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Engineering collaboration via electronic media: How to promote reflective thinking skills and visualize data with technology

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Engineering collaboration via electronic media: How to promote reflective thinking skills and visualize data with technology

by

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Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Master of Arts

The University of Texas at Austin

August 2011

Dedication

This work is dedicated to my family; Mom, Dad, Marcy, Gabi, Brian, Tyrell, Kylie, Ella, Sofia, Mikey, and Zira. They have always been there for me and I love them very much. I hope this dedication inspires my nieces and my future children to pursue their own educational dreams.

Acknowledgements

I would like to thank Phil Janisiewicz for helping me develop my instrument for this report. Without his superior IT skills, I would have never have figured it out in a timely manner. Also, a shout out to www.wordpress.com for allowing me to modify their software to create my educational ideas.

Abstract

Engineering collaboration via electronic media: How to promote reflective thinking skills and visualize data with technology

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Online discussion forums and reflective writing are proven methods for enriching conceptual understanding and are hallmarks of engineering education. Plagiarism and many students' apprehension to contribute to online journals can plague the effectiveness of these educational tools. Using elements of the engineering design cycle, I have created a blogging website that addresses these problems by restricting comment visibilities for users and includes a graphic visualization called a "word cloud" to supplement discussion. A prototype was tested with UTeach Engineering teachers for feedback on design and use. The critiques provided examples of classroom use, constructive design feedback, and ideas for its use as a formative assessment. The design could be used as a pedagogical tool for an investigation of formative assessments in engineering education, but further research for "word cloud" visualizations and journal data collection is needed to expand the current design.

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Chapter 1: Introduction

It has been asked of us to become a nation of innovators. In the past, if a product or tool was not available, you created it. Engineering is no longer a practice confined to the corporations of IBM or Siemens; anyone can do it. If you have the desire to create something, you are an engineer. Creations can range from solar cars to television scripts. Everyone engages in some aspect of the engineering design process, sometimes without notice. It is important to inform and educate students that they probably are engineers already.

There is a growing necessity for classroom teachers to conduct their own research and collect data that will help them guide their classroom instruction. Pedagogically, formative and summative assessments are commonly employed tools, specifically formative assessments that check for conceptual understanding. However, there are not many assessment tools that observe desired learning objectives in real time. Digital response systems or the classic whiteboard can quickly assess a large group of students, but it is arguable whether these systems lend themselves to class discussions or reflective writing. Factual knowledge is the extent of many formative assessment devices and they rarely test the conceptual knowledge of the student. Although, it is at the teachers' discretion to ask probing questions into a students' learning, it is necessary to incorporate newer technologies and re-design them to meet the needs of today's classrooms.

As an educator, it is desired to have equal, but distinct input from all the students in the classroom. Yes, this is an idealistic endeavor. In practice, many students are reluctant to share their ideas or opinions. The goal of this report is to research and design

software to meet needs in collaborative learning using the newest technology in visualization and electronic communication software.

Electronic media in education is primarily used as an auxiliary teaching device, prompting a student response, for organizational purposes, or used as concept introduction within the lesson. If used as a discussion or response system, after the response is collected, the job of the electronic media is essentially done. It is left to the instructor, either through the discussion or review, to determine whether the desired learning objective was achieved. In online discussion forums, the line between plagiarism and originality is never a clear one, especially in secondary education. In practice, it is very difficult to distinguish between genuine answers and shared answers, therefore the main objective of this project was to design and engineer a software system that met certain criteria:

1. Provide an avenue for students to collaborate democratically and independently.
2. Create a source of researchable data.
3. Accessibility to anyone with Internet.
4. Promote critical thinking skills and spark discussion across a variety of disciplines.

This report will outline the design process for discussion software that is supported by pedagogical research. As part of the design cycle, the software will be tested for feedback and will collect data submitted by teachers, undergraduates, and graduate students for the following questions.

1. What are some things that you would change on the site?
2. How would you use this tool in your classroom?
3. How could you use the tool as a formative assessment?
4. Do you see any potential pitfalls for using this tool in a classroom?
5. How would you use the Word Cloud function in discussion?
6. Any feedback you would like to add.

The feedback provided from the evaluators will be used to create a final prototype. The documentation of the re-design and development of the software will be outlined as well as the pedagogy supporting the use of electronic media for discussion. The report will incorporate features of the engineering design cycle and demonstrate the iterative process.

Chapter 2: Review of the Literature

General Overview

There is established literature explaining the benefits of discussion *blogs* (web logs) in an educational setting. Significant increases in students' cognitive abilities have been explicitly measured when oral discussion is changed to a written one. The theoretical framework for a text-based environment is well documented in the domains of perceived learning, collaborative constructivism, and communities in education (Halic, Lee, Paulus & Spence, 2010). Moreover, using a blog to enrich the classroom discussion or even for the exchange of ideas is a great venue for constructivist learning (Wang and Hsua, 2008). Ideally, the use of online discussion forums should be democratic allowing each contributor to add his or her unique input with a community of learners. However, one of the consequences of using online discussion forums is plagiarism. As an educator, it is inherently difficult to balance collaboration and plagiarism in an online setting, because the students do not have to physically be in the classroom to submit their ideas online. For this reason, it is imperative to promote the exchange of conceptual knowledge without jeopardizing the integrity of the course or the submitted content. Thus, the modified *Wordpress* blog created in this study has been designed to address this issue. With this new tool, it is the intent of this report to investigate the cognitive aspects of online communication and use this knowledge to design unique features for this tailor-made blogging software. The following review will focus on the pedagogical literature pertaining to the use of electronic media in education.

Electronic media and Education

The convenience of computer-mediated communication (CMC) for discussion has made it a popular tool in the last decade. Despite this fact, blogging and discussion forums do not dominate overall Internet usage, there is a significant amount of research on its incorporation as an academic device. Blogs are viewed as a great reflective experience for the students that can allow for knowledge transfer. CMC has been integrated into three of the elements of the educational experience: social, teaching, and cognitive presences (Garrison, Anderson and Archer, 2000). These aspects of any learning community are especially important when the discussion is occurring remotely. CMC enacts these critical roles through the online learning community and many reports document cognitive increases for CMC users.

The Social Presence

The social presence is simply the gathering of learners. As a contributor to the online discussion forum, the student is accepted to a community of learners. The social aspect of the online community gives the participant a sense of security, which allows them to share their ideas with the other group members freely and comfortably. However, there is no documented evidence whether this social presence actually contributes to the quality of responses or even meets any educational goals (Garrison, Anderson and Archer, 2000). In many cases, students may be reluctant to contribute to oral discussion for a multitude of reasons, whether for fear of ridicule, linguistic barriers, or simply not knowing the answer. These same factors can be attributed to a lack of participation on CMC, which is just another form of communication despite the indirect contact. The reluctance to contribute online may intuitively be attributed to a variety of reasons. The fear that others are reading and judging your posts, that their entries contain grammatical

or nonsensical errors, or the fear that the student simply does not know how to answer the question will lead to a hesitation to respond. The pressure to fulfill course requirements often leads to a failure to participate or in the worst case, plagiarism.

The Teaching Presence

The teaching presence is the regulatory aspect of CMC, it provides the avenue, the inquiry, and the scaffolding necessary for discussion. Without it, there is very little reason for students to participate, even with the establishment of the social and cognitive presence (Gunawardena, 1991, Hiltz & Turoff, 1993). The teaching presence has the potential to dominate the conversation when the instructor is facilitating an oral discussion, but the role is downplayed when using CMC. The blog administrator, which may or may not be the teacher, will post a discussion prompt and contributors respond to it. The students take on the central role in that it is up to them to develop the discussion, and the input from the instructor is kept to a minimum. This is one of the benefits of blogs and discussion forums, it provides the students with a venue for their own unique ideas outside the traditional classroom. As an instructor, it is important to engage students with a certain level of involvement, especially online where this tends to get overlooked. The article, *Critical Inquiry in a Text-Based Environment: Computer Conferencing in Higher Education* explains the importance of building a community of learners and acknowledges that it is not clear how this is done in an asynchronous text-based environment, though the authors suggests the instructor should initially meet the students face to face before engaging in online discussion (Garrison, Anderson and Archer, 2000).

The Cognitive Presence

The cognitive presence in CMC is dependent on how communication is managed by the conveyed medium. There were a series of studies conducted in the nineties that compared learning and thinking in face-to-face learning situations to computer-supported learning contexts (Newman, Johnson, Cochrane, and Webb, 1996). The results yielded significant differences in critical thinking. The face-to-face students had a slight advantage at idea generation, whereas the computer-conferencing students were able to incorporate new ideas and link ideas to solutions. The authors suggested that computer conferencing seemed to encourage deeper critical thought even with less interaction, while the face-to-face interactions were found to be more creative (1997).

The community of learners is greatly affected by the presence of the three educational aspects, social, teacher, and cognitive. In a 1997 study regarding these ideas, Gunawaradena, Lowe, and Anderson found that a lack of teacher presence resulted in a lower construction of knowledge for students. The teacher acts as a guide for the discussion, redirecting the conversation, and scaffolding. Without this scaffolding, the development of the cognitive presence has unintended consequences that results in discourse of little educational value. The article found that learning experiences with all three educational presences were the most fruitful.

The Garrison, Anderson and Archer article (2000), reiterates the interdependence and importance of these three concepts for a successful community of learners in CMC. It is necessary for students to feel comfortable enough to share (the social presence) and they must have an active facilitator guiding the discussion (the teaching presence). With these two criteria, the prompts must also encourage critical debate and allow the students

to demonstrate their transfer of knowledge through their reflective entries (the cognitive presence).

Reflective Writing using Blogs

It is the consensus that reflection is critical for meaningful learning. Xie, Ke, and Sharma produced an empirical study to investigate this in, *The Effect of Peer Feedback for Blogging on College Students' Reflective Learning Processes* (2008). The research is correlated to Dewey's work on cognitive reflection, which he stated as, "the gathering of new information and our attempt to balance the disequilibrium that these experiences bring," (1933). Journaling is an effective means for reflection and provides evidence of this reflection process (Stickel & Trimmer, 1994). For this reason, journals are used extensively as an educational tool, as they allow students to document and reflect on their knowledge and the recorded work provides the teacher with evidence of this process.

Similarly, Xie and Sharma contend that weblogs allow bloggers access to different perspectives on situations, problems, and discussion questions, thus enriching their construction of knowledge. The journaling process deepens the blogger's reflective experience, more so when critical feedback is received from someone he or she regards as an expert or mentor (Moon, 1999). Figure 1 shows

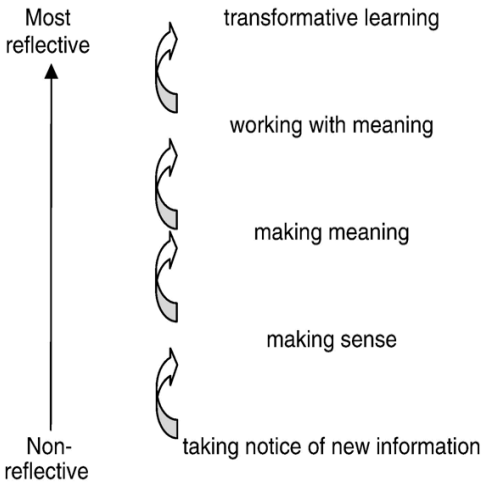

Figure 1 A simplified model on the stages of learning, adapted from Moon's Map of Learning (1999)

Moon's reflective model of learning maps out the steps in the learning process, which coincide with online journaling. This makes sense because the discussion becomes more intimate for the student (blogger) and they are able to reflect with greater understanding when it is supplemented with the guidance of someone who can provide meaningful feedback.

Journaling and blogging is a great way for students to evaluate their own work and the entries of others. First of all, the students must construct ideas in their minds to articulate in their writing. Then, as the student read their entries, they have to reinterpret what they wrote. Reflective thinking levels increase over time as they engage in blogging activities (Xie, Ke, and Sharma, 2008).

The authors also found that peer feedback did not promote reflective thinking skills when it was introduced with journaling. The reservation in the students' journaling was attributed to their knowledge that the journals were going to be critiqued by their peers. The entries did demonstrate a true representation of students' ideas, as they were writing for an audience. Another finding was that the journal entries did not receive the same caliber of feedback from their peers as they did from the instructor. Knowing this, the authors of the journals were reluctant to really make an effort in their writings. The peer feedback tended towards more social commenting rather than a more constructive critique of the material. As a teacher, it is important to structure the online journaling experience so that the students are fully engaged in answering the prompted questions. Having a system where the students do not have immediate access to each other's entries allows the students to freely respond without hesitation.

Collaborative Learning via Electronic Media

In order to create a tool for collaborative learning, careful examination was given to Salmon's 5-stage model of electronic learning, or e-learning (2006). This model was chosen because of its relevance to social constructivism. The first stage of the model is access and motivation. The students must be able to easily access information and be motivated to construct their own knowledge. This may be achieved in a variety of ways and can be supplemented by the electronic medium in which the information is being collected and processed. The accessibility of the online blogging websites make it easy for students to contribute as long as they have Internet access. It is up to the teacher to motivate the student to want to share their ideas with thoughtful questioning.

Online socialization is the second stage of e-learning, and is inherently built within the framework of online discussion forums. The discussion can range between the community of learners and the instructor, between peers, or individually with the instructor. Having the ability to switch the socialization aspect with your discussion tool can greatly increase the versatility and depth levels of the conversation. Socialization is what allows students to freely share their thoughts and ideas; they have to feel comfortable with their community of learners.

The third stage is information exchange and that happens when blog contributors have completed the first two stages of the model. The exchange occurs when the teacher asks a question and the students begin to formulate and compose their responses. Feedback from the teacher or their peers is crucial in regulating the quality of the exchange. It can be modified by how the journaling site is structured or how the

instructor wants the discussion to proceed. This leads into the fourth stage, knowledge construction.

Knowledge construction manifests as the student begins receiving feedback from whom they see as an expert in the classroom, i.e. teachers or fellow classmates. Ultimately, it is up to the instructor to clear up any student misconceptions and this is done with constant supervision of the content that is being created. Due to the nature of blogs, there is a level of reflection that students undergo, which allows them to develop their knowledge. This final stage of e-learning is the goal of this particular educational experience and is dependent on the completion of the previous stages. The reflective process of journaling is thus the impetus for knowledge development and the evidence is documented within the blogging database.

Chapter 3: The Software Design

Design impetus

Based on research and personal classroom observations, I wanted to design software that could be used primarily for discussion purposes or as a formative assessment tool. I also wanted to create a tool with the potential to be used in pedagogical research. I chose to re-design the *Wordpress* software due to its existing features as a stable and efficient blogging platform. The goal of the re-design was to meet criteria that I desired for my own classroom use, but it was also my intention to present the product to a group of teachers for evaluation and feedback. I was able to justify the modifications to the current software with pedagogical evidence, but was willing to take the input of the evaluators to further improve the design. In this section, I will outline the needs of a typical discussion forum as it pertains to a K-12 setting, although its uses could go beyond the typical classroom. Figure 2 shows the hierarchal brainstorm for the software design, with initial ideas on the bottom of the pyramid and future work on the top.

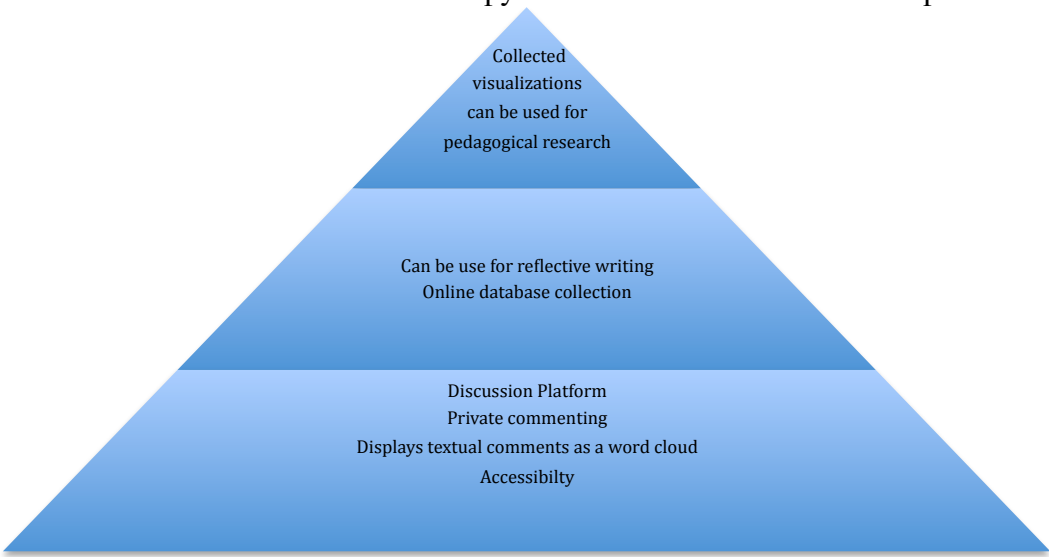

Figure 2: Concept Generation

Problem/Needs and Constraints

I have created a design matrix that documents the needs of the software from a pedagogical or functional perspective. The pedagogical constraints are desired educationally based specifications that needed to be integrated into the software. Functionality specifications were essential for product effectiveness and met broader goals, often too, of educational value. I have listed the performance criteria and the marked corresponding category associated with each. The categories relate to a user frame of reference, and a user is defined as a teacher or student. I designed the software around my personal experiences as a teacher dealing with discussion, critical thinking, and collaboration. Though, this product was created independent of a customer needs analysis, I used the same product to gather feedback from other teachers who have an engineering frame of reference and are familiar with the younger student audience for which this software is intended.

Criteria	Pedagogical	Functionality
1. Accessibility		X
2. Private Commenting	X	X
3. Collects and stores researchable data	X	X
4. Promotes discussion and critical/reflective thinking	X	
5. Easy to use		X
6. Generates visuals from textual inputs	Potential	X
7. Communication between users	X	X

Table 1: WordPress Re-design Constraints Matrix

The accessibility of the design will allow duplication of the software in any classroom with Internet access. I chose to use the free *WordPress* source code as my platform, changing only pieces of the software to meet the other criteria. *WordPress* is a

blogging and discussion software, containing many of the features of a forum like administrator access, posting privileges, and commenting threads. It has technical and software support, as well as online libraries with developer documentation. The user or developer can quickly find information regarding *WordPress* software due to its preeminence as a blogging tool. Due to this, the design constraints of comment privacy and user capabilities required very little effort to satisfy since *WordPress* has plug-ins available to fully modify the software without altering the code. A plug-in is a piece of software code that embeds itself and runs within the *WordPress* framework. With the plug-ins, I was able to modify the privacy settings for users, set up capabilities for each role (author, contributor, subscriber, administrator, editor), and control access to the environment from the user. I chose to design a system that restricted visibility for the comments posted on each blog page. One of the main issues documented as a consequence of online discussion is plagiarism, so I engineered the software to have privacy levels that could be changed depending on how much read access a teacher wanted the students to have. I also desired a clean and uncluttered template and one that allowed me to easily grant or restrict access for users at multiple levels within the software.

For the data collection criterion, I used university resources to have a database set up and a server to host the finished site, which took care of the storage need. The database stores all textual input that is placed into the site from the front end (comments, posts, etc), in hope that it can be accessed for other uses (research) or as documentation

for reflective activities. Lastly, as a teacher, it is important to be able to contact any user for administrative purposes or to provide feedback on student work. The design required communication capabilities, which could email to individual users and groups.

Model of the Problem System

The online classroom discussion forum follows a typical protocol, the instructor posts a question or a journal article on a page and the students (users) will post their responses to the query, which are then collected in a thread underneath the question. Because of the collaborative nature of online discussion, everyone who is a member of the learning community can read the responses of their peers, thus the intended result is that ideas are exchanged and knowledge can be created from this process. The question arises, how can this process be regulated so the submissions of each user are truly unique and responses are not plagiarized from within the community, yet maintain the essence of collaboration? The discussion tool I have engineered seeks to find a solution for this problem.

As previously discussed, successful e-learning is attributed to the social, teaching, and cognitive presences. The social and teaching presence is maintained inherently by how the classroom is set up, in this case through an online discussion forum. The social aspect is the online community of learners who would be made up of students that meet on a regular basis. The teaching presence is the instructor that sets up the online learning environment and posts questions that invoke thought and reflection. Online, the teacher structures the environment with feedback and constructive commenting. I wanted to design a tool that contributes to the cognitive presence of the learning experience. The problem system for this project is the how the design can be used to promote critical and

reflective thinking skills. Ultimately, the nature of the questioning is going to play a central role in determining whether the students will engage in the cognitive presence. As an educator, there is always a need to supplement this process with any tool or exercise to ensure maximum exposure and understanding by the students. In the case of online discussion, it is necessary to design around two focal points; respecting a persons' input as uniquely valid, and maintaining a student's visual engagement in an activity that can be excruciating for visual learners.

Online Discussion Needs
1. Private commenting
2. Visual representations
3. Easily navigable
4. Maintains blog structure and flow
5. Communication channels between users/admin

Table 2: Problem System Needs

Table 2 shows a list of desired environmental requirements for an online discussion system. The final design needs to address these specifications within the structure of the software or at least be designed so it can be upgraded at a later date. The requirements that were dealt with in this initial design are private commenting and visual representations with word clouds. This is the first iteration of the software design, however after feedback is gathered from a prototype test, the software can be redesigned to meet more specific customer needs.

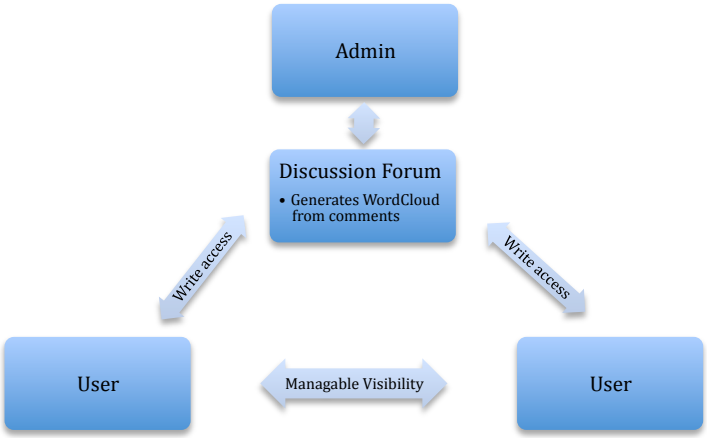

Figure 3: Software Flow Diagram

The software flow diagram in Figure 3 shows the hierarchy of the design with user read/write and visibility permissions set accordingly. It is important to remember that the flow mirrors that of a traditional discussion forum, with the only key differences being the visibility between users and the imbedded Word Cloud visualization.

Prototype Design

The software created in this report is built on a *Wordpress* platform. The key features of this modified blogging software are the visibility of the comment thread for users, simplified front-end access for users, and a "word cloud" template. The "word cloud" template imbeds a visualization of the comment thread. A "word cloud" is a graphic visualization comprised of text generated from the frequency of words. The higher the frequency of a word within a body of text results in a bolder and larger image of the word within the cloud.

The software prototype went live on July 11, 2011 and was presented to engineering cohort teachers. It contains all of the design specifications mentioned in the needs section of this report. Due to the organic nature of the design, it has upgradable features that will continue to change with the evolution of the software. The software restricts visibility of comments within users, so that any comment a contributor posts cannot be seen by anyone other than the administrator. The initial design also contains a WordCloud template that can be selected by the administrator to imbed the visualization within the discussion. It is up to the discretion of the teacher to choose this option for the type of discussion they want. Other than these specific changes, the *WordPress* code remains unaltered, so it contains all of the features of the original blogging site. The administrator can create new pages, post, and restrict the access that each role has within the framework.

I installed three plug-ins offered within the *WordPress* plug-in directory; Custom Word Clouds, Front-End Users, and Semi-Private Comments. The Custom Word Cloud plug-in contains the code needed to create the visual that is imbedded into the template. On any page, the cloud forms below the discussion question followed by the comments thread. The plug-in was written into the template code and is called every time the template is used. Front-End Users is a plug-in that restricts access to the dashboard for the users. In the dashboard, the users can see their profile and communicate with the host or other users. The Semi-Private Comments plug-in provides a selectable feature to the creation of a new page that can make commenting within users visible or invisible. The screenshot shows the visualization made by the WordCloud plug-in. The cloud changes dynamically as the comments are added. As mentioned before, this tool can be referred

back to the default template if the WordCloud is not desired. Below the cloud, will be the comment thread that remains invisible to other users unless changed by the administrator.

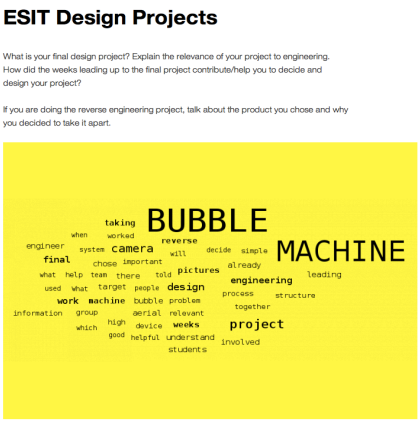

Figure 4: WordCloud screenshot

Prototype Test Data with Evaluation

The product was tested with two groups of teachers within UTeach Engineering. UTeach Engineering is a subsidiary of UTeach, the University of Texas at Austin teacher preparation program. The first group of teachers belonged to the ESIT program (Engineering Summer Institute for Teachers) and the other group belong to the second cohort of the MASEE (Masters of Arts in Science and Engineering Education) program. I chose these groups to test and evaluate the software because of their involvement in STEM education and knowledge of pedagogy within their own disciplines. With instructor permission, I incorporated use of this tool within the structure of the ESIT/MASEE courses in the summer of 2011, asking the members to explore the site and

prompting them with questions related to their engineering courses. I asked the ESIT students to comment about their final design projects as my first test of the WordCloud template. The MASEE students were asked to comment on engineering concepts they enjoyed the most or least, and which ones they believed were essential to an engineering textbook.

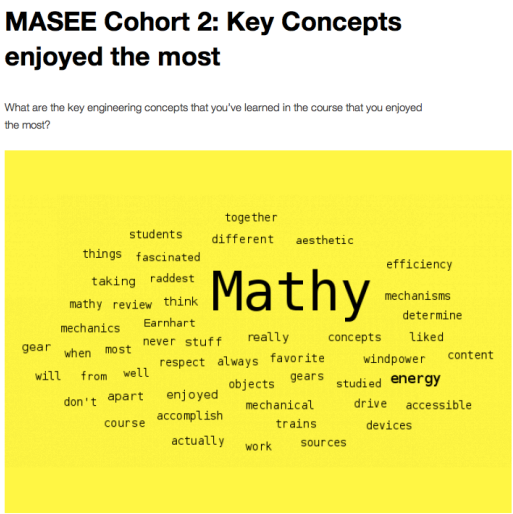

Figure 5: MASEE discussion screenshot

The screenshot in Figure 5 shows the outcome a discussion prompt given to the teachers in regards to their favorite engineering concepts covered within the summer course. These initial tests were mainly performed to showcase the visualization capabilities of the site and test the server the site is hosted on. As the week progressed, I performed a walk-through of the site to the members of both groups discussing the administrative accesses and the modifiable templates invisible to them as users. After a few days of exploration, the teachers were asked to leave feedback regarding the site, its function, and layout. The feedback was collected directly on the site, as I created a new page with feedback questions on it.

Feedback

1. What are some things that you would change on the site?

2. How would you use this tool in your classroom?

3. How could you use the tool as a formative assessment?

4. Do you see any potential pitfalls for using this tool in a classroom?

5. How would you use the wordcloud function in discussion?

6. Any feedback you would like to add.

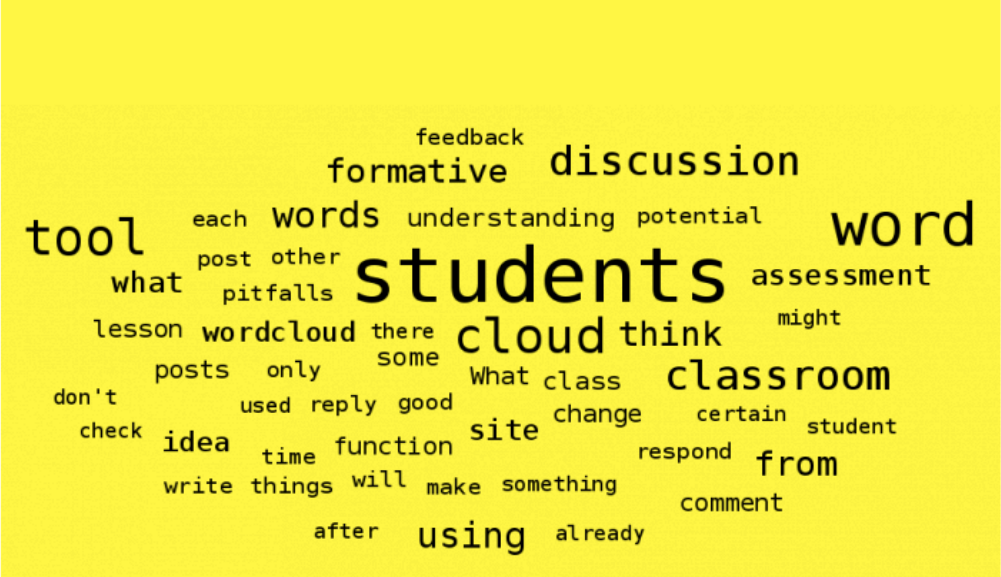

Figure 6: Feedback WordCloud screenshot

The next section will evaluate the feedback left by ESIT and MASEE members for the questions in Figure 6. The purpose of the feedback questions was to investigate how the teachers could use this tool in their classrooms, identify any pitfalls regarding student use and how to improve the site overall.

Evaluator Feedback

The evaluators were asked to comment on these questions and the responses can be organized into two categories; pedagogical and functional.

1. What are some things that you would change on the site?
2. How would you use this tool in your classroom?
3. How could you use the tool as a formative assessment?
4. Do you see any potential pitfalls for using this tool in a classroom?
5. How would you use the Word Cloud function in discussion?
6. Any feedback you would like to add.

Table 3: Teacher feedback

Feedback	Pedagogical	Functional
1. Better word filtering in cloud		X
2. Can be used for assessment	X	
3. Can not be used without Internet		X
4. Editing comments	X	X
5. Communicating with other users and the teacher via site	X	X
6. Vocabulary introduction	X	
7. Scale it down to an applet		X

I have created a table that documents and organizes the responses into these two categories. I have synthesized the feedback comments to only include general responses shared by the entire group. These comments will be used to make functional revisions to the software, while the pedagogical feedback will be evaluated for potential structural improvements on the software. As for the pedagogical recommendations, consideration will be made if they can be incorporated into the code, permitting that it does not change the essence of the original idea.

The majority of the feedback focused on how the students could sabotage the cloud with inappropriate words. This issue can be dealt with the Custom Word Cloud plug-in framework. The plug-in can be edited to exclude certain words from the cloud. Any word the user would like to exclude can be submitted, but due to a primitive filtering system, it may not omit all the variations of spelling of particular words. The third feedback response in Table 3 mentioned accessibility for students. Since the software is essentially a website, it does require that the students have school Internet access, at the very least. Response number four questioned the ability to edit your own comments as a user. The software is set up to allow users to post comments, but once a comment is submitted, it does not allow the user to edit the posted comment, the user must enter in an entirely new comment. In order to make the blogging a reflective process, the user must be able to modify their responses. A contributor to a discussion question should be able to change his or her original post without having to resubmit the comment. This is definitely a functional and pedagogical change that needs to be implemented in the final design. The fifth feedback comment asked for a communication system to be created so users can contact each other and the administrator. This suggestion will be taken into consideration for final design because it allows for the exchange of ideas, which is the goal of any educational discussion forum. Response number seven suggests if the software could be scaled down to an applet. This endeavor seems suited for work done after the final design, although it already is compatible with handheld Internet devices like iTouchs and any mobile browser.

Responses two and six were deemed solely pedagogical feedback. They suggested how the software could be used in the classroom. Particularly, how the tool could be used for vocabulary purposes or as a check for conceptual understanding. Once the final functional design of the software is complete, these ideas can be implemented. Feedback question number two generated several responses worth documenting,

2. How would you use this tool in your classroom?

"I like this idea but I would like for students to provide feedback to others post, however, since anonymity is important, you could choose a few well thought out posts to share w/out names. I could have them use this to write their analysis and conclusions for a lab. I would print out the word cloud to use as a formative assessment tool. You could cut out eat word and put it in a paper bag and have each student pick two words. They could then write a sentence or two of how those two terms are related. Use it as an exit ticket…"

"It could be useful for checking students' understanding of a reading assignment. The student would have to read the assignment and then answer a few questions about it. The word cloud could spark some ideas without allowing the students to copy each other's answers…"

"Maybe you could have the students briefly summarize what was done in class each day. If a student forgot what was covered, the word cloud might help jog their memory. Then, you could check the students' replies to see how well they understood the material and adjust your lesson for the next day based on what you see…"

"I would really like to use this as a reflection tool for my students to get a sense of their initial understanding and their growth/gain in understanding after a unit of study…"

These responses demonstrate how to implement the site as a formative assessment tool in a variety of classrooms. The intent of the feedback menu option on the site is to gather input from a variety of disciplines and users, so changes to the site are ongoing. The software can be constantly updated as input is received regarding its uses in the

classroom. In a way, the site is in constant iteration, which is one of the hallmarks of the engineering design cycle.

Revisions and Updates

Based on the feedback I have received on the site, I have begun to exclude "problem" words that would occur in the typical classroom. This issue was the greatest concern for the members of the ESIT and MASEE cohorts. The process of excluding words is tedious, but manageable within the *WordPress* plug-in framework. Inevitably, it is difficult to avoid every word and its derivative from the word cloud, but most words can be excluded with a couple of edits to the Custom Word Cloud plug-in code. While the visualization created by the plug-in is a rudimentary version of a word cloud. More elaborate clouds can be created with code from the creators of the word cloud visuals at http://www.wordle.net. The site creates very unique and colorful displays, and contains better filtering methods for certain words. The website does contain more advanced calls to the word-cloud generation function which may yield better results for the visuals in the software. An investigation will be made to see if the two pieces of software are compatible, though the final design will retain the original Custom Word Cloud plug-in.

The original design of the software did not give users the capability to communicate with each other, as the comment thread can be rendered invisible to users. I have decided to add an email feature, available through *WordPress* plug-ins, to give the users access to a simple email system so they can contact the administrator and the other

users. This will satisfy the feedback related to the communication aspect of the software. It certainly gives the users another avenue to discussion and exchange thoughts with other members of the learning community. With the new email feature, as the administrator creates new pages, he or she can quickly email any user alerting them of the new content. This is a convenience to the teacher, as they can promote discussion between groups of students or individuals, with a click of a button. This user access to the email feature can be modified or revoked at the administrator's discretion. The user capabilities are fully adjustable by the administrator with a plug-in called Capabilities Manager, thus the site can be customized to suit the needs of any discussion.

Documentation of the Final Design and Final Performance Report

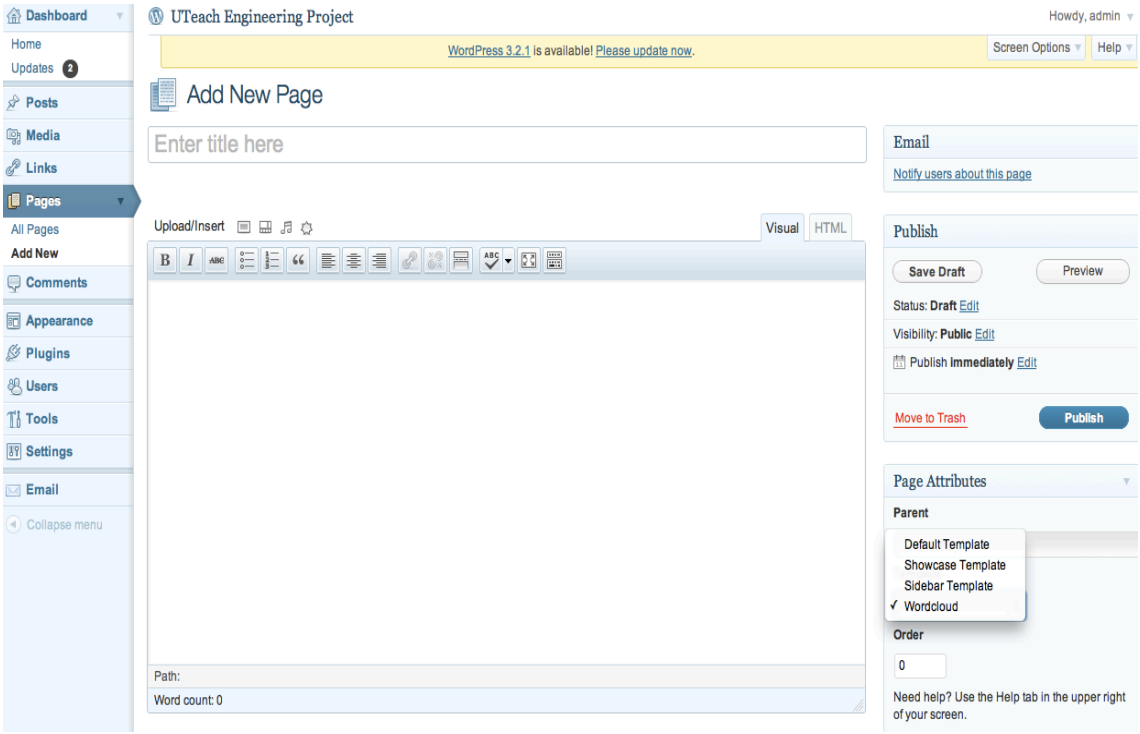

Figure 7: Admin Dashboard layout

The final design of the software hosts a variety of upgradable features that are available to the administrator (teacher). Many of the features are included on the WordPress platform, for example the menu option listed on the left in Figure 7. I have extended the user capabilities to include editing of comments on the front-end since it was mentioned in the feedback. Digital media can be added to the content of any page that is created, a feature that is versatile amongst the different subjects taught at a typical high school. As the teacher creates a new page, they have the option of several templates that allow them to shape the discussion. The Word Cloud template is part of the re-design to this blogging software, along with invisible commenting. In Figure 8, there is a screenshot of the applied plug-ins for the final design. The Capabilities Manager and Front End Users set restrictions on user capabilities within the site.

	Plugin	Description
☐	**Akismet** Activate | Edit | Delete	Used by millions, Akismet is quite possibly the best way in the world to **protect your blog from comment and trackback spam**. It keeps your site protected from spam even while you sleep. To get started: 1) Click the "Activate" link to the left of this description, 2) Sign up for an Akismet API key, and 3) Go to your Akismet configuration page, and save your API key. Version 2.5.3 | By Automattic | Visit plugin site
☑	**Capability Manager** Deactivate | Edit	Manage user capabilities and roles. Version 1.3.2 | By Jordi Canals | Visit plugin site
☑	**Custom Word Cloud** Deactivate | Edit	Creates custom word cloud images based on page content or POST variable named content. Version 0.3 | By Bryan Nielsen
☑	**Email Users** Deactivate | Edit	Allows the site editors to send an e-mail to the blog users. Credits to Catalin Ionescu who gave me some ideas for the plugin and has made a similar plugin. Bug reports and corrections by Cyril Crua, Pokey and Mike Walsh. Version 3.4.1 | By MarvinLabs / Vincent Prat | Visit plugin site
☑	**Front End Users** Deactivate | Edit	Hides the WordPress admin section from specified user roles, allows users to edit their settings from the front-end, and allows for customization of user-specific pages on the front-end. Version 1.0 | By Tom Benner | Visit plugin site
☐	**Hello Dolly** Activate | Edit | Delete	This is not just a plugin, it symbolizes the hope and enthusiasm of an entire generation summed up in two words sung most famously by Louis Armstrong: Hello, Dolly. When activated you will randomly see a lyric from Hello, Dolly in the upper right of your admin screen on every page. Version 1.6 | By Matt Mullenweg | Visit plugin site
☐	**Manage Your Posts Only** Deactivate | Edit	Makes it so normal users can see only their posts and drafts from the manage posts screen. Great for multi-user blogs where you want users to only see posts that they have created. Wordpress already makes it so they cannot edit the posts, but still allows them to see the titles. This can get annoying to find your posts mixed in with thousands of others. Version 0.1 | By Allen Holman | Visit plugin site
☑	**Semi-Private Comments** Deactivate | Edit	Masks comments so that user X can't see comments he didn't write (or that weren't from an admin). Version 1.0.1 | By Cleek | Visit plugin site

Figure 8: WordPress Design Plug-in screenshot

I have defaulted a user's role as contributor, which allows a registered user to send emails, read posts, leave/edit comments, and update profile information. All of these user capabilities are modifiable at the discretion of the instructor. I used the Custom Word Cloud and Semi Private Comments plug-ins to create the Word Cloud template that is visible in Figure 6. The site is hosted on a server in the George I. Sánchez Building at the University of Texas at Austin. It can be located at the URL:

http://all.edb.utexas.edu/noel-wordpress

It was the intent of this report to investigate several objectives:

1. Provide an avenue for students to collaborate democratically and independently.
2. Create a source of researchable data.
3. Accessibility to anyone with Internet access.
4. Could be used to promote critical thinking skills and spark discussion across a variety of disciplines.

I believe that the tool I have designed satisfies the first objective. It was demonstrated in the first product evaluation when the cohort members were asked to comment on several discussion questions. Every registered user left a comment and each was done independently of each other, since the comment threads were invisible. I received a total of 79 comments overall from 41 registered users. The software is linked to a database, so the inputs are logged as entries into that system. Whether the data collected is researchable could be explored at a later date, but is not included in this report. The

information is there, regardless of whether it is mined or not. The third and fourth objectives were both reached when I used the discussion tool in the ESIT and MASEE classrooms. The feedback suggested its potential to be used in many subjects, as well as a formative assessment device.

The re-designed *WordPress* site with the word cloud feature shows promise in data visualization research. Further investigation of the word cloud visualization is needed in order to utilize this tool for educational research. It would be necessary to understand how the function chooses the words from a body of text see how it discriminates between different words as it creates the cloud. In order for a more precise investigatory instrument for research, an accurate account of the word selection, frequency distribution, and quantifiable measures would have to be incorporated into the software. The re-programming of the word cloud plug-in could allow this discussion forum to be used for pedagogical experiments. Pre and post visualizations could be examined for changes in word frequency or quality. The investigator could have experts in appropriate fields assign weights to certain vocabulary, so that visualizations would have some value that could be measured. Overall, this discussion tools satisfies the preliminary objectives set prior to the design, but will continue to be modified as needed.

Chapter 4: Applications to Practice

Developing Engineering Awareness

Having a degree in physics and teaching mathematics in the Austin Independent School District, it was extremely fruitful for me to be a part of engineering education. The word "engineering" is casually used in conversations, with little regard to the practice. I, along with many students, did not understand the engineering process until I spent the last three summers doing the engineering coursework. Now that I have completed the program, I can incorporate my math and physics background with engineering design to create products in a thoughtful way. This knowledge is crucial for STEM education in the high school level because many students will never fully engage in the design process unless it is introduced to them in their high school courses. The engineering design cycles seems applicatory to a variety of disciplines and it is a shame that it is not a part of every pedagogical program. The iteration process in design can be used in anything from writing a novel to building a better alarm clock. Not only did my participation in the MASEE program and the engineering design process prepare me to re-design the *WordPress* software, but it also allowed me to bring engineering to my own students. I have been asked to teach an introductory engineering course at my high school, William B. Travis High School, next year.. I have no doubt that I will have a wealth of resources in professors, curriculum, and knowledge available to me through the MASEE program.

My professional goals are to continue my education by pursuing a doctoral program in Engineering Education. I hope to apply in 2 to 3 years, after practicing my newly developed skills in the classroom. I will take these upcoming years to research schools and programs around the country, while continuing to teach in a high school setting. I also hope to continue to expand my engineering curriculum and UTeach Engineering has been instrumental in doing so. Although, I have yet to teach an engineering course, I can develop an engineering habit of mind by leading the students in activities, which highlights the design process. It is important for me, as a math teacher to incorporate this process in all of my classes to show the relevance between science and mathematics. I feel that I have a unique advantage, being a newcomer to engineering education, especially since it will be a learning experience for the students and myself. In engineering, it is the moments that are not pre-determined that hold the most educational value. I expect to bring these moments to my students.

My re-design of the *WordPress* blogging software was ultimately an exercise in the engineering design cycle. Last fall, we were asked to brainstorm and identify a problem situation. I chose to design a visual discussion forum and developed a list of needs for my classroom for this discussion tool. I created software design flows and mapped out the admin-user hierarchy. Once I created a prototype, I had it evaluated with a group of teachers affiliated with UTeach engineering, where they provided feedback and new ideas. This was the first iteration of the product evaluation, and I have already changed the prototype according to that feedback. My final design reflects changes to the

software related to evaluator input. My final design will grow, therefore, I hesitate to call it my final design. I will continue to iterate the design process until the product reaches optimal effectiveness.

Having completed the MASEE program, I now realize the influence it will have on my classes and teaching style. I have experience and ideas that I can incorporate into my mathematics and future engineering courses. I have met some great teachers that I feel I can freely collaborate with and network. I really enjoyed the mechanics course because of its relevance to math and physics. I can bring aspects of this topic into algebra, calculus, and physics. It is also important to educate students regarding our global struggles with energy consumption. Starting the conversation with reflective thinking about our own energy needs gives opportunities to launch into a variety of topics in STEM education. Participating in the MASEE program has been a pleasant experience over the last three summers.

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Vita

Noel Hector Ramos was born in El Paso, Texas. At the age of six, he moved to Heidelberg, Deutschland, where he spent four years exploring many of the European countries. For the next eight years, he lived and completed his high school education in Kaiserslautern in Rheinland-Pfalz. He returned to the United States in 1998 to study at the University of Texas at Austin. In 2003, he was awarded a B.S. in Computational Physics. In 2004, he entered the UTeach post-baccalaureate program and was certified to teach Math/Physics for 8-12 education two years later. He began teaching mathematics at William B. Travis High School in December of 2006. In 2009, he entered the UTeach Engineering masters program on a fellowship and in 2011, has been awarded a Master's of Arts in Science and Engineering Education.

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