Advancing Engineering Education through Technology-Driven Teaching Innovations

Dr. Mohamed Yousef Ismail, Texas A&M University - Qatar

Mohamed Y. Ismail received the B.Sc. degree in Electrical Engineering from the University of Toledo, Toledo, Ohio, USA, in 1989, and the M.E. and Ph.D. degrees in Electrical and Computer Engineering from the University of Florida, Gainesville, Florida, USA, in 1992 and 1997, respectively. He is currently a Senior IT Consultant with Texas A&M University at Qatar, since 2014. During 2013 and 2014, he taught a course on cyber security for the University of Maryland University College. From 1998 to 2014, he worked for several international companies in senior management roles.

Dr. Hamid R. Parsaei, Texas A&M University - Qatar

Hamid R. Parsaei is a Professor of Mechanical Engineering and Director of Academic Outreach Office at Texas A&M University at Qatar. Dr. Parsaei is also a Professor of Industrial and Systems Engineering and Mechanical Engineering in Texas A&M University in College Station. Dr. Parsaei is a Fellow of American Society for Engineering Education and Fellow of Institute of Industrial Engineers. he has published over 250 articles in the refereed archival journals and conference proceedings. Dr. Parsaei is a registered professional engineer in Texas.

Dr. Bing Guo, Texas A&M University - Qatar

Dr. Bing Guo is Assistant Professor of Mechanical Engineering and a Dean's Fellow at Texas A&M University at Qatar. He teaches introductory engineering mechanics, thermal dynamics, thermal fluid sciences, and experimentation design. Dr. Guo has been involved in teaching innovation with technology since 2013, with notable products such as an app for enhanced learning of 3-D objects and video lecture libraries for mechanics and thermodynamics. Guo received his bachelor's, master's and doctoral degrees in Thermal Engineering from Tsinghua University.

Prof. Konstantinos E. Kakosimos, Texas A&M University - Qatar

Dr. Konstantinos Kakosimos received his PhD from the Chemical Engineering Dept. of Aristotle University of Thessaloniki in 2009. He worked as Postdoctoral Research Fellow/Assistant in the same university, as visiting Research Assistant in the National Environmental Research Institute, Aarhus University Denmark and also as a Design Engineer and Environmental Consultant for a number of private firms (Hellenic Petroleum, Titan Cement Company SA, Hellenic Gold, HYETOS GP etc). In October 2012 he has been appointed Assistant Professor of Chemical Engineering in Texas A&M University at Qatar and he is also affiliated with the Mary Kay O'Connor Process Safety Center extension in Qatar. He has co-authored 3 books (among which "Fires, explosions, and toxic gas dispersions: Effects calculation and risk analysis" published by CRC Press) and more than 20 papers in international peer-reviewed journals.

Ms. Raelene Dufresne, Texas A&M University - Qatar

Ms. Dufresne is an educator with 20 years experience in both secondary and tertiary educational institutions in North America and abroad, teaching students from all over the world. A proponent of using technology in the classroom, she currently flips her classes using videos and interactive learning activities to improve student understanding, as well as to level the playing field for her freshmen mathematics-for-engineers classes at an overseas branch campus of Texas A&M University. Notably, her secondary students at the American School of Doha in Qatar had an impressive record on the AP Calculus AB/BC and AP Physics Mechanics C exams. Ms. Dufresne holds a Master's and PhD (ABD) in Applied Mathematics from the University of Waterloo and a B.Ed. in Secondary Mathematics and Physics Education from The University of Western Ontario. She has delivered workshops around the world on topics such as: Using Technology in the Mathematics Classroom; Main Math Myths - Dispelling Mathematics Misconceptions; Teaching for Conceptual and Enduring Understanding; and Interactive Engagement in the Mathematics Classroom.

Dr. Nasser Alaeddine, Carnegie Mellon University - Qatar

Nasser I. Alaeddine is the Director of Educational and Media Technologies at Carnegie Mellon University Qatar. He previously worked as the Director of Enterprise Applications and Educational Technology at Texas A&M University at Qatar. Dr. Alaeddine also taught courses as an adjunct faculty at University of Phoenix and University of Maryland University College. He has more than 18 years of experience in managing, developing, and leading enterprise IT projects. Dr. Alaeddine has published a number of papers in refereed journals and conference proceedings.

Advancing Engineering Education through Technology Driven Teaching Innovations

Abstract

With the proliferation of technologies that are able to overcome the obstacles of time and space, it is inevitable that change would transform and reshape the traditional ways of doing things. In higher education, the impact of educational technologies and their potential to enhance the teaching and learning experiences as well as improve learning outcomes is yet to be felt in any tangible way. This is mainly attributed to the lack of motivation by faculty to utilize new technologies in their classrooms. To further motivate faculty to introduce and integrate digital technologies into the classroom as teaching aids, a comprehensive plan was developed at Texas A&M University at Qatar (TAMUQ) to promote and encourage the use of technology in innovative ways.

The groundwork for triggering successful technology adoption cycles requires developing targeted strategies that promote the use of technology. Transitioning from the state of non-acceptance to the state of adoption involves going through several intermediary stages that inform, train, and reward faculty members. Although strategies employed at TAMUQ address each of the three stages, they go beyond the goal of adoption to stimulate innovation. In order to promote the innovative use of technology, an annual Teaching Innovation with Technology competition was introduced with the goal of encouraging faculty to experiment with new technologies and assess their impact on their classrooms. The competition has been running for two years and has resulted in several innovative ideas.

This paper summarizes the results from the three finalist projects coming out of the second year competition. The results demonstrate that technology can reshape teaching and learning in engineering education in productive ways. On one hand, students involved in classes that employed technology to complement the educational process have become more interested and engaged in their classrooms. On the other hand, faculty exposed to motivational strategies have become more receptive to the idea of employing and experimenting with new technologies in innovative ways.

Introduction

We live in an era where digital innovations have significantly impacted our lives. The Internet, mobility, and social media – along with other emerging technologies - have irrevocably altered the way we live, work, play, and learn [1, 2, 3, 4]. The outburst of relatively cheap digital technologies that breakdown the boundaries of time and space present organizations with transformational tools to realize higher efficiencies, improve productivity, and achieve better outcomes.

In this age of pervasive technology use, grew a new generation of students who are adept at using sophisticated technologies at home, work, and in school. Anytime-anywhere communication, collaboration, and sharing are a mere selection of trends shaping the attributes of new student learners. Technology is becoming a catalyst to student engagement in classrooms and the exclusive reliance on traditional lecture format cannot hold their attention [5, 6, 7]. Instructors need to adopt innovative pedagogical approaches that incorporate technology and interactive elements in order to support teaching practices that are coherent with the cultural attributes of a tech-savvy student population [8].

The integration of technology into a complex system such as higher education, is a difficult and challenging task. A major challenge is resistance to change by organizational members. In the rush to build the educational technology infrastructure, many higher education institutions missed to address the question of technology adoption by faculty and staff. Despite the important affordances educational technology brings to the learning context, many academic staff continue to prefer traditional lecture format and their engagement with technology remains limited [9, 10, 11, 12]. Incorporating motivational strategies that encourage the adoption of educational technologies is a necessary task for the success of technology implementations in higher education [13, 14, 15].

The goal of this paper is to summarize the results of the three finalist projects coming out of the Teaching Innovation with Technology competition. The competition is one of the core measures implemented at Texas A&M University at Qatar in order to promote technology adoption while stimulating innovation. The competition has been running for two years and has resulted in several interesting projects.

Background

Effective use of technology in higher education continues to be hindered by low adoption rates among faculty and motivation, or lack of it, remains the primary reason behind this negative trend. Dismal adoption rates don't bode well with administrators who view technology integration in mainstream teaching and learning as a necessity to survive the onslaught of challenges facing higher education. Frameworks such as the ARCS model [16] provide a structured approach for developing motivational strategies that support engagement in the technology adoption cycle.

Motivating academic staff to accept and utilize technology requires implementing specific strategies to increase awareness about the technology, demonstrate relevance to the role, establish confidence-building measures, and attain satisfaction with the outcomes [17]. Several schemes have been introduced at Texas A&M University at Qatar to increase motivation to adopt technology. The Teaching Innovation with Technology competition has been one of the primary measure implemented to achieve the stated objective [18].

Teaching Innovation with Technology Competition

The Teaching Innovation with Technology Competition is an annual event that restricts participation to faculty members with each being limited to one entry per competition. The competition was initially proposed and developed through joint efforts between Academic Affairs and the Educational Technology group at Texas A&M University at Qatar in 2013. The primary objectives were to promote technology adoption and stimulate innovation in engineering education. A team from the Academic Affairs Office and Information Technology group jointly announced the availability of this annual competition and developed guidelines for preparation and submission of proposals. The team also developed criteria to review and assess the originality and practicality as well as the potential benefits of proposed projects. Several faculty with strong computer skills and teaching experience were invited to judge the proposals based on the established criteria. Out of close to a dozen proposals three were recommended by the panel of judges. The Academic Affairs Office provided financial incentives in the form of travel support to investigators of selected projects to attend academic conferences and symposia related to their proposed interest. The Information Technology group provided the selected investigators with a six month technical and development support to help them implement their proposed ideas. By the end of the development period, the investigators were invited to present their completed projects to the panel of judges in an open forum with audience from academia and regional industry. The final products were judged based on the established criteria as well as their potential to enhance students learning. The panel members were unanimous in reporting their satisfaction with the quality of the developed tools and the innovative approaches pursued to enhance learning. Per instructions provided to the judging panel, one project was recommend as the grand winner and additional fund was provided to its investigator to attend engineering education related conferences to present the new development.

A consequences of the competition was the development of the Educational Innovation through Implementation lifecycle, shown in Figure 1, for moving from the initial prototyping stages to mainstream adoption in teaching practices [18].

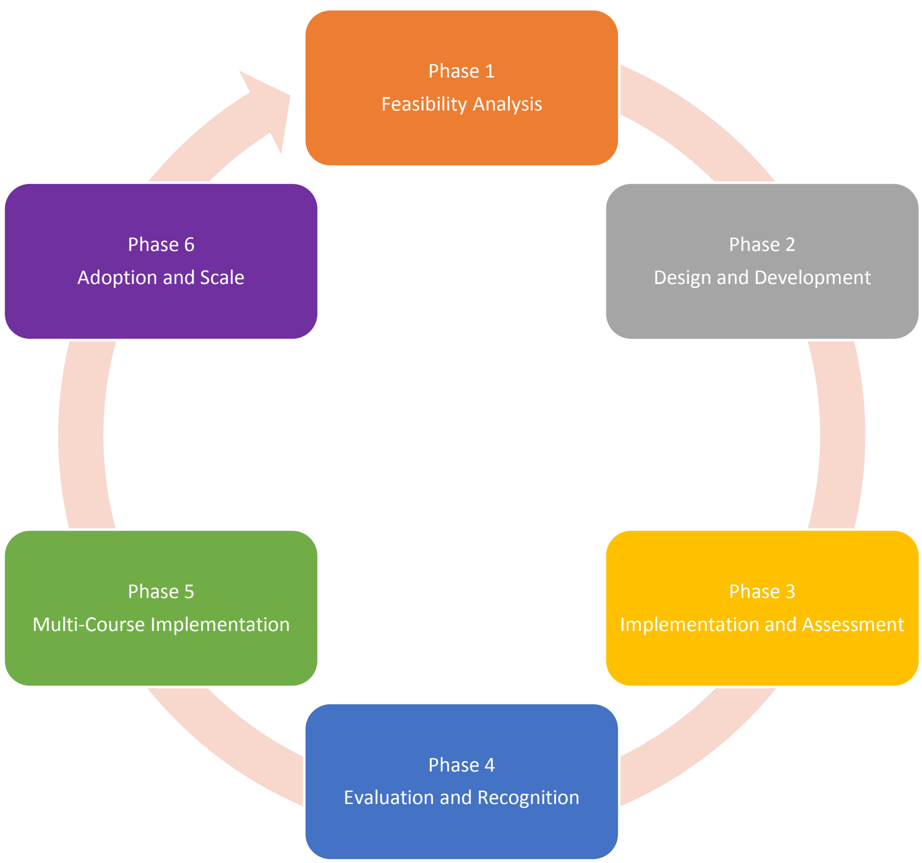

Figure 1. Education innovation through implementation lifecycle.

The two stated objectives for the competition represent the explicit goals meant to directly affect faculty participants. An implicit goal is to provide faculty audiences with an opportunity to see peers representing variety of disciplines showcasing their innovative ideas for advancing engineering education. In essence, the competition offers a venue for increasing awareness, demonstrating relevance, building confidence, and proving satisfaction for faculty audiences.

Furthermore, the influence of peers can play an important role in promoting change in the attitudes of faculty audiences [19, 20, 21, 22]. The competition acting as a medium for triggering a contagion effect, or social spillover effect, can lead faculty audiences to imitate the adoption behaviors of their peer group of participants.

Finalist Projects

Results from the 2013 competition have demonstrated the potential of the approach in promoting innovation in engineering education [18]. In 2014, there was a variety of projects reflecting the vision of contributing faculty members in relation to advancing education through technology, however, only the three finalist projects are discussed here. Two of the contributions primarily focused on experimenting with the flipped classroom practice due to availability of the state of the art video and recording equipment purchased and provided by the University. However, one implementation targeted introductory math courses while the other focused on a core mechanical engineering course. Developing a visual support tool to aid learning and training activities for a chemical engineering laboratory was the theme of the third project. Table 1 lists the projects and their status.

Table 1. Three finalist projects from the 2014 Teaching Innovation with Technology Competition.

Project Title	Status
Flipped Classroom and Interactive Engagement for Improved Student Learning in Mathematics	Complete
Flipped Classroom for Mechanical Engineering Statics and Particle Dynamics	Complete
Explore and develop tools for visual support of learning and training - "Google Glass"	Complete

Flipped Classroom and Interactive Engagement for Improved Student Learning in Mathematics

Objective: Utilize technology to flip Pre-calculus, Calculus I, and Calculus II and exploit Interactive Engagement (IE) teaching methods to improve student learning.

Project Description

A Concept Inventory is a test designed to measure the gain in students' conceptual understanding that a semester of teaching can produce. The *Calculus Concept Inventory* (CCI) [23], like its physics predecessor the *Force Concept Inventory* (FCI) [24, 25], is administered to students as pre- and post- tests. The data gathered by the FCI in first year mechanics classes and by the CCI in differential calculus classes to evaluate different teaching approaches at universities show two things: (1) traditional instruction has little effect on basic conceptual understanding, and (2) Interactive Engagement (IE) and Inquiry-Based Learning (IBL), produce nearly 20% higher gains from pre- to post- tests on the FCI and the CCI than traditional instruction [26, 27]. Hake [26] defines IE methods as "those designed at least in part to promote conceptual understanding through active engagement of students in heads-on (always) and hands-on (usually) activities which yield immediate feedback through discussion with peers and/or instructors".

The goal of the project is to build upon the findings of the FCI and CCI to improve students' conceptual gains in three calculus courses. The proposed approach employs the flipped learning methodology as a way to enact the Interactive Engagement practice. The implementation of the flip involved delivering lecture content via online streaming videos prior to class while reserving the face-to-face class time for interactive engagement. Furthermore, homework was delivered in part using an online homework management system and "virtual office hours" were held in an online forum.

The online streaming videos provide pedagogical differentiation in a variety of ways. The pace of instruction is customized: any English-as-a-foreign-language students may wish to replay the video for better linguistic understanding, or in order to repeat a mathematical concept; conversely, students who have already mastered the content may wish to move ahead faster than traditional lecture would allow. Students may refer back to the video at any time during the semester for reinforcement and connection making. Multiple representations of each concept can be presented in the video using graphing technology. Face-to-face class time and office hours provide the opportunity for interactive engagement: heads-on and hands-on collaborative problem solving, discussion of strategy efficacy, clarification of misconceptions and receipt of detailed, personalized and immediate feedback from the instructor and peers.

Due to cultural reasons, not all TAMUQ students attend office hours. When they do, students may attend in pairs or small groups though not often in mixed-gender groups. Faculty may address the same question more than once. The idea of "Virtual Office Hours" can facilitate more "attendance" in office hours or post facto and provide another forum for IE.

Assessment Methodology

Subjective and objective measures were planned to assess the impact of the proposed model on student learning and long-term retention of basic concepts. At the time of this writing, however, the only data that was available is that resulting from student surveys. The data sought by the surveys pertained to three themes: integrity of instruction via online video, efficacy of interactive engagement activities to enhancing learning, and perceived improvement of own learning in flipped classroom.

A 5-point Likert scale survey was administered to every student who has been taught using this flipped classroom with IE approach in any of the three calculus courses since spring 2013. Out of 77 registered students, only 25 completed the survey leading to a 32% response rate.

Results and Remarks

It is expected that students will attain greater learning in the form of retained knowledge and deeper conceptual understanding as a result of their involvement in the IE teaching approach. Such results would be consistent with three decades of data from the FCI and physics education reform and the early results from the more recent CCI and calculus education reform.

The Likert survey had a total of 20 questions with the first question being "I watch most (80% or more) of the videos". The goal of the question was to limit the analysis to students who met the 80% minimum as the benefit of the proposed approach cannot be achieved without students watching the majority of the recorded material. Only students meeting this criteria were considered in the rest of this study. A total of 18 students met the established criteria thus restricting the analysis to 72% of the total respondents. Responses to the rest of the survey questions were filtered to restrict the analysis to the 72% group of respondents. Figure 2 displays results of the survey pertaining to integrity of instruction via online videos.

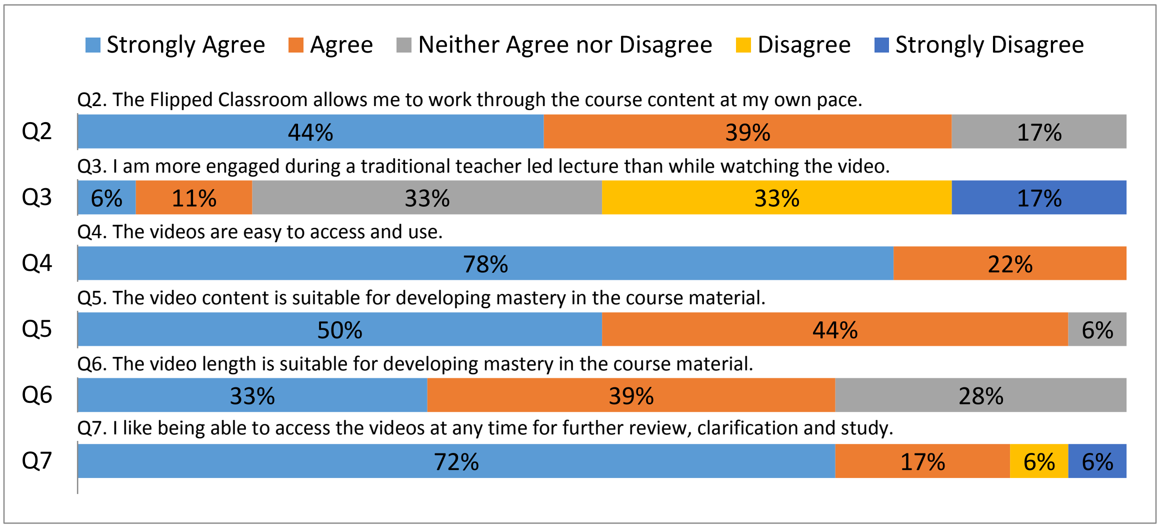

Figure 2. Survey results pertaining to integrity of instruction via online videos.

The results reveal that students liked the video content and thought it is suitable for developing mastery in the course material. Almost 90% of respondents thought the most appealing reasons for liking the video format is the anytime anywhere accessibility of the content.

Results pertaining to efficacy of interactive engagement activities to enhancing learning are shown in Figure 3.

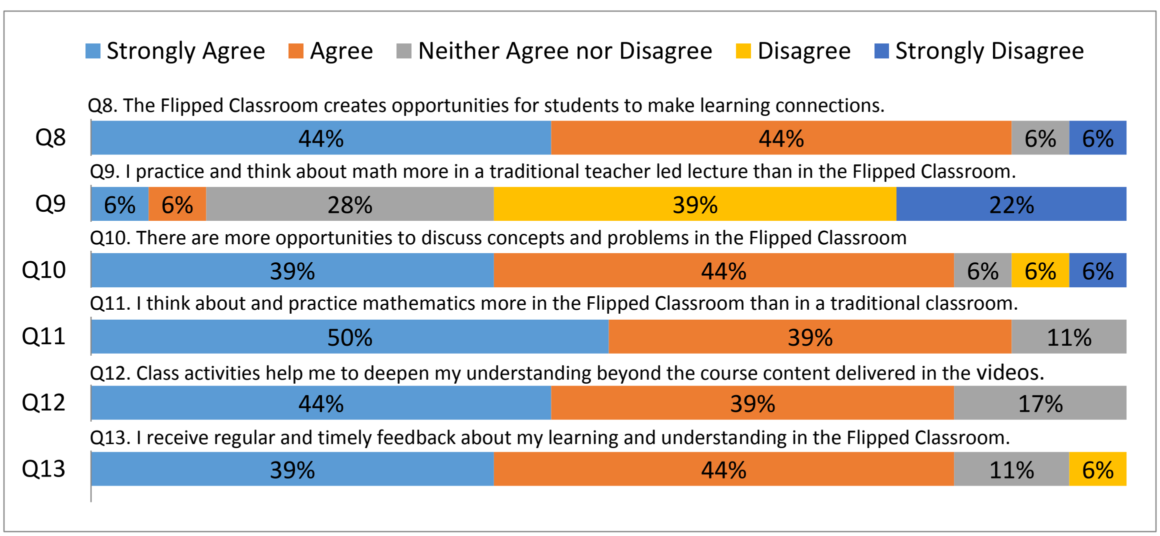

Figure 3. Survey results pertaining to efficacy of interactive engagement activities to enhancing learning.

The results clearly show that students who participated in the study and followed instructions have positive perceptions about the interactive engagement practice:

- 88% of respondents believed the flipped classroom setup creates opportunities for making learning connections.
- 83% of respondents thought the flipped classroom setup is better equipped to discuss concepts and problems.
- 83% of respondents thought class activities improved their understanding of course concepts.

Figure 4 provides the results of the final theme of the survey, namely, perceived improvement of own learning in flipped classroom.

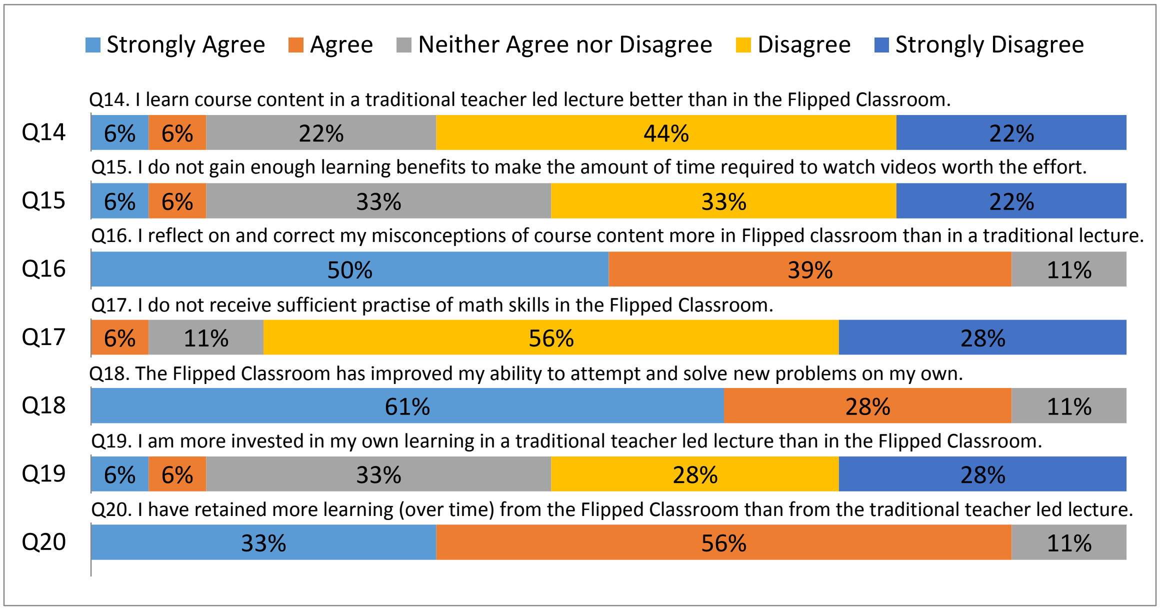

Figure 4. Survey results pertaining to perceived improvement of own learning in flipped classroom.

Again, perceptions toward the flipped learning approach continue their positive trend as evidenced by the results:

- 66% of respondents did not think the traditional lecture approach is better than flipped learning in terms of learning course content.
- 55% of respondents thought time spent on watching videos is beneficial.
- 89% of respondents believe that flipped learning is more suitable than traditional classroom to correct their misconceptions about course material.
- 89% of respondents believe the flipped classroom setup helped them retain more concepts over time than traditional classes.

Incorporating interactive engagement activities via flipped learning can lead to significant improvements in student learning and retention of course concepts. Despite the lack of objective analysis, subjective results clearly show positive attitudes toward the proposed approach.

Flipped Classroom for Mechanical Engineering Statics and Particle Dynamics

Objective: Implement and evaluate a flipped-classroom model in a mechanical engineering course on Statics and Particle Dynamics with the goal of improving student engagement and self-paced learning.

Project Description

Virtually unknown few years ago, the flipped learning methodology is gaining attention in higher education. Flipped learning is a form of blended learning that inverts traditional classroom activities so that instruction or lecture content is delivered outside the classroom using video or some other media while class time is dedicated for hands-on learning, collaborative activities, and personalized guidance and interaction with instructors. Research studies evaluating flipped learning demonstrated improvements in learning basic concepts [28].

The setup for the Statics and Particle Dynamics course had a few challenging aspects. The class was held in an auditorium at late hours and the class size was relatively large. Such arrangement makes it difficult to gain the attention of every student and is not conductive for student-instructor and student-student interactions. The motivation for the project came from the instructor's desire to create a more engaging experience that maximizes learning outcomes for students.

Initial efforts by the faculty member to achieve the stated objective involved implementing a form of blended learning that incorporated game-style elements. The basic routine of a typical class consisted of:

1. Lecturing for 10-15 minutes
2. Dividing the class into two competing teams
3. Instructing the teams to work on a challenge problem where discussions are encouraged
4. Randomly selecting a student from each team to provide the solution on classroom board
5. Evaluating each solution and assigning a score
6. Returning to step 3 until all challenge problems are tackled
7. Announcing the winning team.

Students responded very positively to the game-style activities. Surveys indicated that students look forward to this class because it was engaging. However, as the complexity of the problems increased, the typical routine became harder to maintain and it was necessary to alter some of the activities in order to improve utilization of classroom time. Steps taken by the instructor to optimize the routine included:

- Switching from the short-lecture to the no-lecture format at the beginning of the class. This represents a shift towards a full-fledged implementation of the flip methodology. Students are instructed to view a pre-recorded short lecture before each class and to come prepared to immediately participate in collaborative problem solving.
- Employing web conferencing technology to create an online meeting experience for small group collaboration. Utilizing a technology that allows in-class sharing of tablet computers screens between instructors and students enables real-time feedback even in larger classes, reduces students' fear of presenting in front of the whole class, permits more efficient use of other computer-software visualization tools, allows students to give

much clearer presentations in comparison to writing on the board, and minimizes idle time as students no longer need to explain their solutions on classroom board.

- Recording classroom activities for students' self-paced review.

In essence, using multimedia and web conferencing technologies in conjunction with simple adjustments to the learning methodology resulted in eliminating two of the seven steps employed by the instructor in his first implementation.

Assessment Methodology

Implementing consistent procedures for data collection is imperative for proper analysis of results. Standard methods were followed throughout the semester to develop and share the course content. Prior to each class, the instructor recorded lecture and problem-solving demonstration videos and posted them internally on the Learning Management System (LMS) and externally on YouTube. Students were instructed to watch the proper video recordings in order to satisfy the pre-class assignment. The instructor then devoted the class time for students to work on practice problems with minimal or no lecturing.

In order to assess the pedagogical value of the proposed teaching model, the instructor surveyed his students at the end of the Fall 2014 and Spring 2015 semesters. Survey questions focused on the effectiveness of the proposed model in creating an engaging environment and improving learning outcomes. To increase participation, online and paper varieties were offered. Other objectives measures were in the proposed assessment plan, however, due to the limited amount of time and the lack of a sufficient data sample, such plan did not materialize.

Results and Remarks

Questions in the survey revolved around the flipped methodology and the value of recorded videos. Seven students completed the fall survey while a total of nineteen students completed the spring one. The survey started with a simple question about the utility of the videos. The majority of the respondents agreed the videos were very useful as shown in Table 2.

Table 2. Were the videos very useful?

	Strongly Agree	**Agree**	**Neutral**	**Did not watch**
Fall 2014	29%	57%	14%	0%
Spring 2015	32%	37%	10%	21%
Aggregate	31%	42%	11%	15%

The rest of the survey focused on sentiments regarding the flipped classroom practice. The survey format allowed students to select multiple responses to record their views about different aspects of the flipped methodology. The results are summarized in table 3. The third and fourth columns in the table provide two percentage values. The first value calculates the percentages of responses in relation to the total number of respondents while the second value does the same in relation to the total number of respondents who watched the videos. The last column accumulates the results from the two semesters and calculates the percentages based on a total response count of 26 and 22 respectively.

Table 3. Result of the student survey conducted during Fall 2014 and Spring 2015

Statement	Fall 2014 7 Respondents	Spring 2015 19 Respondents	Aggregate 26 Respondents
Did not watch videos	0 (0%)	4 (21%)	4 (15%)
Videos more effective as problem solving demonstrations	1 (14%)	6 (32%) – (40%)	7 (27%) – (32%)
Videos are useful as a supplement to classroom lecturing but cannot replace classroom lectures	3 (43%)	11 (58%) – (73%)	14 (54%) – (64%)
Flipped classroom is effective for me	1 (14%)	3 (16%) – (20%)	4 (15%) – (18%)
Flipped classroom is not effective for me	3 (43%)	5 (26%) – (33%)	8 (31%) – (36%)
If well prepared, flipped classroom might be effective for me	0 (0%)	7 (37%) – (47%)	7 (27%) – (32%)

The above results reveal some interesting trends:

- The majority of the students thought the videos are very useful but only as a supplement and not replacement to classroom lectures.
- Majority of the students did not think the flipped classroom methodology is an effective learning approach. A student population's opinion about flipped learning may vary, and is possibly correlated to the overall academic performance of the population.

Metrics collected from the video delivery channels provided additional insights into usage patterns. On average, students spent less than 4 minutes on each view. Some students watched videos regularly while many cram watched before exams. The duration per view also regularly spiked with classroom events such as course exams.

Explore and develop tools for visual support of learning and training - "Google Glass"

Objective: Explore the use of wearable technology - Google Glass - as a visual support aid and develop the necessary tools to demonstrate the utility of the approach in improving the instructional experience while mitigating the challenges of laboratory work.

Project Description:

The central role technology plays in higher education is undeniable. The intertwined relationship can be extrapolated from the extent to which technology is exploited inside and outside the classroom [29, 30]. Demonstrations of the utility of multimedia tools and platforms in enhancing the teaching and learning experiences in engineering education are abundant [31, 32].

New and emerging technologies, like wearable computers with optical head-mounted displays, open up the door for many more innovative adaptations that could significantly improve engineering education. Examples of useful applications include allowing faculty and students to share information in various modes of interaction including visual instruction and hands-free recording and transmission of wearer's views. Other practical applications involve connecting remote experts with the scene of an activity where advice is helpful [33]. Google Glass, or Glass, is one of the wearable emerging technologies with promising potential to advance teaching, learning and training. However, many of the opportunities are yet to be explored and the appropriate tools are yet to be developed. Such deficiencies are further exacerbated by the limited amount of related publications.

The idea behind the project stemmed from the desire to enable safe operation in laboratory environments. This matured into the concept of exploring the use of wearable technology as a visual support aid to improve the instructional experience and mitigate the challenges of laboratory work. Although the implementation focused on specific procedures such as Thermo-Gravimetric Analysis and Airborne Particulates Sampling, the framework can be easily extended to other topics within the engineering discipline. The effectiveness of the approach was assessed with respect to the impact of Glass on the following three factors:

- **Teaching**: Glass has the capability to record what the wearer sees. Putting the Google Glass on while performing a Standard Operating Procedure (SOP) allows the user to seamlessly execute and record the procedure steps. The resulting recordings can then be utilized to prepare the multimedia training and instructional material.
- **Learning and training**: A student or researcher going through SOP training wears Glass to watch the training material while sitting in front of the proper equipment. The experience of following the recorded material in the actual laboratory provides users with direct feel of the SOP, thus, contributing greatly to proper understanding of lab procedures and safety instructions.
- **Execution and support**: Instructional videos can be used at any time as a visual support aid to follow an SOP. Information that can be fed through Glass is almost unlimited. Augmented Reality and Quick Response codes can be employed to provide additional assistance such as object recognition, sample identification, and automatic retrieval of safety messages.

Glass and other similar technologies offer many possibilities for the fields of training and education. Yet, utilization remains very limited and development tools remain nearly non-existent. Producing a functional prototype for the trials required doing much of the development and integration work.

Through an open announcement, a group of twenty students was assembled to participate in assessment activities but only thirteen completed all phases of the study. Prior to start, students were put through an orientation session that provided information about the objectives and stages of the experiment as well as the motivation behind it. Video content demonstrating the basic features of Glass as well as the more advanced augmented reality capabilities was played during the session. Students were then asked to select two slots of 15 minutes each that are at least two days apart. The instructions called for one slot to be used for executing the SOP without the Glass and the other with the Glass. Students were split to perform one of two trial sequences: A referring to Glass-OFF Glass-ON and B referring to Glass-ON Glass-OFF. Shortly before the start of each session, information and training material necessary for the trial is provided to the student for review. The information consisted of standard paper instructions with typed text and images for the Glass-OFF trial and brief training video for the Glass-ON session.

Even though student participants were awed by the augmented reality capabilities of Glass during the orientation session, the use of Glass was much more limited in scope throughout the study. The visual support provided during the Glass-ON experiments was limited to the digital form of the standard paper instructions. None of the augmented reality capabilities were employed despite the fact that they were partially developed. The temporary shift in direction is attributed to competition timeline restrictions and the need to provide an accurate evaluation of the trials. Assessing performance based on partial results would have put the whole experiment into question.

Assessment Methodology

Assessing the pedagogical value of a project is a critical judging measure for the competition. Due to time constraints, the demonstration and assessment phases took place at the same time. Students were instructed to complete three surveys about their opinions and experiences before and during the study. The first survey was conducted right after the orientation session but before the start of any trials. The goal of the survey was to establish a comparison baseline, assess initial student biases whether positive or negative, and examine student expectations. The second and third surveys were conducted after each training session to assess the impact of the followed approach and examine whether it fulfilled student expectations.

Identifying objective and quantitative measures to assess the impact of the Glass on students' performance in a short period of time proved to be quite challenging. As a result, only two assessment measures were investigated: The number of successful SOP steps completed and time to complete the entire SOP. For the purpose of this assessment, an SOP with ten well-defined steps was selected.

Results and Remarks

The findings of the pilot study and ensuing assessments are presented in the following paragraphs to address the impact of the proposed solution on the three factors discussed earlier.

Teaching

Use of the Glass to record instructional video material proved to be quite simple and straight forward. Resulting videos had the potential to be extremely useful in demonstrating the steps of an SOP because they delivered a first-person perspective in the real laboratory environment. In the presence of a Wi-Fi connection, all material is automatically uploaded to the cloud and becomes available without the need to reconnect the Glass for access. A discussion of the editing process for the recorded material is out of the scope of this study, however it is important to note that recorded videos often looked tilted and grainy. This is primarily caused by the mounting of the Glass. Even light nods caused the Glass to shift position and slightly change the point-of-view. Although the final material is judged as satisfactory, the necessary time to prepare it was quite significant.

Learning and Training

As expected, use of the recorded training material to help students conduct the SOP was assessed positively by all students in the pre and post trials surveys. Students were so strongly positioned in favor of the use of the pre-recorded material for lab training that they ignored any possible defects in the prepared videos. The Likert survey pertaining to the learning and training factor mainly consisted of three questions that are included with the filtered survey results in table 4. The filtering was done to account for "Agree" and "Strongly Agree" values only.

Table 4. Pre and post survey results for the Google Glass trials.

Question	Pre-Trials %	Post-Trials %
Q1. I prefer recorded material over written instructions for this type of training	100%	100%
Q2. Video instructions are useful and easy to follow	100%	85%
Q3. Paper instructions are useful and easy to follow	30%	60%

In the pre and post surveys, 100% of the students preferred recorded material over standard paper instructions. In the pre-trials survey, 100% of the students believed the recorded material is useful and easy to follow while only 30% of the respondents believed the same for paper instructions. Opinions about the usefulness of the recorded videos remained positive in the post-trials surveys although the percentage dropped to 85%. In contrast, Sentiments about the usefulness of the traditional paper approach jumped to 60%. The drop in the number of votes in favor of question 2 and the corresponding increase in the number of votes in favor of question 3 can be attributed to negative Glass-ON experiences resulting from defects in video quality and commentary as well as other unaccounted for instabilities that could have been avoided.

Execution and Support

Contrary to initial expectations, the use of Glass in combination with the developed application for the support and execution of the SOP did not prove as satisfactory. This was evidenced by the lack of significant variation in the results from performing the two trial sequences A and B. Sentiments of the two student groups taking role in the trial sequences essentially converged to convey comparable messages. Due to the similarity of the outcomes, the results are presented altogether hereafter. It is important to note that the SOP under study was completely unknown and new to participating students with 25% reporting no previous experience in any chemical engineering laboratory.

Before the use of Glass for visual support, 80% of the students expected the Glass-ON experience to be far more positive than the typical SOP. In a question about the major advantages of the Glass approach, 90% anticipated the hands-free operation to be a major advantage while only 10% predicted the same about the visual support capability. Furthermore, 30% of the students foresaw the small size of the head display as being problematic while 1 students expressed the opinion that Glass will not properly fit in place and that it will need to be readjusted continuously. At the end of the study, 70% of the students thought the need to readjust Glass fit continuously was the biggest disadvantage. Another 25% felt the size of the head display was an inconvenience while 15% reported the same about the need to frequently touch the Glass to prevent it from going into standby mode. The last distraction could have easily been avoided but since it was omitted in the initial stages, the trials continued without any modifications.

Data about the number of successful SOP steps completed and time to complete the entire SOP was collected and analyzed in order to quantify the impact of Glass on student performance. Overall, students successfully completed all SOP steps with and without the Glass. Two students missed one step while using the Glass due to entering the standby mode after remaining inactive for more than one minute. Attempting to reactivate Glass to resume the SOP caused both students to miss a step. Average required time to complete the SOP was around 2 minute longer when wearing Glass. The bias in favor of the Glass-OFF option was expected as a result of students lacking previous exposure to the device. The unfamiliarity with Glass and its navigational controls lead to difficulties in simultaneously using Glass while conducting the SOP. Such issue is not considered critical as it could be easily resolved through proper training.

Although the results did not identify any clear trends that positively correlate Glass usage with student performance, it is our belief that a more interactive implementation that employs the full capabilities of the glass would accomplish the intended objective.

Conclusion

Promoting technology-driven teaching innovations in engineering education through an annual competition has been an effective strategy for encouraging the development of practical applications that facilitate improvements in teaching and learning methods. The Competition has been well received by faculty and technical staff per our observations. Several projects have been sponsored since the inception of the competition and variants of the proposed ideas have since been adopted by other instructors. While the examples presented focused on specific engineering courses, the strategies discussed could easily be adapted to accommodate other engineering topics. The three projects shared the view that interactive engagement activities are important to help students achieve a richer understanding of course material. In essence, the explanation of ideas through technology-assisted methods excites students and makes learning simpler. While many of the ideas resulting from the competition did not come without challenges, the insights they provide are worth the potential difficulties. Despite the continuous focus on technology, it is not really what is important as implementing new technologies is not a cure to all challenges and does not automatically lead to improved education and enhanced learning outcomes. What really matters is the educational and social implications of technology on the student population. Using technology is a means to achieve the fundamental objective of making the learning process more effective and better suited to student needs.

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