Evaluating the Impact of Interactive Technology in the Classroom on Student's Perception of Learning

CERTI Mini-grant Final Report

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SUMMARY

Workplace requirements continually evolve to keep pace with the developing global market. To meet ever-increasing standards, educational institutions have been investigating methods to prepare students for future employment. Course modifications should be carefully considered to meet the requirements of all stakeholders, including those of the students. The objective of this research was to provide students with a stronger overall learning experience that tailors the teaching methods to a student's individual learning preferences. A comprehensive survey was provided to an undergraduate class at Missouri University of Science and Technology. The survey documented the student's individuality when learning and made note of his or her expectations from the class. After documenting this information, quality function deployment, an organized approach to take the voice of the customer into the design of products and services, was used to modify the course design. The results indicated the implemented techniques and tools were beneficial to the students and helped their comprehension of the course material. The outcome provided students with an overall better learning experience while improving content retention and engagement.

PURPOSE OF THE PROJECT

As technology persistently progresses, the workforce requires employees to continually develop their knowledge and improve their skills. "In a world where advanced knowledge is widespread and low-cost labor is readily available, the advantages of the United States in the marketplace and in science and technology have begun to erode. A comprehensive and coordinated federal effort is urgently needed to bolster competitiveness and pre-eminence of the United States in these areas" (Lantz 2009, 248). There is a need to inspire motivation, self-

directed learning, and critical thinking skills within the classroom to prepare students to remain competitive in today's global market.

Educational institutions have been researching ways to meet this need and incorporate thought-provoking activities into the curriculum for years. Numerous alternatives, including virtual technology and social media, have been used to transform the traditional classroom. Curriculum alternatives that are being applied in various classroom settings were evaluated as potential options to incorporate into an undergraduate engineering management class on quality at Missouri University of Science and Technology (S&T). The alternatives were judged on their ability to meet the student's preferences: multiple intelligences, learning styles, and motivators. This study focused on implementing technology and teaching techniques that would inspire students to achieve high retention and engagement. The research objective was to better understand students' individuality when learning and processing information and to also make note of their expectations from the class. After documenting this information, an organized approach called quality function deployment (QFD) was used to consider class modifications. The desired outcome was to enhance the overall better learning experience, increase content retention, and improve student engagement.

Various techniques have been used to measure intelligence, motivation, and learning styles in an attempt to interpret human differences. Three different survey instruments were used in this research to assess the goals and abilities of the students: 1) theory of multiple intelligences (MI); 2) visual-auditory-kinesthetic (VAK) learning style survey; and 3) motivated strategies for learning questionnaire (MSLQ).

The theory of multiple intelligences defines intelligence as the skills required for a person to gain new knowledge and solve problems beyond the intelligence quotient (IQ). The intelligences

were classified into eight learning styles by Gardner in 1983 as the following: 1) visual–spatial (picture smart); 2) logical–mathematical (logic smart); 3) verbal–linguistic (word smart); 4) auditory–musical (music smart); 5) interpersonal (people smart); 6) bodily–kinesthetic (body smart); 7) naturalistic (nature smart); and 8) intrapersonal (people smart) (Ostwald-Kowald 2015). The VAK learning style questionnaire evaluates a student's learning preferences by asking how he or she would generally behave in different real-life situations (Chapman 2015). VAK is similar to the MI concepts; however, VAK does not overlay the MI model, but rather provides a different perspective for explaining a person's dominant thinking and learning preference (Chapman 2015). The MSLQ was developed to measure motivational factors in college students to assist in the selection of different learning strategies and their use in college courses (Pintrich et al. 1991). The MSLQ contains 81 questions and is divided into two main categories: motivation and learning strategies. The motivation category contains 31 questions and is divided into three sections, which evaluate students' goals and value beliefs for a course, their beliefs about their own skills to succeed within a course, and their anxiety with regard to tests in a course. The learning strategies category contains 31 questions to evaluate the students' meta-cognitive and cognitive strategies as well as 19 questions in order to evaluate the students' resource management.

In an effort to improve the quality of education, QFD was used in this study for the course redesign. The voice of the customer (VOC) is determined using an integrated survey comprising a combination of these three well-known existing surveys (MI, VAK, and MSLQ). These surveys were specifically selected based on their ability to capture student learning styles, learning preferences, and motivation. An analysis of existing teaching techniques and tools was conducted to determine the best practices for course implementation. QFD provides a structured

approach to evaluating which tools will best meet customer needs given the allotted timeline and budget. To accomplish this goal, the standard QFD process was expanded to seven steps to complete the initial research pilot study.

The following section presents the research methodology for evaluating student learning styles and how the subsequent curriculum alternatives were selected. Then the results of implementing the proposed methodology are presented. Finally, discussion and recommendations based on these results are provided in the conclusion.

LITERATURE REVIEW

Advances in modern technology aid in the development of new educational tools to enhance the extensive value of interactive education and focus on motivational factors. This research focuses on three educational practices: 1) the use of surveys to assess learning styles and perceived motivation; 2) the implementation of technology and techniques to support student motivation; and 3) the application of QFD in education. The objective of the literature review was to evaluate current research studies related to available teaching practices and course improvement applications.

Assessing Learning Styles and Motivation

The use of surveys, interviews, and small group discussions provides a baseline for understanding individual student learning styles. According to Gardner, “No longer is the purpose of education simply to pick out those students who are intelligent, on one or another definition, and give them special access to higher education. Rather, the purpose of education now is to educate an entire population, for we cannot afford to waste any minds” (Gardner 2006, 238). Campbell (1997) discusses the applications of MI across a variety of curriculums, spanning

from liberal arts to mathematics and science. MI can influence the design and implementation of a range of curriculums within elementary, high school, and college education. Wares (2013) demonstrated how Gardner's theory of multiple intelligences could be applied in mathematics classrooms by teaching students in a broader manner to capitalize on an individual's strengths and balance his or her weaknesses in learning.

The three learning styles assessed in the VAK learning style questionnaire are visual, auditory, and kinesthetic (Chapman 2015). Vaishnav (2013) used the VAK survey to determine the prevalent learning style among secondary school students. The results of the study found that kinesthetic learning was more common within this class of students than visual and auditory learning. Vaishnav (2013) also found a positive high correlation between kinesthetic learning and the academic achievement of the students.

In 2012, Taylor performed a reliability study on the MSLQ to determine potential sources of measurement error within studies using these scales. According to Taylor, "Overall, results of reliability generalization studies for both the motivation and learning strategies sections of the MSLQ demonstrate that the MSLQ can be used across a variety of different samples with reasonable confidence for obtaining generally reliable scores" (2012, ii). McClendon (1996) performed a similar study at the University of Akron to estimate the validity of the MSLQ within an open admissions university.

Implementation of Technology and Techniques

Applications involving virtual technology and flipped classrooms are examples of teaching techniques that are increasing student enthusiasm. In a study by Martin et al. (2011), students watched a prerecorded lecture before each class period. Classroom time was then used to help

the students develop a better understanding of the material before completing the homework. Similarly, Chen and Chen (2014) proposed a learning system using flipped classrooms that allowed students to interact with the teacher and learn the material on a deeper level. In addition, Dillon and Stolk (2012) found that the type of motivation students receive during their education will frame their academic engagement, performance, and satisfaction. In a study by Harding et al. (2007), project-based education encourages students to study as a means of furthering their personal growth instead of influencing grade-oriented motivations. Improving motivation within the classroom improves academic performance but also enhances the overall learning experience (Cudney et al. 2011).

Quality Function Deployment in Education

QFD was selected for this research to help determine which emerging teaching practices would be most effective when incorporated into course curriculums. This method was intended to give product or service developers an orderly method for incorporating the VOC into product design. Details and guidance of modern QFD methods and tools can be found in ISO 16355. The classic QFD process may include using one or more matrices, which are called quality tables (Ficalora and Cohen 2010). The matrix diagrams show information about how well expectations are being met. They can also show resources that exist to better meet those expectations (Singh, Elrod, and Cudney 2012).

Data collected from the students regarding motivation and learning preferences are compared with the curriculum capabilities. Since a large range of educational tools are becoming available, the house of quality (HOQ) helps narrow down the options and focus on the tools that will have the largest impact on meeting students' needs. With its roots planted in industrial sectors, QFD

has made its way into and found acceptance in education. These applications range from the redesign of departmental operations to textbook selection.

Mazur (1996) used QFD to design a course curriculum and Web-based learning for a course in total quality management. Technical employer needs were used to prioritize the content of the course, and student needs were used to design the websites for each lecture. Yearly reviews fine-tuned both sets of matrices as professional and student needs changed in priority. Competitive assessments were performed against other college elective courses for the course redesign, which led to an enrollment increase from 12 to 130 students in one year.

Chan and Mazur (2010) used newly hired graduates to act as proxies between common job tasks for new employees in the Chinese textile industry. This focused the curriculum design on job skills that would be needed during the first year of work after graduation. In a similar study, Liu et al. (2012) used QFD in industrial design education to help align the competencies and abilities of graduates with the ever-changing professional field requirements. This process allowed researchers to determine which competencies should be cultivated. Proficiencies required in the field were identified and ranked by importance. Using these proficiencies, curriculums could be developed that would address the needs of the industry. Subjects and courses could then be recommended to prepare students for their careers after graduation. Ultimately, QFD was used to help close the gap between industry and education.

Muda and Roji (2013) used QFD to determine what learning outcomes should have the highest priorities in the School of Mathematical Sciences. For the purposes of this study, the students were the customers and their needs were input into the HOQ as the customer needs. The HOQ was employed to take the voice of the student and determine how effective the existing program was at preparing students for the working environment they would experience after

graduation. The learning outcomes were prioritized and the skills that were necessary and should be emphasized were determined. The results of the study were used to modify the curriculum to ensure that the skills required could be incorporated into the industrial training course. In a similar study, Louhapensang and Seviset (2014) used QFD to design an educational program in industrial education, and evaluate the student's learning and satisfaction. The research found that students who participated in a program developed using QFD principles had higher achievement scores than students who participated in traditional classrooms.

QFD has many proven benefits, such as improving the understanding of customer needs, decreasing late changes in development, reducing implementation problems, improving quality, and increasing customer satisfaction. Therefore, QFD was selected as the approach for redesigning this course.

METHODOLOGY

The main focus of QFD is on evaluation, timing, and resource commitment (Lockamy and Khurana 1995). Ficalora and Cohen (2010) explain that QFD utilizes the following four phases: phase 1: product planning; phase 2: product design; phase 3: process planning; and phase 4: process control.

The four phases of QFD are used to frame the outline of this study. However, the phases were expanded from four phases (beginning with phase 1) to seven phases (beginning with phase 0) in an effort to make each phase more meaningful and manageable in an educational setting. The additional phases provided the case study participants with the opportunity to thoroughly visualize the project progression, provide timely feedback, and anticipate challenges during the course redesign. The additional phases acted as guideposts to direct the study by outlining the

distinct activities that should be performed in sequence. The proposed methodology follows this progression: phase 0: process outline phase; phase 1: product concept planning phase; phase 2: product specification phase; phase 3: parts development phase; phase 4: implementation phase; phase 5: acceptance testing phase; and phase 6: recalibration phase. Each phase is composed of subdeliverables, as illustrated in Figure 1.

RESULTS

The proposed methodology was applied in an undergraduate core quality course in the Engineering Management Department. As a core course, the typical enrollment is approximately 45 students, which consists of mainly juniors and seniors, every spring and fall semester. This course was selected due to its large class size and frequent offering.

Phase 0: Process Outline

The initial phase is used to organize the resources required to meet the objectives. This step provides an opportunity to evaluate the current curriculum and establish a baseline. Within this phase, the significant customers were identified, stakeholder alignment was achieved, and objectives were identified.

At the beginning of the study, the syllabus included traditional lectures, homework problems, tests, hands-on activities, a group project, a group report, and a group presentation. Each method was paired with the learning style that would find it the most appealing. The results can be viewed in Table 1.

Phase 1: Product Concept Planning

The purpose of this phase is to identify student needs. After initially planning the QFD progression, the subsequent step was to collect data to define the VOC. A comprehensive survey was distributed at the beginning of a semester to collect data from the undergraduate students. The results were analyzed to determine the perceived intelligence, learning preferences, and motivation of each individual.

The survey included five sections: 1) demographic questions; 2) self-evaluation and learning preferences questions; 3) theory of multiple intelligences; 4) VAK learning style; and 5) MSLQ. The initial survey was based on a five-point Likert scale. The rating consisted of the following categories: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, and (1) strongly disagree. The data collected remained anonymous for the 41 students surveyed to ensure that the students provided candid feedback about their learning experience and style. The results obtained from this 63-question survey were used to form the HOQ. Since a five-point Likert scale uses ordinal scale values, the data were converted later into ratio scale values using the analytic hierarchy process (AHP) for the QFD matrices. Ratio scales are necessary, because unlike ordinal scales, they support mathematical functions such as addition, subtraction, multiplication, and division (Saaty 1990).

Section 1: Demographic questions. The first set of questions within the survey contained demographic questions on major, work experience, class standing, and gender (see Appendix A). The demographic questions also inquired about the student's reason for taking the class. This information was captured since it provides initial motivation for taking the course and may indicate reasons for possible fluctuations in motivation throughout the semester. From the analysis shown in Table 2, 75.9 percent of the quality class enrolled because it is a required

course within their major curriculum, 74.1 percent agreed that the content would improve their career prospects, and 48.1 percent agreed the content seemed interesting. These results show that even though students are primarily taking the course to fulfill degree requirements, there are additional positive motivators for taking the class.

Section 2: Self-evaluation and learning preferences. The second portion of the survey inquired about students' preferred classroom activities. The students were given four teaching methods and were asked to provide constructive feedback from their previous experiences. The four techniques each student ranked were hands-on exercises, traditional lectures, independent learning, and group activities, as shown in Table 3. These four options were selected because they could be found in traditional classes at Missouri S&T. Therefore, the students were familiar with each practice and could identify which they found to be the most useful. The results indicated that this undergraduate class of engineers preferred hands-on exercises (75.55 percent strongly agree and agreed). The students rated the opportunity to learn through group activities and traditional lectures similarly with scores of 57.77 percent and 55.55 percent, respectively. The question also revealed that the students ranked independent learning the lowest (42.23 percent) of the four options.

The students were also asked six open-ended questions to inquire about their self-perception: 1) What would make this class interesting? 2) What are your career goals? 3) What are your three biggest strengths? 4) What are your three biggest weaknesses? 5) What three things can be done to help you succeed? Since this is a pilot study, the responses were analyzed through an affinity diagram and a focus group consisting of student volunteers in the engineering management undergraduate curriculum, as shown in Figure 2. The surveys are being distributed

each semester to capture a broader perspective, and advanced analysis of the taxonomy is planned once a larger sample size is reached.

Section 3: Theory of multiple intelligences. The third portion of the survey investigated the combination of multiple intelligences. In order to understand the learning style of each student, the students were asked to rank how they affiliated with eight different statements. These statements were descriptions of each of the eight intelligences determined by Gardner. The students' responses indicated the highest learning preference for the class.

From the data collected, the top four preferred learning preferences in descending order are: verbal–linguistic (86.95 percent of students strongly agree or agree); interpersonal (78.26 percent); visual–spatial (73.91 percent); and logical–mathematical (73.91 percent), as shown in Appendix B. On the contrary, auditory–musical (13.05 percent) was the least preferred method of learning. The high standard deviation in each of the data areas indicates the data are spread out over a wide range of values. It can be concluded that the students do not have one dominant method for learning new information, but the class makes use of multiple intelligences. The traditional course curriculum incorporated lectures, homework, tests, and group projects. By incorporating additional emerging teaching practices that cover various learning styles, the students can reach greater potential by utilizing multiple learning combinations.

Section 4: VAK learning style. The fourth instrument used to assess the undergraduate students is the VAK learning style questionnaire. This portion of the survey consisted of 13 questions that evaluated students' learning preferences by asking how they would generally behave in different real-life situations. The responses for each question are provided in Table 4.

To determine the learning preference, the averages were calculated. The results indicated that the largest percentage of students are visual and kinesthetic learners. Table 5 shows that 45.30 percent of students are kinesthetic learners, 34.87 percent are visual learners, and 19.83 percent are auditory learners.

Section 5: Motivated strategies for learning. The MSLQ is an instrument that is self-reported. It is used in this application to measure the motivation factors of the undergraduate students. The MSLQ contains 81 questions and is divided into two main categories: motivation and learning strategies. The motivation category contains 31 questions and is divided into three sections. The sections evaluate students' goals and value beliefs for a course, their beliefs about their own skills to succeed within a course, and also their anxiety with regard to tests in a course. The learning strategies category contains 31 questions in order to evaluate the students' meta-cognitive and cognitive strategies, as well as 19 questions in order to evaluate the students' resource management. The different portions within the MSLQ can be used together or individually. Overall, the instrument is designed to be segmental to meet the needs of the researcher or instructor. For this reason, only a portion of the MSLQ survey was used in this data collection.

For this research, 23 questions were selected from the original 81 question MSLQ based on their relevance to the research. This specific mixture of questions was selected to focus on the

student's value components, expectancy components, cognitive and metacognitive strategies, and resource management. More specifically, 10 subcategories were evaluated, and the results are provided in Appendix C. A description of each subcategory is provided next.

- Intrinsic goal orientation: "Goal orientation refers to why a learner engages in an academic task. Learners with intrinsic goal orientations possess real interest in the learning process and aspire to increase their knowledge of the subject matter" (Taylor 2012, 4).
- Extrinsic goal orientation: "Extrinsic goal orientation describes learner's interest in engaging in a task due to causes outside the individual, such as to demonstrate their ability, to outperform others, and/or to receive some external benefit such as getting good grades, recognition, or a reward" (Taylor 2012, 4).
- Task value: "Task value refers to an individual's appreciation for a task's relevance. Task value relates to the degree of personal interest a learner has for a given task and includes beliefs about utility, relevance, and importance" (Taylor 2012, 5).
- Self-efficacy: "In general, self-efficacy refers to a person's judgments of their capabilities to perform an action successfully. Academic self-efficacy applies this general definition of efficacy to one's internal belief for executing and succeeding in academic tasks at designated success levels" (Taylor 2012, 5).
- Elaboration: "Elaboration is a learning strategy in which a learner paraphrases or summarizes learning material to help the individual understand the material. This strategy is intended to build internal connections between one's prior knowledge and the new material. This strategy is considered a higher-order learning skill because the strategy allows learners to store learned information into long-term memory" (Taylor 2012, 5).

- Metacognitive self-regulation: “Metacognition refers to how one thinks about thinking; it encompasses methods of a learner’s awareness and knowledge of their cognitive processes” (Taylor 2012, 6).
- Time and study environment: “Time and study management involves choosing environments that are conducive to learning (that is, free from distractions) and effectively scheduling, planning, and managing one’s study time” (Taylor 2012, 6).
- Effort regulation: “Effort regulation enhances the ability of the learner to handle setbacks and failures within the learning process by correctly allocating resources and appropriate effort to increase more successful learning in the future” (Taylor 2012, 6).
- Peer learning: “Peer learning involves using peers (friends, classmates, and so on) to collaboratively understand course material or information to be taught” (Taylor 2012, 6).
- Help seeking: “Help seeking can be an adaptive learning strategy that allows a learner to optimize learning by seeking help from local resources such as instructors, peers, tutors, or even additional textbooks” (Taylor 2012, 7).

Instead of following the seven-point Likert scale used in the original MSLQ study, the undergraduate quality class students continued using the five-point Likert scale to maintain consistency throughout the survey. The results for each question are provided in Appendix C.

The final scores are constructed by taking the mean of all the questions within each subcategory. For instance, intrinsic goal orientation has four questions. The class score for intrinsic goal orientation would be calculated by summing the four items and taking the average. The question marked as “reversed” under “Help Seeking” is negatively worded and was inverted before calculating the final score. The averages are provided in Table 6.

The analysis indicates the students have a very high task value (100 percent agree), have

devoted time and dedicated study environment (92.68 percent), have self-efficacy (89.03 percent), and use elaboration (82.93 percent). Some of the less prevalent student strategies included extrinsic goal orientation (62.60 percent), help seeking (60.98 percent), intrinsic goal orientation (56.71 percent), peer learning (53.66 percent), effort regulation (48.40 percent), and metacognitive self-regulation (26.83 percent).

SURVEY CONCLUSIONS

By combining questions from the theory of multiple intelligences survey, VAK learning style survey, and MSLQ, a detailed perspective of the students' perceived intelligence, learning preferences, and motivation were gained. The survey results indicated that the students appreciated hands-on activities, group projects, and traditional lectures in previous classes. The open-ended questions reiterated their interest by requesting hands-on projects and real-world scenarios that would tie the course material into their future careers. The students also showed a great concern for improving their future career prospects and being marketable by improving their grade point average (GPA). The students demonstrated strengths including intelligence and leadership skills, but activities were required to maintain their focus and inspire them to learn more about the topics being presented. The students also reported struggling with perfectionism. The MSLQ survey confirmed this observation by having low scores within the effort regulation (only 48.40 percent agreed that they could handle setback and failures).

The multiple intelligences survey concluded that verbal–linguistic, interpersonal, logical–mathematical, and visual–spatial learning methods should be considered while incorporating new activities into the curriculum. Likewise, the VAK survey questionnaire advised activities that tailored toward visual and kinesthetic learners. It is important to note that incorporating specific

activities that assist visual and kinesthetic learners decreased the percent of teaching methods and techniques that would cater to the auditory learner. This information was used in the HOQ to rank these decisions to provide the most appropriate solution based on students' needs in the second phase of the process.

Phase 2: Product Specification Phase

The purpose of this phase was to identify teaching methods and educational requirements. The sequence for constructing an HOQ began with constructing the list of customer needs and benefits from the initial survey given to the class. Data collected from the learning style preference survey was used to determine the customer needs as well as their weight/importance. The emerging teaching tools identified in the literature review were evaluated as possibilities to be incorporated into the course.

After creating lists of the student's learning style, the university requirements, and optional teaching tools/techniques, a focus group was assembled to build the HOQ. The focus group consisted of six students from different majors (including mechanical engineering, aerospace engineering, and engineering management) and degree progression (freshman, sophomore, junior, and senior). The group was designed to be diverse to provide different perspectives when determining correlations and weighting. The focus group met for two hours and members were asked open-ended questions regarding their learning styles, classroom teaching preferences, and course needs and expectations. The outcome of this discussion can be found in Figure 3.

Phase 3: Parts Development (Tool Selection)

Based on the results of the HOQ, three tools were incorporated into the course syllabus based on continued discussions with the focus group. The tools implemented into the curriculum were TED-Ed lessons (rank order 15), Quizlet (9), and Scoop.it (4), which were demonstrated to the focus group. These items were selected based on meeting the customers' needs as prioritized in the survey results. These tools also had lower difficulty levels for implementation and could be incorporated into the class curriculum in a succinct timeframe. In addition, these tools incorporated aspects of items such as social media (Scoop.it), field experts (TED-Ed lessons), blended/hybrid delivery (TED-Ed lessons), and games/competition (Quizlet), thereby meeting multiple student needs.

- **Tool 1: TED - Ed lessons.** TED-Ed is an educational website where teachers can create or share educational lessons with students. This online website also encourages collaboration among educators to create customized lessons. Users can then distribute the lessons, publically or privately, and track the impact it has on the individual student. This tool catered to the visual – spatial, auditory–musical, and interpersonal individuals. Figure 4 shows an example of a TED-Ed lesson provided in the undergraduate quality class (http://ed.ted.com/on/4tiYu2Gv). Students were able to receive supplementary explanations and examples of the course material by initially viewing a video. Students could explore the subject further by answering questions within the "Think" section, explore additional resources within the "Dig Deeper" section, or converse with classmates within the "Discuss" section.
- **Tool 2: Quizlet.** Quizlet is a website that provides learning tools for students. These learning tools include: 1) flashcards: review the material by shuffling/randomizing; 2) learn mode: track correct/incorrect answers to focus study time on ones the student

missed; 3) speller mode: challenge the student to type the auditory message they receive; 4) test mode: randomly generates tests based on the student's flashcard set; 5) scatter: student races against the clock by dragging and matching terms with correlating definition; and 6) space race: the student types in the answer as the term/definition scrolls across the screen. Quizlet is tailored for the logical – mathematical and bodily – kinesthetic learners. This tool helped the students master the course concepts and prepare for exams by playing games. Figure 5 shows an example of the "Scatter" game (https://quizlet.com/class/1424580/). The terms and definitions have been randomly dispersed across the screen and the student has to classify the correct term and definition. The continual movement holds the attention of kinesthetic learners and encourages them to continue participating.

- **Tool 3: Scoop.it.** Scoop.it combines the benefits of a social networking site with educational materials. This particular tool allows students or teachers to create content based on topics they select, and then share thoughts on the content. Sharing thoughts and material allows individuals to connect based on similar interests. Scoop.it allows teachers to share real-world applications of the learning material and connect the students with subject-matter resources. Scoop.it provides students with the ability to relate the class material to real-world applications. These articles also offer students the opportunity to connect course principles to their future career interests. The intent was to make the information meaningful to the students and inspire continual self-directed learning on the topics. Figure 6 shows an example of the Scoop.it page used in the quality class (http://www.scoop.it/t/six-sigma-by-beth-cudney).

The tools selected incorporated many of the customer requirements into the course. These

three tools focused on the student's preferred methods for learning, and provided more opportunities for him or her to learn the material. Even though these tools highlighted the strengths of the visual and kinesthetic learner, they did not detract from the auditory learner. Instead, the tools provided additional group interaction through the discussion board (see Figure 3, column 6), games (column 7), and test preparation guides (column 27).

Phase 4: Implementation Phase

After using the HOQ to select the learning instruments, preparation began to modify the tools to fit the class application. Within the case study, the use of the new tools was optional but highly recommended. To motivate the students to try the tools, one to two test questions were taken from the TED-Ed lessons or Quizlet offered within the section.

Periodic checkpoints were conducted throughout the semester to monitor the student's enthusiasm and use of the tools. These checkpoints included looking over the participation within each program and having informal conversations with the students. The intentional checkpoints provided an opportunity for students to ask for clarification.

Phase 5: Acceptance Testing Phase

After the new learning tools were incorporated, a survey was provided to the students at the end of the semester. The purpose of the end-of-semester survey was to collect feedback from the students regarding their experience with Quizlet, Scoop.it, video solutions, and TED-Ed lessons. The survey inquired about the students' use of the tool (see Table 7), questioned if the tool was helpful in their studies (see Table 8), and asked if the students would recommend this tool for the next semester.

The survey results reported 45.45 percent of students used Quizlet, 47.83 percent used

Scoop.it, 69.76 percent used the video solutions, and 50 percent used the TED-Ed lessons either daily or weekly. These results indicate a frequent use of each of the tools. The students also appraised the helpfulness of each tool and specified if they would recommend this tool for future classes. The results to both questions can be viewed in Table 8.

From the results, students found the video solutions and TED-Ed lessons to be the most helpful tools with 73.91 percent and 63.64 percent, respectively, in agreement. The students also agreed that Quizlet and Scoop.it were helpful at 56.82 percent and 56.52 percent, respectively. Furthermore, the students advocated using the tools in the next class with 73.92 percent in agreement for the video solutions, 65.91 percent in agreement for Quizlet, 58.70 percent in agreement for Scoop.it, and 56.82 percent in agreement for the TED-Ed lessons.

The final survey also inquired about the group project and gave students the opportunity to provide open feedback on their experience. The application of project-based learning was previously analyzed through an end-of-course survey (Cudney and Kanigolla 2014; Kanigolla et al. 2014). Select questions from the previous survey were employed for this final survey. Table 9 provides statistical results of the students' view of the group project. Overall, the students had a very positive experience and offered suggestions for making enhancements for the next semester. One student commented: "I thought the project was beneficial to my learning but there was not very much structure in what was expected of us. I would consider maybe more structure in the group project so we fully understand what needs to be done." The periodic checkpoints and anonymous feedback provided through the survey permitted the opportunity to make even the existing course tools stronger.

Phase 6: Recalibration Phase

Feedback was gathered from the students about eight additional teaching tools and techniques (see Table 10). Their opinions were used to assemble a schedule for incorporating more tools into the future curriculum, as shown in Table 10.

The students indicated enthusiasm for making a certificate in Six Sigma available (89.47 percent agreed), coordinating a company/site visit (76.32 percent agreed), and providing additional video solutions (76.31 percent agreed). This feedback was taken into consideration, and further curriculum adjustments are currently in progress. Due to the positive feedback from the initial surveys, these surveys are now distributed every semester in the course to monitor the implementation and adjust accordingly. It is important to frequently gain the VOC. Based on this feedback, the instructor was able to develop a partnership with the Institute of Industrial and Systems Engineering (IISE) to offer a Six Sigma Green Belt certification starting in December 2015. The certification was well received by the students and will be offered at the end of each semester.

CONCLUSIONS

The quality of education was improved by using QFD to redesign the undergraduate course. The survey results suggest that introducing new learning tools into the curriculum was beneficial to the students, and there were no negative impacts observed on the student's education. Students felt the tools were relevant when learning the course concepts and would recommend using them in future classes.

Based on the final survey results, the quantity of Scoop.it and Quizlet used within the class curriculum will remain the same. Since the students had a positive response to the TED-Ed lessons, additional videos will be incorporated into the class. Furthermore, alterations will be made to the group project outline to offer clarity. Students will be provided with a table to use as

a checklist and guide for completing the project. The table will supply a list of all the quality topics taught in the class. The students will be prompted to justify if the quality tool should be used in their project, how they will use it, and what the data results tell them. This method acts as an outline to guide the student's thought process and progression through the project.

The VOC was clearly defined using the integrated survey comprising theory of multiple intelligences, VAK learning questionnaire, and MSLQ. The HOQ translated the student's needs into development goals and technical capabilities. This method was a proactive approach to education development and maintained an intense customer focus. The curriculum and student's interest were enhanced when suitable technology was applied and clear personal feedback was permitted. This was possible by gaining the VOC to determine what met their learning styles, motivations, and preferences. Instructors are then able to map appropriate technology to meet these needs and expectations.

Future Research and Implications

Future semesters will continue to participate in a beginning and end-of-semester survey to create a longitude trend that can be used in future studies. The current analysis was performed using anonymous surveys, but future studies could benefit from using analytics software. The software would correlate the student's grade with his or her learning preference and use of the tools.

In addition, the demographic background of the students surveyed within the case study is almost homogeneous. A majority of the students were seniors majoring in engineering management. Future studies could extend the survey into additional undergraduate and graduate classes. The learning styles and motivation factors may change between semesters and between degree programs.

The QFD analysis will be re-examined every two to three semesters to compare student learning preference trends with evolving teaching methods.

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Appendix A: Student demographics for the Quality Course

Degree Major (first major)	**Percent Response**
Engineering management	87.8%
Mechanical engineering	4.9%
Civil engineering	4.9%
Other	2.4%
Work Experience	**Percent Response**
One internship	20.6%
One co-op	11.8%
More than one internship	20.6%
More than one co-op	11.8%
0 – 1 year	32.4%
2 – 4 years	2.9%
Class Level	**Percent Response**
Freshman	2.4%
Sophomore	0.0%
Junior	22.0%
Senior	75.6%
Graduate	0.0%
Gender	**Percent Response**
Male	92.7%
Female	7.3%

Appendix B: Multiple Intelligence Questions

Output	Questions	Percent				
		Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**
Verbal – Linguistic (word smart)	I learn through reading, writing, listening, and speaking. I absorb information by engaging in reading materials and by discussing and debating ideas.	34.78	52.17	13.04	0.00	0.00
Logical - Mathematical (logic smart)	I learn by classifying, categorizing, and thinking abstractly about patterns, relationships, and numbers.	39.13	34.78	17.39	8.70	0.00
Visual - Spatial (picture smart)	I learn by drawing or visualizing things using the mind's eye. I learn the most from pictures, diagrams, and other visual aids.	43.48	30.43	26.09	0.00	0.00
Auditory - Musical (music smart)	I learn by using rhythm or melody, especially by singing or listening to music.	8.70	4.35	30.43	34.78	21.74
Bodily - Kinesthetic (Body Smart)	I learn through touch and movement. I am best at processing information by standing up and moving rather than sitting still.	4.35	13.04	39.13	39.13	4.35
Interpersonal (people smart)	I learn through relating to others by sharing, comparing, and cooperating.	17.39	60.87	17.39	4.35	0.00
Intrapersonal (self-smart)	I learn by working alone and setting individual goals. I consider myself independent and organized.	21.74	43.48	26.09	4.35	4.35
Naturalistic (nature smart)	I learn best by working with nature. I enjoy learning about living things and natural events.	17.39	13.04	47.83	21.74	0.00

Appendix C: MSLQ Survey Results

Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
INTRINSIC GOAL ORIENTATION					
In a class like this, I prefer course material that really challenges me so I can learn new things.	7.32	39.02	43.90	7.32	2.44
In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.	24.39	60.98	14.63	0.00	0.00
The most satisfying thing for me in this course will be understanding the content as thoroughly as possible.	7.32	46.34	39.02	7.32	0.00
When I have the opportunity, I choose course assignments I can learn from even if they don't guarantee a good grade.	7.32	34.15	41.46	14.63	2.44
Getting a good grade in this class is the most satisfying thing for me right now.	19.51	46.34	14.63	19.51	0.00
The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.	17.07	39.02	17.07	19.51	7.32
I want to do well in this class because it is important to show my ability to my family, friends, employer or others.	26.83	39.02	21.95	12.20	0.00
I think the course material in this class is useful for me to learn.	46.34	53.66	0.00	0.00	0.00
I believe I will receive an excellent grade in this class.	24.39	65.85	9.76	0.00	0.00
I'm certain I can understand the most difficult material presented in the readings for this course.	29.27	48.78	19.51	2.44	0.00
I'm confident I can learn the basic concepts taught in this course.	70.73	29.27	0.00	0.00	0.00
I'm confident I can understand the most complex material presented by the instructor in this course.	24.39	63.41	12.20	0.00	0.00
I try to relate ideas in this subject to those in other courses whenever possible.	26.83	56.10	17.07	0.00	0.00
When reading for a course, I make up questions to help focus my reading.	4.88	21.95	41.46	21.95	9.76
I attend class regularly.	53.66	39.02	7.32	0.00	0.00
When course work is difficult I give up or only study the easy parts (REVERSED).	2.44	4.88	7.32	65.85	19.51
Even when the course materials are dull and uninteresting, I manage to keep working until I finish.	21.05	68.42	10.53	0.00	0.00
When studying for this course, I often try to explain the material to a classmate or a friend.	14.63	43.90	31.71	9.76	0.00
I try to work with other students from this class to complete course assignments.	17.07	56.10	19.51	4.88	2.44
When studying, I often set aside time to discuss the course material with a group of students from the class.	7.32	21.95	43.90	21.95	4.88
Even if I have trouble learning the material for a class, I try to do the work on my own without help from anyone (REVERSED).	7.32	46.34	19.51	17.07	9.76
I ask the instructor to clarify concepts I don't understand well.	17.07	58.54	14.63	9.76	0.00
When I can't understand the material in a course, I ask another student in the class for help.	21.95	58.54	7.32	7.32	4.88

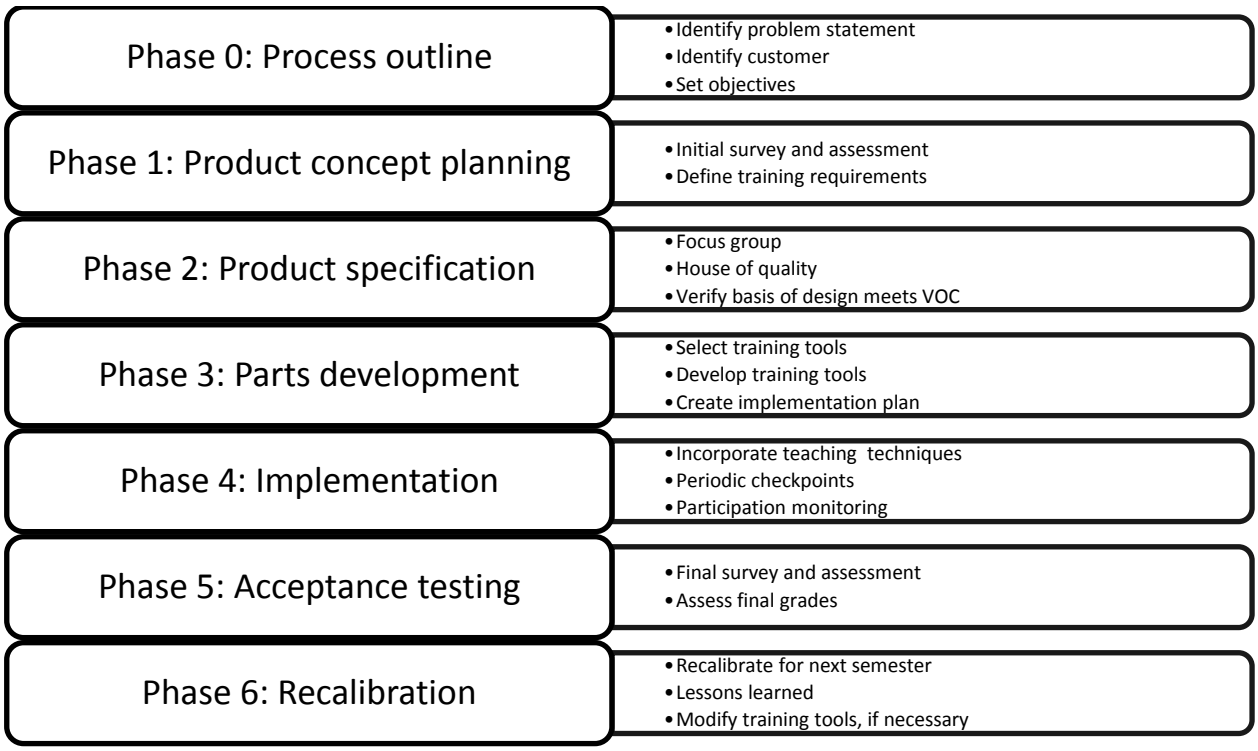

Figure 1 Course redesign phases

Table 1 Initial class assessment

Teaching Method	Learning Style
Traditional lectures	Auditory-Musical Visual - Spatial Verbal - Linguistic
Homework problems	Logical - Mathematical
Tests (interpret situation)	Real-world applications
Hands-on activities	Bodily – Kinesthetic, Logical – Mathematical
Group project	Verbal – Linguistic, Interpersonal
Group report	Verbal – Linguistic, Interpersonal
Group presentation	Verbal – Linguistic, Interpersonal

Table 2 Students percentage responses for survey in quality course

Reason for Taking Class	Percent response (%)
Fulfills major/program requirement	75.9
Will improve career prospects	74.1
Content seems interesting	48.1
Material will be useful to me in other courses	38.9
Will help improve my academic skills	35.2
Fits into my schedule	25.9
Easy elective	1.9
Was recommended by a friend	1.9

Table 3 Student learning preference

I prefer to learn using the following practices:	Percent					Standard Deviation	Variance
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Hands-on exercises	51.11	24.44	24.44	0.00	0.00	0.84	0.70
Traditional lectures	11.11	44.44	35.56	8.89	0.00	0.81	0.66
Independent learning	15.56	26.67	35.56	15.56	6.67	1.12	1.26
Group activities	24.44	33.33	33.33	6.67	2.22	0.99	0.98

Table 4 Student response to VAK questionnaire

#	Question	Visual Learner Response	Visual Learner Percent Response	Auditory Learner Response	Auditory Learner Percent Response	Kinesthetic Learner Response	Kinesthetic Learner Percent Response	Standard Deviation	Variance
1	Operate new equipment	Read instructions	28.89%	Listen to explanation	24.44%	Try it on my own	46.67%	0.86	0.74
2	Travel directions	Look at a map	73.33%	Ask for spoken directions	15.56%	Follow your instinct, and possibly use a compass	11.11%	0.68	0.47
3	Cook a new dish	Follow a recipe	57.78%	Call a friend for explanation	4.44%	Follow your instinct, tasting as you cook	37.78%	0.97	0.94
4	Teach someone something	Write instructions	2.22%	Explain verbally	24.44%	Demonstrate and let them try it on their own	73.33%	0.51	0.26
5	You are most likely to say	Show me	48.89%	Tell me	13.33%	Let me try	37.78%	0.93	0.87
6	You are most likely to say	Watch how I do it	35.56%	Listen to me explain	37.78%	Try it on your own	26.67%	0.79	0.63
7	You are most likely to say	I see what you mean	53.33%	I hear what you are saying	11.11%	I know how you feel	35.56%	0.94	0.88
8	Faulty goods	Write a letter	2.22%	Call in your complaint	13.33%	Send or take it back to the store	84.44%	0.44	0.19
9	Leisure	Sight seeing	17.78%	Music and conversation	26.67%	Playing a sport or DIY	55.56%	0.78	0.6
10	You would prefer	Books	15.56%	Music	28.89%	Gadgets	55.56%	0.75	0.56
11	Shopping	Browse	68.89%	Discuss with clerk	4.44%	Try on options	26.67%	0.89	0.79
12	Selecting a vacation	Read a brochure	13.33%	Listen to recommendations	44.44%	Imagine the experience	42.22%	0.69	0.48
13	Buying a new car	Read the reviews	35.56%	Receive recommendations from friends	8.89%	Test-drive all options	55.56%	0.94	0.89

Figure 2 Affinity diagram of most frequent student responses to open-ended questions

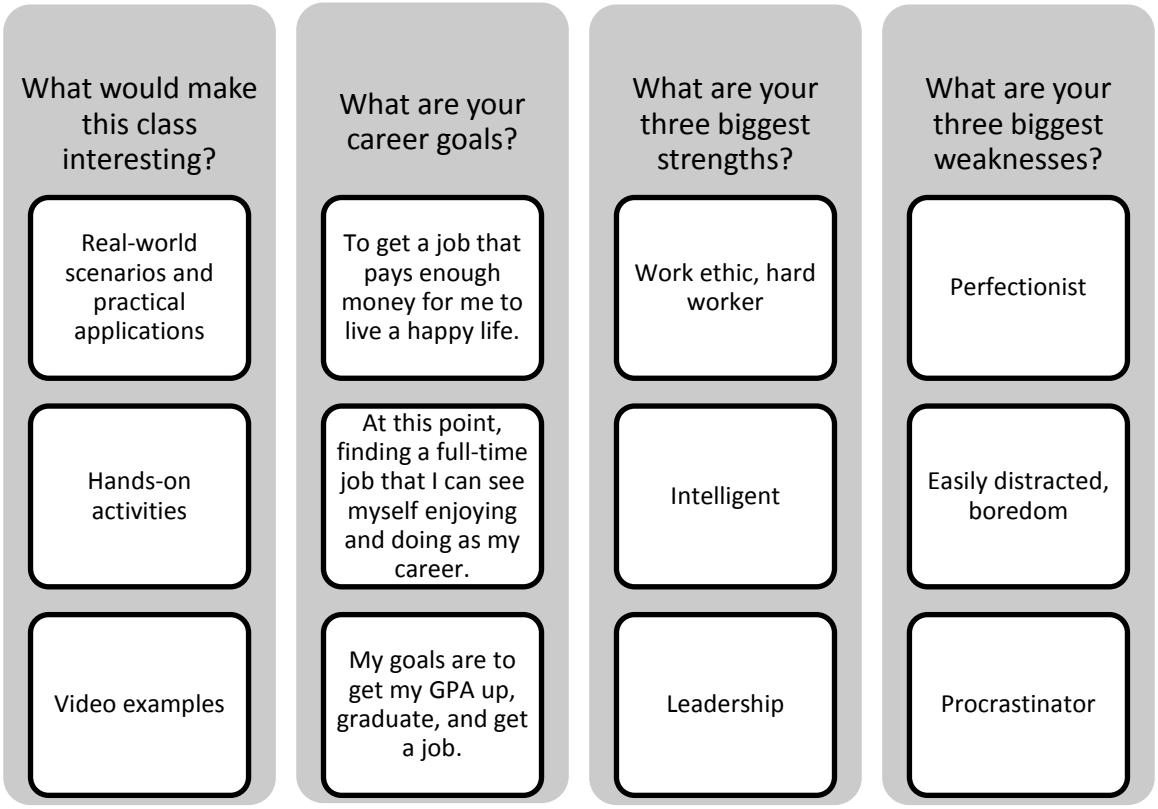

Table 5 Individual results

Learning style	Percent of students
Kinesthetic	45.30%
Visual	34.87%
Auditory	19.83%

Table 6 Averages percentage selecting each category

	Percent Response				
Questions	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Intrinsic goal orientation	11.59	45.12	34.76	7.32	1.22
Extrinsic goal orientation	21.14	41.46	17.89	17.07	2.44
Task value	46.34	53.66	0.00	0.00	0.00
Self-efficacy	37.20	51.83	10.37	0.61	0.00
Elaboration	26.83	56.10	17.07	0.00	0.00
Metacognitive self-regulation	4.88	21.95	41.46	21.95	9.76
Time and study environment	53.66	39.02	7.32	0.00	0.00
Effort regulation	11.75	36.65	8.92	32.93	9.76
Peer learning	13.01	40.65	31.71	12.20	2.44
Help seeking	16.26	44.72	13.82	21.14	4.07

Figure 3 House of quality

θ	Strong Relationship	1
0	Moderate Relationship	0.112
Δ	Weak Relationship	0.059

			Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
			Teaching Methods and Educational Tools / Student Needs	Flipped Classroom	Synchronous Instruction	Asynchronous Instruction	Mobile App instead of textbook	Hands - on Examples	Discussion Board	Games/Competition	Social Media	Field Expert - Guest Speakers	Blended/Hybrid Delivery	Company Project	Networking Opportunities	Quality Certificates	Leadership Positions	Research Projects	Clickers	Quizlet	Ted-Ed Videos	Assignment Weighting System	Required Attendance	Case Studies	Group Project	Traditional Lectures	Global Projects	Video Solutions with step by step explanation	Scoop.IT
Row #	Weight / Importance																												
1	1.000	Learning Style	Verbal - Linguistic						1		1				0.112						0.112				1	1			0.059
2	1.000		Interpersonal	1							0.1				0.059		0.112								1		1		
3	1.000		Logical - Mathematical					1		0.059										1									
4	1.000		Visual - Spatial																		1					0.112		1	
5	0.112		Intrapersonal	0.112	1	1							1					0.059		0.112	0.059								1
6	0.112		Naturalistic																										
7	0.059		Bodily - Kinesthetic	0.112				1		1										1									
8	0.059		Auditory - Musical		0.112	0.112															1					1			
9	0.059	Motivaiton	Task value									0.112		0.112															
10	0.059		Time and study environment																1										
11	0.059		Self - efficacy																										
12	0.112		Elaboration									1		1										0.112			0.112		1
13	0.112		Extrinsic goal orientation							1					0.112	1			0.059										
14	1.000		Help seeking	1			0.059		0.112						0.059													0.059	
15	1.000		Intrinsic goal orientation									1		1															1
16	1.000		Peer learning	1					0.112	0.112	0.112		0.112		0.112								0.059		1		0.112		
17	1.000		Effort regulation																				0.059						
18	0.112		Metacognitive self-regulation																										
19	1.000	Requests from open - ended questions	Improve career prospects									0.059		0.112	0.112	1	0.112							0.059			0.059		
20	0.112		Measure performance	0.112							1		0.112						1	0.112	0.059					0.059		0.112	0.059
21	1.000		Increase motivation	1				1	0.112	0.112		0.112	1	0.112	0.112					1				1				1	0.112
22	1.000		Provide real world examples					0.059			0.112	1		1	0.059			0.059					0.059			0.059	0.112		1
23	0.112		Improve group (social) interaction	1					0.112	0.112	0.112		0.112		0.112								0.059		1		0.112		
24	0.112		Inspire continual learning				0.112					0.112						0.059											1
25	1.000		Payback cost of education									0.059		0.112	0.112	1	0.112							0.059			0.059		
26	1.000		Increase confidence in graduating	0.112									0.112																
27	1.000		Maintain focus during class time	1				1			1		1						1				0.059	1		0.059		0.112	0.059
28	0.112		Improve grade point average	0.112				0.059	0.112	0.112	0.112		0.112						1	0.112	0.112		0.112					0.112	0.112
29	0.112		Provide congruency between classes											1				0.112						0.112		0.112		1
30	0.112		Improve self-directed learning			1														1	1							0.112	
31	0.059		Provide leadership opportunities													0.112	1								0.059				
			Technical Requirement Importance	5.27	0.12	0.23	0.07	3.12	1.36	0.48	2.47	2.36	2.37	2.57	0.76	2.12	0.40	0.08	1.29	2.21	1.31	0.00	0.20	2.14	3.12	1.30	1.38	2.21	2.70
			Rank Order	1	24	21	26	2	14	19	6	8	7	5	18	12	20	25	17	9	15	27	23	11	3	16	13	9	4
			Difficulty (0 = Easy to Accomplish, 10 = Extremely Difficult)	9	9	9	9	3	3	6	3	6	9	9	6	9	6	9	3	1	6	3	3	6	3	1	9	6	3

Figure 4 TED-Ed lessons

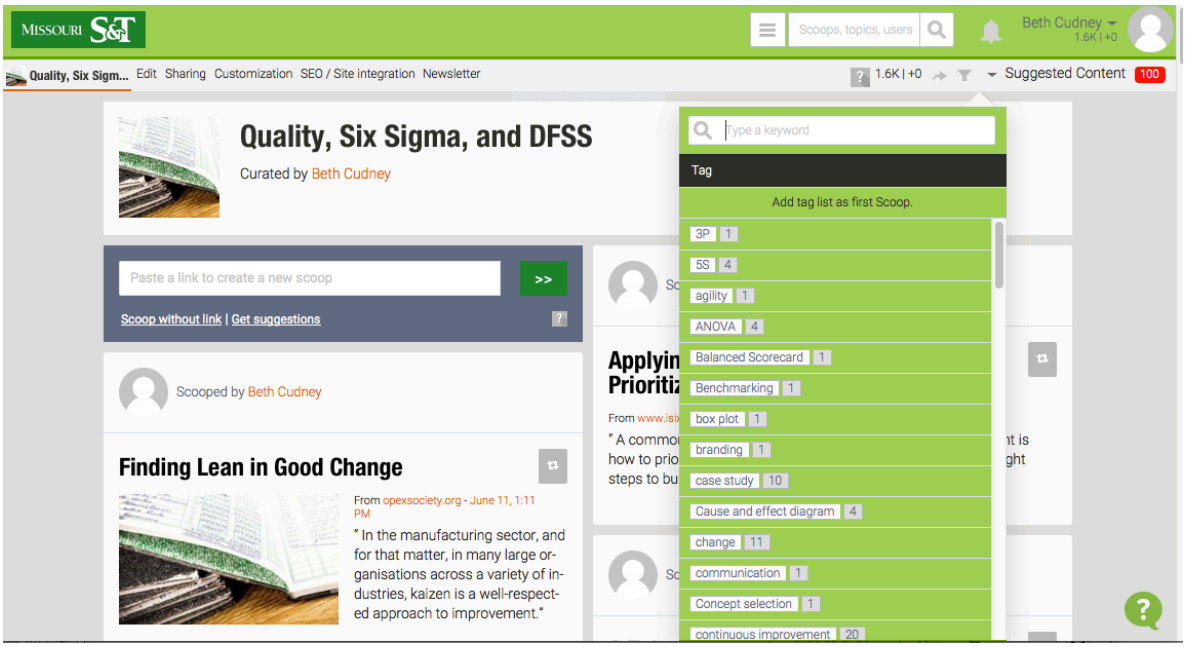

Figure 6 Scoop.it

Figure 5 Quizlet

Table 7 Student's responses to survey

How often did you use the tool?	Percent Response				
	Daily	**Weekly**	**Monthly**	**Once a Semester**	**Did Not Use**
Quizlet	11.36	34.09	9.09	25.00	20.45
Scoop.it	4.35	43.48	21.74	19.57	10.87
Video Solutions	18.60	51.16	9.30	11.63	9.30
TED-Ed Lessons	20.45	29.55	18.18	11.36	20.45

Table 8 Student's responses to survey

Questions	Percent Responses						
	Strongly Agree	**Agree**	**Neutral**	**Disagree**	**Strongly Disagree**	**Standard Deviation**	**Variance**
Quizlet							
The tool was helpful.	15.91	40.91	25.00	0.00	0.00	1.65	2.71
I would recommend this tool for the next class.	18.18	47.73	20.45	0.00	0.00	1.52	2.30
Scoop.it							
The tool was helpful.	10.87	45.65	32.61	0.00	0.00	1.34	1.79
I would recommend this tool for the next class.	15.22	43.48	28.26	0.00	2.17	1.42	2.02
Video Solutions							
The tool was helpful.	23.91	50.00	17.39	2.17	0.00	1.45	2.10
I would recommend this tool for the next class.	26.09	47.83	10.87	4.35	0.00	1.48	2.19
TED-Ed Lessons							
The tool was helpful.	22.73	40.91	22.73	2.27	0.00	1.47	2.16
I would recommend this tool for the next class.	31.82	25.00	25.00	4.55	2.27	1.59	2.53

Table 9 Group project

Questions	Percent Responses: Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Standard Deviation	Variance
I would recommend having a group project next semester.	34.78	47.83	10.87	4.35	2.17	0.91	0.84
The group project helped clarify the course concepts.	32.61	50.00	8.70	8.70	0.00	0.88	0.77
I struggled with the ambiguity of the course project.	11.36	15.91	27.27	34.09	11.36	1.19	1.41

Table 10 Student's responses for survey in quality course

THE FOLLOWING TOOLS SHOULD BE IMPLEMENTED NEXT SEMESTER	Percent Responses: Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Watch lectures outside of class and use class time to participate in more hands-on activities	13.16	23.68	28.95	18.42	15.79
Additional video solutions	18.42	57.89	21.05	0.00	2.63
Expert guest lectures	26.32	36.84	31.58	2.63	2.63
Certificate in Six Sigma	57.89	31.58	7.89	2.63	0.00
Global projects	18.42	23.68	50.00	2.63	5.26
Mobile app instead of textbook	26.32	21.05	31.58	13.16	7.89
Company visit (site visit)	44.74	31.58	23.68	0.00	0.00
Clickers	10.53	13.16	36.84	15.79	23.68