An Innovative Teaching Method to Increase Engagement in the Classroom: A Case Study in Science and Engineering

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Abstract

This Evidence-based practice paper describes a learning process developed and used in several STEM courses. Learning is a process unique to each individual and can be accomplished by watching, reading, doing, experiencing, repetition and even teaching. Learning according to [1] is a two-step process where the first step is to receive information and the second is to process. This study is an active learning method that combines these two steps in a repetitive process that encourages engagement and collaboration in the classroom. Memory related research has identified and confirmed the power of repetition on the recall ability. Repetition has a profound impact on the event related brain potential eliciting a longer recall period and has been reported to speed up the learning process [2,3,4]. In addition, paired learning combined with paired testing has been proven to enhance learning more than it would in paired learning combined with individual testing [5].

This paper discusses a pedagogy that combines the above mentioned theories. This pedagogy aims to maximize learning in within a short time frame. Students learn while creating questions and answers to these questions, preparing for the quiz, taking the quiz and finally grading the quiz. The students work with a partner or in a group throughout the process of the quiz. The paper also discusses the modifications done to accommodate for the change in a classroom size. It also gives the feedback gathered from the students while implementing this pedagogy in a small and a large classroom setting and what improvements have been done in addressing students' concerns. 93% of the students - found the process of creating the questions for the quiz to be helpful in reviewing the material learned in the class and the process of taking the quiz to be helpful in learning the material; 93% of the students indicated that they learned from their classmates; and 13% of the students preferred lecture only class.

The project is a result of an international collaboration with professors from two different universities across three different disciplines in STEM including Civil Engineering, Computer Science and, Mechanical and Industrial Engineering, Slight variations of the method was employed based on the specific nature of the class. The project consists of the students working in groups to create questions and answers related to a topic briefly described in class. The questions and answers are presented in an online forum monitored by the class instructor for all the students to see. The students are then quizzed on questions from the pool asked by them online. The project was implemented in a range of class sizes from 20 students to 120 students.

Introduction

The current generation of students are typically overcommitted and have little time to devote to learning outside the classroom. At the University of Minnesota Duluth (UMD), it is common for students to work part-time or even full-time jobs to meet their living needs. This is less common at the University of Waterloo (UW), largely due to the co-op program, where students alternate between four months of school and four months of co-op. On co-op terms, students typically

work for an engineering company and can earn enough to fund their school terms. Despite this, students in first and second year engineering must usually attend classes, labs, and tutorials for the majority of the day. This leaves little time for students to explore concepts learned in class outside of lecture hours, and in larger classes it is increasingly difficult to actively engage students. We are proposing a pedagogy which uses an active learning method based on rapid question and answer class discussion in an attempt to increase student engagement, collaboration, and confidence in the material, and ultimately improve student learning in a time efficient manner. The method was adopted from the "speed learning" method presented by Khan and Madden [6] which they used in small-sized (<40 students) computer science classes. This paper discusses a small class implementation, as well as two modified approaches that have been developed and used in medium-sized classes (about 60 students) and a larger (~120 students) engineering class. The approach is centered on creating an environment where students work in groups to collaboratively create questions related to a discussion topic, study the questions, answer a quiz on the questions, and evaluate their responses to the quiz. This process of going through these different steps challenges students' understanding and reinforces their knowledge.

A key learning approach implemented in this method is collaboration, where students work with their peers to complete the required tasks, as opposed to working individually. The effectiveness of collaborative learning compared with individual learning has been established in other studies. In a meta-analysis of 168 studies, Johnson et al. [7] found that collaborative learning activities improved academic achievement, quality of interpersonal interaction, improved self-esteem, and improved perceptions of greater social support. Similarly, Springer et al. [8] found that collaboration improved academic achievement, student attitudes, and retention in academic programs. The peer learning that students are exposed to is very beneficial for developing deeper levels of understanding. As Golub [9] states, "The mutual exploration, meaning-making, and feedback often lead to better understanding on the part of students, and to the creation of new understandings for them." In the question creation phase, students have a chance to explore their understanding in depth while they try and create questions that challenge their peers. Any gaps in understanding that an individual identifies can be immediately raised and potentially filled by other members of the group. The result of this is that the questions developed by each group have the potential to be much higher quality than if they were developed individually. After questions have been created, students have the opportunity to challenge their understanding of the topic by trying to answer questions that other groups have made. Students can also listen to their peers perspective on the questions as they're being answered, which promotes an open-minded approach to problem solving.

The modified approaches discussed in this paper make use of online discussion tools as a medium for asynchronous question and answer activities. A significant amount of research has been done on the effectiveness of online discussion forums for improving learning experiences [10-17]. Although specific results drawn from individual studies vary, the resounding conclusion is that when online discussion forums are implemented with care, they can provide a beneficial learning experience. Some benefits noted in other implementations of online discussion forums include:

- The ability to communicate simultaneously or even participate in multiple discussions at the same time [18];
- the creation of a permanent record of their thoughts [19];

- the convenience of choosing the time and place to learn [20];
- the creation of a sense of community [11];
- the development of skills for working in virtual teams [21];
- the ability to spend time developing their thoughts and creating more clear and better composed questions [22].

Exposing the students to the information over and over again can be effective at improving retention of knowledge. In the proposed method, students are exposed to repetition as they move through the question creation phase, the learning stage, the quiz stage, and the evaluation stage. Students are repeatedly taking a topic and challenging their understanding. Every time they create or answer a question they are associating it with the topic of discussion and with all the other questions and answers related to the same topic. Studies have been conducted which support the claim that with every repetition students are able to add more information to their current understanding [23].

Working in a group also helps with developing skills like communication and teamwork, which are being increasingly identified as “a necessary skill for industry” [24, 25]. In formulating questions students must give careful thought to how their question will be interpreted by other students. Similarly, as students are answering questions they gain interpretive communicative skills as they try to understand what is being asked.

Summary of the original “Speed Learning” method

The original speed learning method proposed by Khan [6] had four stages that took place in a single lecture. In the first stage, the students worked in groups to create questions along with answers in a Google Doc (synchronous online discussion). In this stage, the instructor would make sure the questions created by the students were relevant and worded clearly. In the second stage, students reviewed the questions and answers created by the entire class. In the third stage, students worked in groups to take a short quiz where the questions were taken from the Google Doc. In the fourth and final stage, students evaluated each other's quizzes. This process involved learning by repetition and collaborative learning.

Quality assurance of the methodology

To ensure the quality and consistency of the questions created by the students the instructor will monitor the question creation and verify that all the questions are not only worded correctly but the answers are also correct. In addition, to ensure the questions created are challenging, the instructor has the option to offer extra credit for every five questions created or the instructor has the option to disqualify questions that are too easy. When a question is deemed disqualified by the instructor the student is required to recreate the question. This mechanism also has a policy where no question can be repeated. If a question is repeated, any student or instructor who first discovers the repeated question is required to highlight the question and then the student who created this question is required to recreate a new question.

Small size classroom implementation

The speed learning method was applied in an industrial engineering course at the University of

Minnesota Duluth that consisted of nine students including one distance who joined the class via Google Hangouts. The students in the class included both graduate students in an Engineering Management program as well as undergraduate students in Industrial Engineering and Industrial Engineering/Mechanical Engineering double majors. The details of the implementation are outlined as follows:

Stage 1- Creation: The students on campus work in assigned pairs to develop questions while the distance student works alone. A Google document is shared with students prior to the class and students are asked to come up with questions (using web, textbook, notes) related to specific chapters, which they add to the shared documents. These questions, which must be related to the course content, can be multiple choice and open-ended questions. Each pair is required to come up with at least four questions (2 for each type of question), while the distance student comes up with at least two questions. A first-come-first-served basis is applied, whereby students can not repeat questions that have already been previously entered by other pairs. For the first quiz, all the questions are created during class and students are given about 10-15 minutes for this part of the activity. For subsequent quizzes, some students started creating questions prior to class but most of the question creation occurred during class.

Stage 2 - Learning and Revision: After the questions are created, the instructor and the students spend about 10 minutes studying the questions and revising some of the questions to improve clarity. In addition, the revision of questions allows students the opportunity to go through the questions and prepare for the upcoming quiz but also to practice how to write succinctly and clearly, a skill that is increasingly critical in the STEM workplace. This revision also emphasizes the importance of the quality and consistency of questions created by students.

Stage 3 - Quiz: Once the learning and revision part of the activity is over, students are given a quiz on selected questions from the material that was covered.

Stage 4 - Evaluation: The quiz is graded by the instructor and returned to students to review. For this course implementation, four quizzes are given and are assessed as 40% of the class participation grades or 4% of the total course grades.

Analysis and discussion of the small size classroom implementation

The objective of implementing this method in the classroom was to increase engagement in a class that already had multiple active learning activities incorporated. Given that the class met once a week at 6 p.m. for 160 minutes, it was very important to devise new ways to keep the students active in the classroom. This method was applied in a limited manner in this classroom with the aim of obtaining feedback from students on this first implementation, which will then be incorporated into a second expanded implementation the next time the class is taught. At the end of the semester, students completed a web-based anonymous survey aimed not only at gathering feedback on this specific teaching/learning strategy but also at providing some insight into how students perceived the effectiveness of this strategy relative to other activities in the class.

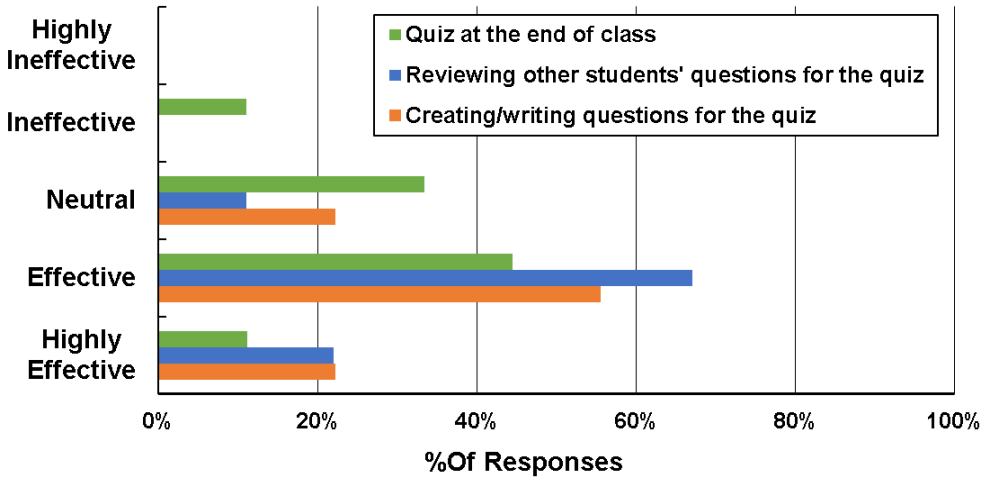

Figure 1: Student perception of the effectiveness of specific speed learning activities in helping them review and learn course concepts (9/9 respondents).

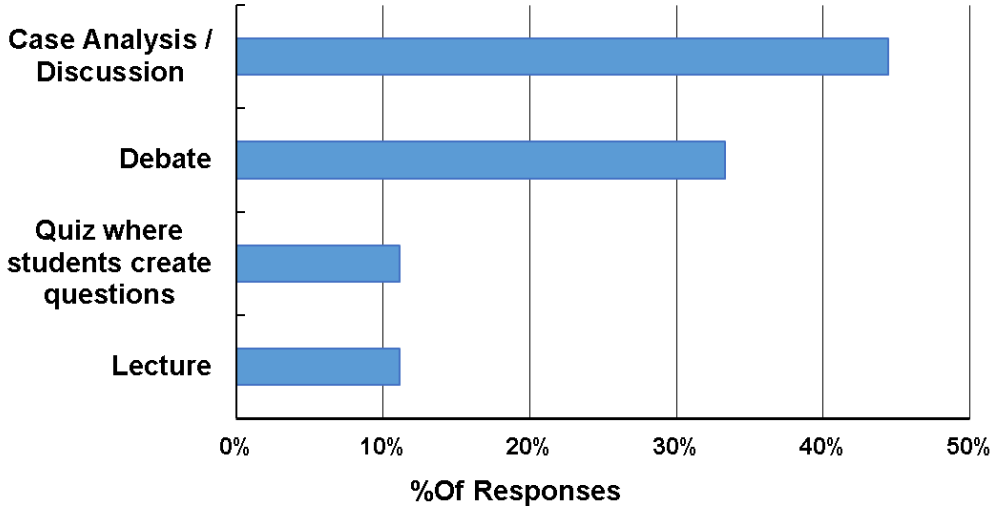

Figure 2: Student perception of the class activity that was most helpful for learning course concepts (9/9 respondents).

The results of the survey show students' perceptions of the effectiveness of the method with regards to reviewing and learning the topics in the course. As shown in Figure 1, most of the class thought that the speed learning method helped them master the subject effectively. Eighty-nine percent and 79% of the class indicated that the creation of questions and reviewing other students' questions respectively was either effective or very effective in reviewing and learning the course materials. Roughly 56% indicated the same for the associated quiz. When compared with other active learning activities in the class, 100% of the students indicated that the debates between students on concepts covered in the classroom were either effective or very effective in learning the concepts covered in the class. In addition, 89% of students indicated that the case analysis and discussion were effective or very effective. These responses are also reflected in Figure 2, where the aforementioned activities are ranked higher than the quiz with student

created questions which students indicated are as useful as the lecture. On closer examination, feedback from students indicated that they felt that more time was needed to complete this activity, particularly the quiz, in order to increase the effectiveness. Since the speed learning was usually the last activity in the class, students indicated that additional time for the quiz, in particular, was necessary.

Medium size classroom implementation

In this section, we discuss how the speed learning approach was modified and implemented for a medium size class with 41 students at the University of Minnesota Duluth. The course was a required second-year course and was mainly composed of sophomore and junior computer science students.

The original speed learning system worked well if the class size was small, but in a class of 41 students this approach was inefficient for two main reasons. First, the students did not have sufficient time to review all the questions created by their classmates. Secondly, the instructor did not have sufficient time to review and select the questions for the quiz. To fix these shortcomings so that the speed learning method can be used for a class between 15 and 60 students, the discussion was moved to an online medium, Google Docs. Google Docs can be shared with an unlimited number of participants and hence is suitable to be used as the medium to create the questions and answers. Another advantage of using Google Docs is that the participants can edit the doc simultaneously and see the edits being made in real time. Similar to the speed learning method, the modified approach for medium sized classrooms has four stages, the details of which are discussed below.

Stage 1 - Question Creation: A Google Doc is created on the first day of the week and the students are asked to form groups with no more than 3 students to create questions and answers related to the material covered in class for the given week. The allowed formats of these questions are short answer and multiple choice questions. Several sample questions are shared with the students in addition to questions from quizzes from previous implementations. The students are encouraged to use multiple types of resources such as textbooks, the internet, lecture notes, online course materials, etc. This broadens their perspective on the materials and helps develop self-learning skills. Each student is required to create one question along with the answer for a total of 41 questions and answers.

The instructor monitors the Google Doc frequently and highlights any questions that are not related to the materials covered during the week, offers suggestions, and flags any repeat questions. To encourage and motivate the students to create challenging questions, extra credit is offered for every 5 challenge questions created by them. The instructor would identify the challenge questions. This helps to maintain the quality of questions being posted. In addition, it is easy to review who creates which question and also view a timeline of the edits to the Google Doc. This helps to ensure that students take responsibility for the questions they create and that no inappropriate questions are posted.

By moving the discussion out of class it gives the students sufficient time to create questions and helps to ensure the questions are not repeated. This mechanism is applied to a Monday/Wednesday/Friday class schedule. Since the quiz is administered on Friday the students

have ample time to create questions, as long as they are submitted before noon on Thursday.

Stage 2 - Learning: The deadline for the question creation is set to noon on Thursday so the students can review the questions and answers created by all their classmates until the class period on Friday when they take a quiz. This also gives enough time for the instructor to vet the questions and answers created by the students and also prepare the quiz.

Stage 3 - Quiz: The process of speed learning culminates in the administration of a quiz. The instructor creates a quiz with 10 questions out of the 41 questions from the Google Doc. The students are encouraged to work in their teams to answer these questions. They were allowed to discuss the questions and share their answers. This better reflects learning and problem solving in real-world environments, where access to resources is not restricted. The goal of the quiz is not to test how well the students can memorize the material.

Stage 4 - Evaluation: This modified method for medium class sizes retains the same quiz grading process used in the original speed learning method. After the quiz the students are instructed to swap their quizzes and grade each other's work, further reinforcing the material covered.

Analysis and discussion of the medium size classroom implementation

Three mechanisms were employed in evaluating the modified speed learning teaching method for the medium class size implementation. First, after the course was completed the instructor met with students and conducted a verbal evaluation. Most of the students spoke up and described the pros and cons of the speed learning mechanism. The pros identified were that this mechanism helped solidify the materials covered each week. The students did not feel stressed despite being tested every week. They felt confident because they could rely on their teammates. When it came time for the final exam they felt that they had to do minimal preparation. The students also said that they looked forward to creating questions so they could challenge their classmates. They mentioned that they were not afraid of the quizzes, and although they ended up spending more time creating the questions and answers, they never felt it was a burden. Most importantly, all of the students said it helped them stay on top of the materials and they did not want to miss any classes. The students were happy to learn in short amount of time. They felt they were more productive in terms of learning and were more focused due to the mechanism. The students also identified cons, such as students putting questions up late leaving insufficient time to prepare for the quiz. Another con identified by the students was the student to student feedback mechanism where the students considered it to be unpleasant occasionally. The second mechanism of evaluation was the faculty evaluation where students have an opportunity to anonymously evaluate this system. All students wrote that the quizzes were the best part of the learning and it helped them feel confident and stay in tune with the class. They stated that they loved the quizzes and learned a lot from repetition during the creation of the questions and answers, during the review, and during the quiz. Lastly, the final mechanism of evaluation was a survey given to the students to evaluate the modified speed learning mechanism. The survey results are described below.

The students were asked the following questions:

1. Rate the effectiveness of speed learning mechanism in helping you review and learn the

topic presented in class

Result: 100% of students thought the method was highly effective. None of the students found the mechanism to be ineffective.

2. To what extent did you learn from your classmates

   Result: 100% of students experienced high extent of learning from their classmates

3. The speed learning quizzes help me learn my course material better
4. The speed learning quizzes help me understand my course material better
5. I do not get nervous during the quiz

Results for questions 3-5 are shown in Figure 3.

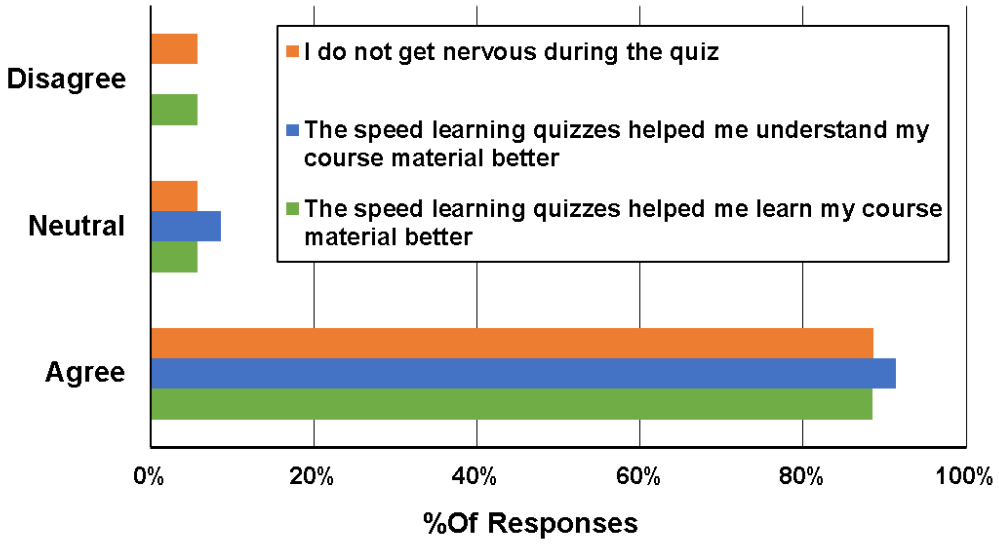

Figure 3: Student perception of the effectiveness of implementation (20/41 respondents).

There were 90 and above percent of students who agreed and strongly agreed to the speed learning mechanism helping them learn and understand the material. In addition, 90% of the students did not get nervous during the quiz, indicating a lower stress assessment mechanism. As evident from the evaluation the students found the modified speed learning mechanism to be beneficial to them in learning and understanding the class materials better. They also found that they learned from their classmates reinforcing the class materials through repetition. This made the students feel less nervous and more confident during the quizzes. From the evaluation results, it is apparent that modification of the speed learning mechanism where the question and answer creating was moved out of the class period time made it more effective in a medium size class. This avoided issues such as insufficient time to create the quizzes and review the questions created. This also gave the instructor sufficient time to review the questions and answers and ensure quality control on the questions and answers created by the students. In addition to learning and engagement, the modified speed learning mechanism also mimics the real world environment where employees work in teams to accomplish tasks and projects during which they have access to all resources. The students are exposed to teamwork and experience the

significance of soft professional skills such as teamwork, collaboration, critical thinking, conflict resolution, and adaptability. The students were able to learn in short amount of time due to the short bursts of repeated learning that was reinforced by this mechanism. Time is of utmost importance and helping develop mechanisms that help shorten the learning time and build confidence is increasingly significant in the current time.

Large size classroom implementation

A difficulty that arises when implementing the speed learning teaching method is that it quickly becomes infeasible as the class size increases. For large classes the level of coordination and time required to create and evaluate such a large volume of unique questions is prohibitive. However, the method can be adapted and the benefits of the question & answer learning style can be realized for large classes by moving the forum for discussion from the classroom to an online social platform. Repurposing online social platforms for education is not a new concept for students. In fact, it is not uncommon for a new cohort of University of Waterloo undergraduate students to actively maintain a closed online discussion group (e.g., Facebook) to communicate class news, course-related Q&A, and other discussion. Instructors are rarely included in these existing conversations. Students who use these online groups to ask course-related questions enjoy the benefits of peer-to-peer learning and convenience of obtaining quick answers without having to leave their study area, but at the possible cost of accuracy and completeness of response. This presents an opportunity to create a formal discussion forum that can be actively moderated by the instruction team and used for question & answer style learning.

While the modified method uses the same four-phase implementation as the original speed learning method, the objectives of the modified method are less concerned with learning things quickly and more concerned with increasing students' active involvement/engagement with the material in a large class setting. The adapted 'online discussion forum' was put into practice for a first-year mechanics course at the University of Waterloo for a class of 120 civil engineering students. A detailed explanation of intended outcomes and the methodology for evaluating the efficacy of the adaptation are presented in this paper.

The website "Piazza" is used as the online gathering place for students to ask and answer questions with their peers. There are other online platforms, but Piazza was selected for its user-friendly interface and broad functionality. Instead of creating questions and answers in class with Google Docs (as done in the traditional speed learning method), students are instructed to use Piazza outside of class to analyze and broadly investigate a given topic by asking and answering relevant questions. Similar to the speed learning method, the procedure for implementing the online discussion forum is broken into four components: Creation, learning, testing, and evaluation. A description of each phase is provided as follows:
Stage 1 - Creation: In the creation phase students are required on an ongoing basis throughout the semester to contribute on Piazza in one of four ways: a) posing a question or problem directly related to topics covered in lectures; b) asking a follow-up question to another question; c) answering a question; or d) improving upon another response. To ensure high quality of questions are being asked, the teaching team (composed of the instructor and four teaching assistants) actively monitors the questions as they are being posted, and flag anything that is incorrect, repeated, or too simple. Students are encouraged to work in groups and discuss their ideas while creating the questions and/or answers. The questions that students create are

primarily concept or problem-based questions related to the course content being covered in class (i.e., some topics are better suited for theory or concept based questions as opposed to problem or application questions). In cases where the instructor notices lack of depth in the questions, they can stimulate the discussion by injecting deeper questions on Piazza without providing the answer.

Stage 2 - Learning: The second phase, learning, happens periodically throughout the term in the day(s) before upcoming mini-tests. Students are given a schedule of when mini-tests occur at the start of the semester. In this phase, discussion on Piazza is frozen, and students are given the opportunity to study each other's questions in preparation for the mini-test.

Stage 3 - Quiz: In the third phase students are required to take the test (individually), where the questions in the quiz will be only from the list of questions on Piazza.

Stage 4 - Evaluation: The fourth and final phase is evaluation, where the quizzes are graded by the instructor and students receive feedback.

To assess the effectiveness of the online discussion forum both quantitative and qualitative data are collected to evaluate if the intended learning outcomes are being achieved. The statistics collected by Piazza on an ongoing basis make it easy to quantify how the platform is being used. In particular, the instructor monitors the following individual student statistics: number of questions posted, number of questions marked as "good" (upvoted questions), number of questions answered, and number of endorsed answers (upvoted answers), and total number of contributions (posts, responses, edits, follow-ups, and comments to follow-ups). These statistics are used as an indicator of the students' active participation in the discussion with their peers. The number of questions answers and endorsed answers reflects upon the student's' successful effort in self-directed learning, as incorrect answers will be flagged as such for revision. The qualitative effectiveness of the project is assessed through student surveys, where students are encouraged to answer survey questions and write about the pros and cons of the model. This feedback is a valuable asset to study the effect of the proposed methodology and the possibility of improving it in the future.

Analysis and discussion of the large size classroom implementation

The main learning objective was to increase the level of engagement and active interaction with the material. To evaluate the success of the implementation in meeting this objective the number of contributions and votes in the discussion forum was used as an indicator, to reflect the level of active participation and interest in the discussion. Overall, the instructor was pleased with the ~1400 contributions made in the 12 week time period. There were expected spikes in usage around test times, but questions were asked and discussions took place throughout the entire term. The quality of responses by the students to each other's questions was very good, and the response time to questions was only 38 minutes (indicating a high level of engagement). One explanation for low response times is the use of the Piazza mobile app which lets students view and answer questions away from their computers. Some notable results on student perception of the effectiveness of the implementation are given in Figure 4 and Figure 5.

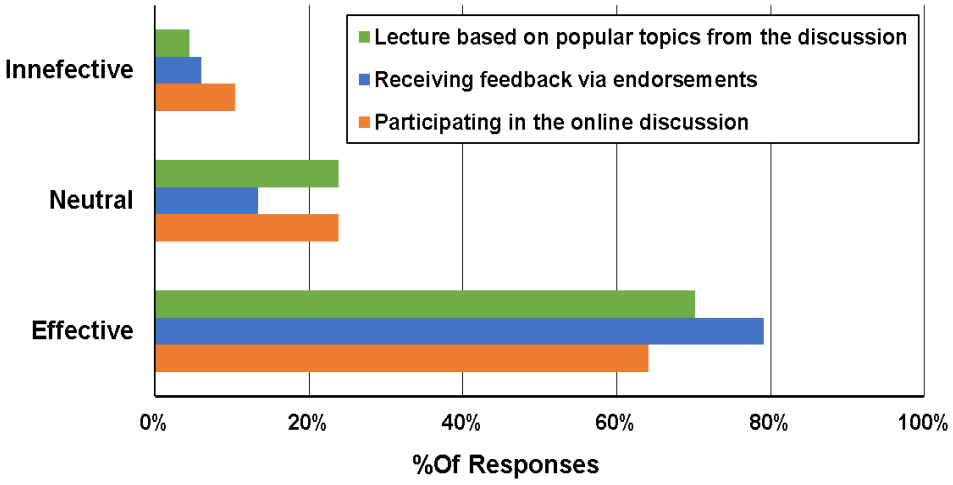

Figure 4: Students perception of the effectiveness of online discussion forum for (a) Having lectures based on popular topics from the discussion, (b) Receiving feedback via. endorsements, and (c) Participating in the online discussion (67/120 respondents).

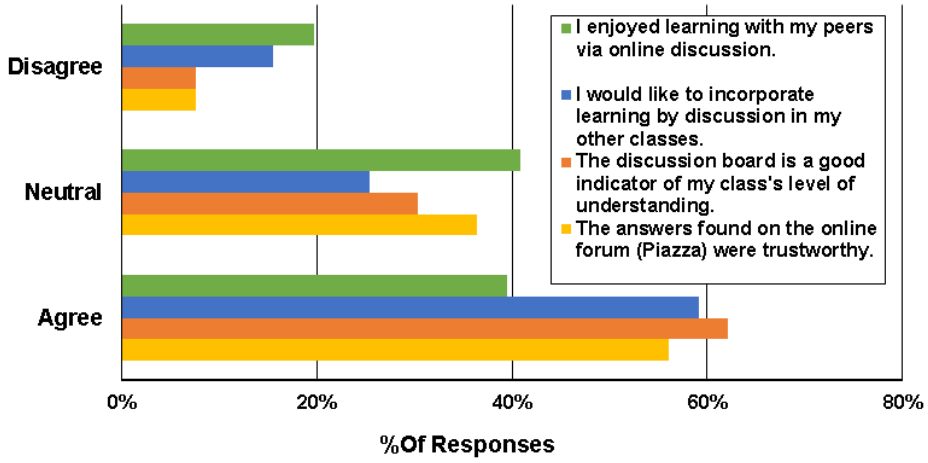

Figure 5: Student opinion on use of online discussion forum: (a) I enjoyed learning with my peers via online discussion, (b) I would like to incorporate learning by discussion in my other classes, (c) The discussion board is a good indicator of my class's level of understanding, and (d) The answers found on the online forum (Piazza) were trustworthy (67/120 respondents).

Any time an online platform is incorporated in the classroom there is concern that technical difficulties will deter participation. To facilitate students becoming accustomed to using the Piazza platform the instructor enforced that all course-related correspondence and Q&A from the beginning of the term must be asked through Piazza, as opposed to direct email. Instructions on how to use Piazza were also made available at the start of the term. In the post-course survey, 83% of the class indicated that they did not have any trouble setting up and learning to use Piazza, and 76% thought that Piazza was a good platform for online discussion. It is worth noting however that for high volume classes the workload for maintaining an organized and high-quality forum increases for the instruction team. Students should be instructed on the use of 'topic' folders which help group related questions and discussion, and question tags which also help other students and the instructing team filter through the high volume. Students can also be

given the ability to flag questions as incorrect or too simple so that the instruction team only needs to monitor these posts. One concern raised by students in the post-course survey was abandoned or 'orphaned' questions, i.e., questions they would ask which didn't receive an answer or weren't followed up on. By updating posts with [Answered] or [Unanswered] tags, it is easy for everyone to focus on active questions and discussions.

A benefit of conducting the discussion forum online is that students have the option to appear anonymous to their peers when asking and answering questions. This provides students who may be uncomfortable voicing their opinion in a classroom the opportunity to gain confidence by asking questions and exploring their own understanding. The survey results support this claim, as ~90% of students agreed that "Having the option to post anonymously motivated me to participate more freely". Another benefit that arose from the online environment is the intrinsic motivation to participate that students gained from having their questions and answers endorsed by other students and the teaching team. This is a familiar concept with students as variants of voting-based discussion are a major feature in popular social media–notably, Facebook, Instagram, and Reddit–and commonly used in online Q&A resources such as Yahoo Answers and Stack Overflow. These votes also let the instructor to quickly identify problem areas and promotes time-saving for students as they can quickly find the most endorsed answer.

Conclusion

Although the implementations for UMD and UW have differences, the core use of an online platform to facilitate question and answer discussion is very similar. As such, it is not surprising that the positive benefits observed by the instructors have significant overlap. In these cases, the procedure exposes students to a process where their knowledge and understanding is continually reinforced. In all three implementations regular testing based on the question and answer discussion was effective for improving students perceived understanding of course materials, and working with their peers motivated students to participate (e.g., wanting to create good questions, or answer questions). Students in these implementations were also more actively engaged in learning the material.

Despite the positive outcome of the implemented approach in the small industrial engineering class at UMD, the medium computer science class at UMD, and the large civil engineering class at UW, there is always room to improve. The main concerns were related to reducing the amount of work for both the students and instruction team. Naturally, as the class size gets larger the number of questions grows. In the large classroom, this meant students were reviewing a significant number of questions for each mini-test, which could be counterproductive. Even though mini-tests were scheduled less frequently (not every week), some students still found this overwhelming. Monitoring the forum also becomes strenuous on the instruction team, as they must ensure that the quality and accuracy of the questions, answers, and discussion remain high. The workload for the students is minimized by giving students the option to answer questions for participation instead of asking questions. In future implementations, other options will be explored, such as making participation on the forum voluntary, or grouping students together and requiring participation on a group basis rather than on an individual basis. These implementations will continue to be modified and improved as more results (student feedback, quantitative measures, etc.) become available.

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References

[1] Felder, Richard M., and Linda K. Silverman. "Learning and teaching styles in engineering education." Engineering education 78.7 (1988): 674-681.

[2] Chiaravalloti, Nancy D., et al. "Can the repetition effect maximize learning in multiple sclerosis?." Clinical rehabilitation 17.1 (2003): 58-68.

[3] Petten, Cyma Van, et al. "Fractionating the word repetition effect with event-related potentials." Cognitive Neuroscience, Journal of 3.2 (1991): 131-150.

[4] Pashler, Harold, and Gordon C. Baylis. "Procedural learning: II. Intertrial repetition effects in speeded-choice tasks." Journal of Experimental Psychology: Learning, Memory, and Cognition 17.1 (1991): 33.

[5] Jones, Melanie S., et al. "Can vocabulary-learning strategies and pair-learning formats be profitably combined?." Journal of Educational Psychology 92.2 (2000): 256.

[6] Khan, A. A., & Madden, J. (2016). Speed learning: Maximizing student learning and engagement in a limited amount of time. *International Journal of Modern Education and Computer Science (IJMECS), 8*(7), 22.

[7] Johnson, D. W., Johnson, R. T., & Smith, K. A. (1998). *Active learning: Cooperation in the college classroom.* ERIC.

[8] Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. *Review of Educational Research, 69*(1), 21-51.

[9] Golub, J. (1988). *Focus on collaborative learning. classroom practices in teaching english, 1988.* ERIC.

[10] Cheng, C. K., Paré, D. E., Collimore, L., & Joordens, S. (2011). Assessing the effectiveness of a voluntary online discussion forum on improving students' course performance. *Computers & Education, 56*(1), 253-261.

[6] Davies, J., & Graff, M. (2005). Performance in e-learning: Online participation and student grades. *British Journal of Educational Technology, 36*(4), 657-663.

[12] Hemmi, A., Bayne, S., & Land, R. (2009). The appropriation and repurposing of social technologies in higher education. *Journal of Computer Assisted Learning, 25*(1), 19-30.

[13] Larkin-Hein, T. (2001). On-line discussions: A key to enhancing student motivation and understanding? *Frontiers in Education Conference, 2001. 31st Annual.*

[14] Palmer, S., Holt, D., & Bray, S. (2008). Does the discussion help? The impact of a formally assessed online discussion on final student results. *British Journal of Educational Technology, 39*(5), 847-858.

[15] Paterson, K. G. (1999). Student perceptions of internet-based learning tools in environmental engineering education. *Journal of Engineering Education, 88*(3), 295.

[16] Seethamraju, R. (2014). Effectiveness of using online discussion forum for case study analysis. *Education Research International, 2014.*

[17] Wu, D., & Hiltz, S. R. (2004). Predicting learning from asynchronous online discussions. *Journal of Asynchronous Learning Networks, 8*(2), 139-152.

[18] Kaye, A. (1989). Computer-mediated communication and distance education. *Mindweave: Communication, Computers and Distance Education*, 3-21.

[19] Hara, N., Bonk, C. J., & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science, 28*(2), 115-152.

[20] Cotton, D. & Yorke, J. (2006). Analysing online discussions: what are students learning? Paper presented at the 23rd Annual Ascilite Conference: Who's learning? Whose technology? Sydney University Press, Sydney, Australia.

[21] Conaway, R. N., Easton, S. S., & Schmidt, W. V. (2005). Strategies for enhancing student interaction and immediacy in online courses. *Business Communication Quarterly, 68*(1), 23-35.

[22] Marra, R. M., Moore, J. L., & Klimczak, A. K. (2004). Content analysis of online discussion forums: A comparative analysis of protocols. *Educational Technology Research and Development, 52*(2), 23.

[23] Mayer, R. E. (1983). Can you repeat that? Qualitative effects of repetition and advance organizers on learning from science prose. *Journal of Educational Psychology, 75*(1), 40.

[24] CEAB (2015) Canadian Engineering Accreditation Board Accreditation Criteria and Procedures, Ottawa: Engineers Canada.

[25] Scalza, A. (2011). Group dynamics: Predicting member performance. *ASEE Middle Atlantic Regional Conference*, Farmingdale State College, SUNY.