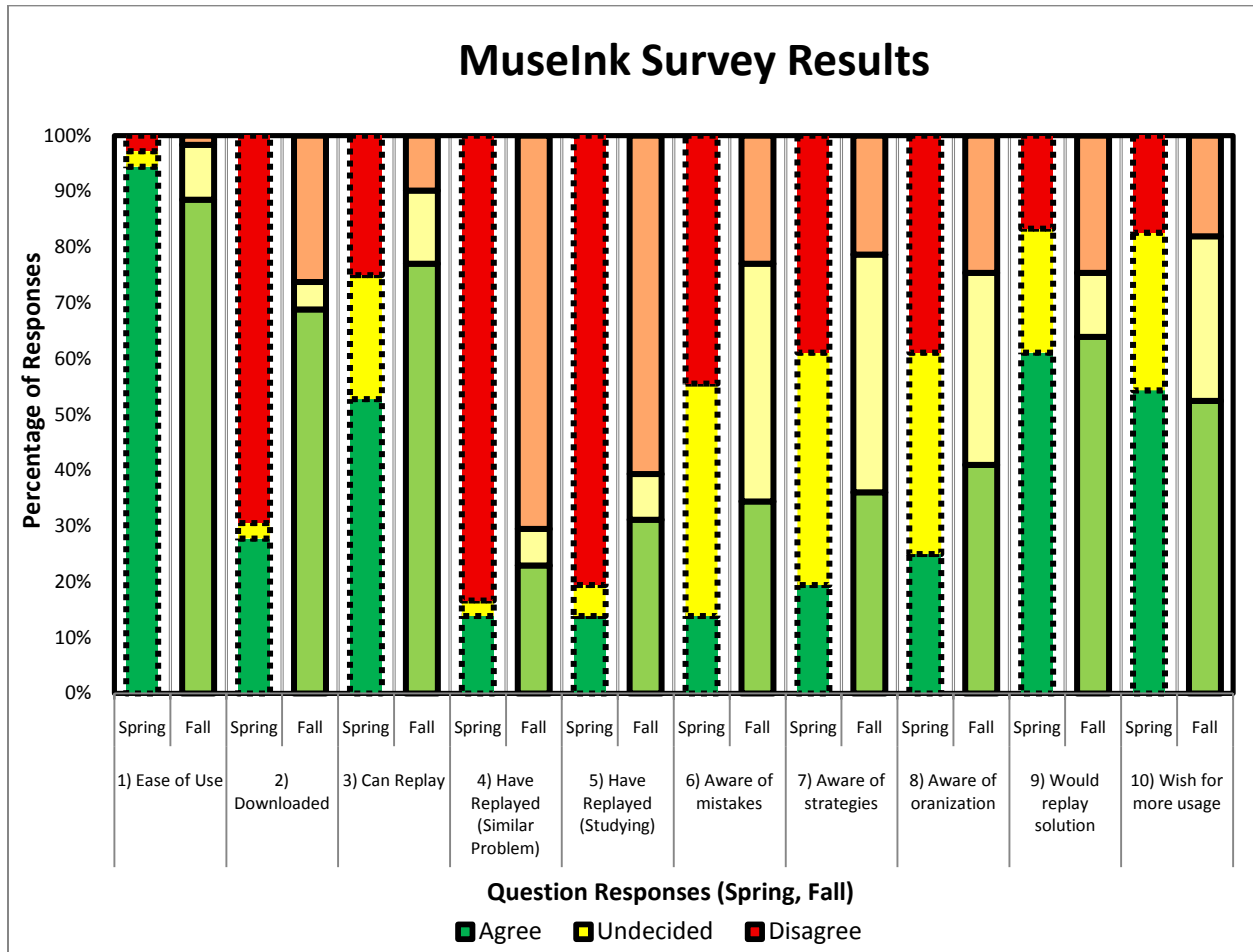


Figure 1: Comparison of Differences in Survey Results across Semesters

Differences Across Semesters: Results from Pearson’s chi-squared tests showed a significant increase in the number of students who downloaded the software ($\chi^2 = 0.0002$), a significant increase in the number of students who know how to use the replay function ($\chi^2 = 0.0395$), and a significant increase in the number of students that believe that MuseInk helps them identify errors in their work ($\chi^2 = 0.0310$).

Product Adoption Process

In our assessment of product adoption, a student was determined to have adopted the software if they utilized it outside of the in-class requirements. The survey responses can be utilized to determine the distribution of students along the product adoption process by determining their position along the 6 phases of effects: 1) awareness, 2) interest, 3) evaluation, 4) trial, 5) adoption, and 6) confirmation. Progression through a phase was indicated by survey response that was neutral or positive, as negative responses are the only ones indicative of displeasure or failing to reach that level of assessment.

To assess progression through the awareness phase of the product development process, question 1 was used to assess perceptions of the software on ease of use. On average, 97.2% and 98.4% agreed in the spring and fall respectively. To identify achieving the interest phase in the product adoption cycle, question 3 was used to assess selective retention by evaluating the ability to use the replay function. On average, 75.1% and 90.2% agreed in the spring and fall respectively. Two survey questions (9 and 10) were used to identify achieving the evaluation phase of product adoption, assessing the perceived rewards of the using the software outside of class, as indicated by whether they would use the software to replay teacher solutions and whether they wish they had used MuseInk more. On average, 83.0% and 78.7% agreed in the spring and fall respectively. A single question (2) was used to identify achieving the trial phase, did they download the software to their personal computer. On average, 30.6% and 73.8% agreed in the spring and fall respectively. Two survey questions (4 and 5) were used to identify achieving the adoption phase of the product adoption process, identifying whether the students replay their work at home, either to solve a similar problem or to help study for a quiz or exam. On average, 18.1% and 34.4% agreed in the spring and fall respectively. The remaining three questions (6, 7, and 8) were used to evaluate achieving the confirmation phase of the product adoption process. On average, 59.3% and 77.1% agreed in the spring and fall respectively. Complete results can be seen in Figure 2.

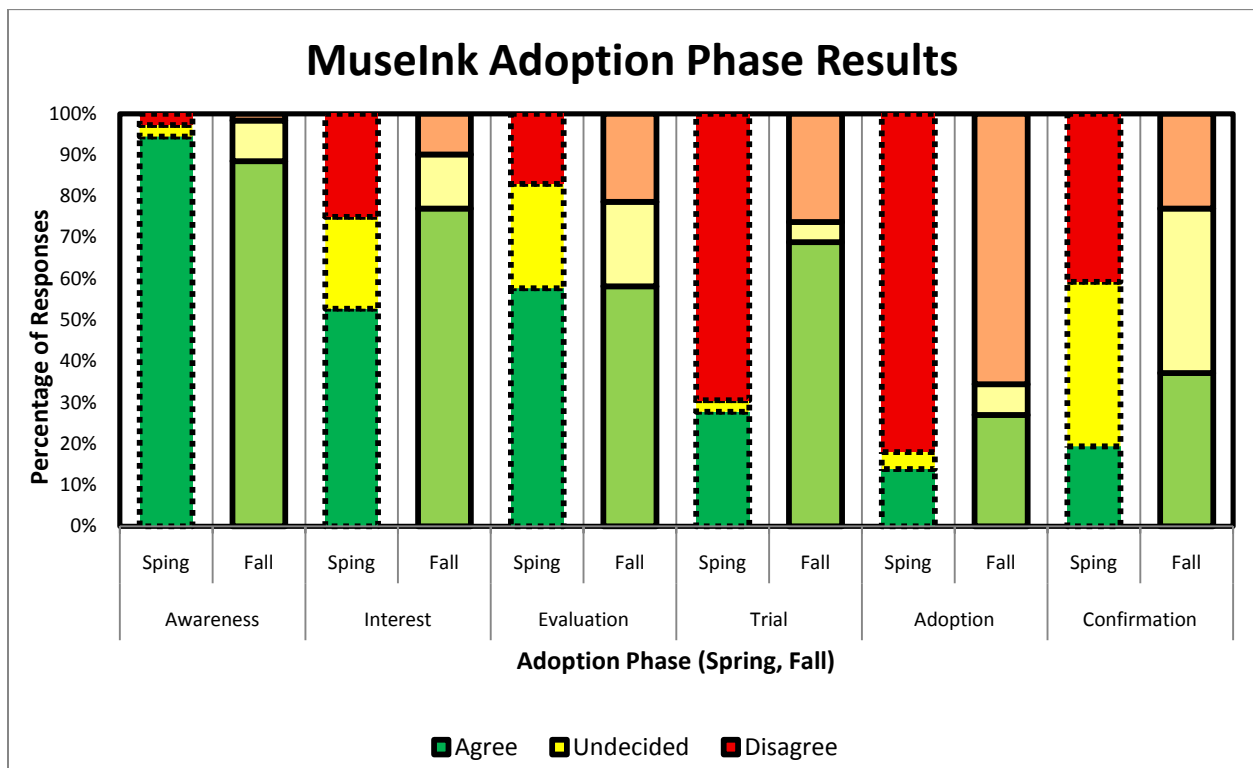


Figure 2: Comparison of Proportions of Students Reaching Adoption Phases across Semesters

Differences Across Semesters: There was a significant increase in the number of students who progressed through the interest phase ($\chi^2 = 0.0500$), a significant increase in the number of students who progressed through the trial phase ($\chi^2 = 0.0001$), and a significant increase in the number of students who progressed through the confirmation phase ($\chi^2 = 0.0300$). While there was also a large increase in the number of students progressing through the adoption phase, the

increase was not statistically significant ($\chi^2 = 0.08$). A summary of percent change across semester is shown in Table 1.

Table 1: Percent Change (Fall – Spring) of Students Achieving Each Adoption Level

Adoption Phase	Agree	Undecided	Disagree
Awareness	-5.92%	7.06%	-1.14%
Interest	24.27%	-9.11%	-15.16%
Evaluation	0.47%	-4.75%	4.28%
Trial	41.07%	2.14%	-43.21%
Adoption	13.16%	3.21%	-16.37%
Confirmation	17.71%	0.08%	-17.79%

The critical point leading to adoption was downloading the software on students’ own computers. Out of the students who downloaded MuseInk, there were higher rates of adoption and confirmation behaviors. More students replayed work at home to solve a similar problem ($\chi^2 = 0.0004$), replayed work at home to study ($\chi^2 = 0.0001$), were aware of mistakes ($\chi^2 = 0.011$), and were more aware of problem solving strategies ($\chi^2 = 0.023$) in fall 2010.

Discussion

The survey results show that the adoption rate of students was improved by the promotional activities incorporated in class with more students reaching the adoption phase in the fall (34.4%) than in the spring (18.1%). There was a slight indication of perception of ease of use declining, with an increase in the number of undecided responses. This may be expected with an increase in utilizing more software features, but the difference was not significant and the number of negative responses also declined. By utilizing more of the features of MuseInk in class, such as requiring students to export an image and making available a teacher solution with audio voiceover, students were made more aware of additional features and were more likely to download the software on their own computer. It was shown that students who downloaded the software on their own computer were more likely to reach the adoption phase and used their problem solutions to study or complete similar problems and raised awareness of errors and strategies used. Therefore, instructors will continue utilizing additional features of the MuseInk software in class in hopes of increasing the adoption rate further. Instructors hope to determine the appropriate level of activities that optimizes adoption of the software for use at home in developing problem solving skills.

Conclusion

Overall the results from the survey were promising in terms of students adopting the tablet technology. Students found the MuseInk software easy to use, and most knew how to access the features of the program without explicit instructions. Some students found that MuseInk helped them see the mistakes that they were making, and made them aware of their problem solving strategies in class and outside of class, and improves student’s awareness of their problem solving strategies outside of class. We believe that with increased adoption, it will also be shown to improve student awareness of their problem organization approach through reflection. Overall, the software has been implemented with limited interruption to the learning process and has shown some positive results. This investigation is ongoing, and future work includes further

promoting student reflection on their problem-solving strategies by routinely having them tag and comment on their work post hoc.

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