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Engaging Engineering Students in Lectures Using Anecdotes, Activities, and Games

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Abstract:

Students being engaged in lectures plays a big role in their learning process. Students come to lectures sometimes tired, bored, or just have lots of things going on in their mind, either personal, or course/program related, etc. As such it is important to set their mind clear to be ready to digest the new material they are going to learn in the course. It is also important to excite them enough to come to early morning classes and keep their attention to stay in the late afternoon classes while staying focused.

This paper discusses the use of different methods to increase engagement, attention and attendance in class and the students' reflection on these methods. Some of these engagement pieces are directly course related and some are just general engagement information. Two instructors used these methods in second and third year engineering courses. The engagement pieces included: mini-games at the beginning of the lecture, unrelated anecdotes in the middle of the lecture, and semi-related special information pieces. All of these are being part of mechanics courses taught in civil, mechanical and mechatronics engineering programs.

Examples of these mini-games include: centroid-balance games, where student participate in groups reinforcing their group dynamics, or "guess the unit games" where students participate individually using Kahoot! website. The instructors also used anecdotes such as the etymology of Greek letters and the effect of climate change. In the other attempts, instructors showed short videos of special mechanisms/machines to emphasize a broader application of the topic that they are learning.

The students were enthusiastic about these engagement pieces (EP) and they mentioned the positive effect it had on their learning. They were looking forward for these EPs, and were asking that they should be used in other courses as well. The use of these EPs also improved instructors' course evaluations.

Introduction

Engineering programs have been growing and student enrollment increasing leading to large engineering classes (more than 100 students). With time, instructors have more and more been resolving to the lecture style, where the instructor lectures at the students with little or no interactions. This led to a distant relationship between the instructor and students and less engagement in the classroom. The requirement for EPs that would help keep student attention with the lecture was obviously needed. This paper discusses some EPs that were used in large classrooms to gain students' attention and engage them through the lecture.

Students learn from many ways, they can learn from their senses, model making, reflection, and they can also learn from games. It is important but extremely hard for a teacher to adopt a teaching style that is compatible with all these different learning approaches. Felder and Silverman (1988) pointed out the mismatch of teaching and learning styles has significant influence on the learning outcome and thus individualized teaching style is recommended. However, for a large class, it is impossible to teach the student base on individual preference. Lecture is mainly the base for the large class. Unlike classes of smaller size, activity in large-sized classes cannot guarantee that all students were actively involved, but it can eliminate the situation that no student was involved (Lammers & Murphy, 2002).

There are many suggestions on how to actively engage students in larger classes. Comparing to the traditional teacher-centered lectures, a lecture with more collaborative activities delivers the course content much more effectively to the students (McCarthy & Anderson, 2000). Promoting active learning in the classroom and encouraging student to cooperate with each other during the activities were recommended by Felder Woods, Stice and Rugarcia in 2000. They also suggested balancing the concrete and abstract class material in each lecture.

In recent years, gamification became a hot topic at the center of many educational discussions, especially those related to students' engagement during the lectures (Kim, 2015). An example of gamification in class is experience points, which can be rewarded to students so that they will have the feeling of accomplishment when they are doing the tasks (Dicheva, Dichev, Agre, & Angelova, 2015). The goal of gamification is to improve learning and problem solving using game-based mechanics (Kapp, 2012). Rieber (1996) pointed out that playing is a powerful mediator for learning and he suggests designing an interactive learning environment for students. To design an educational game that suitable for the learning content is not easy. There are many variables needs to be considered such as the students' characteristics, their academic standing and more importantly, the learning content itself (Kim, 2015). Kim also points out that currently, gamification is not only being applied in the lectures, but also in many other areas, such as software and libraries.

Research indicates that the quality of students' concentration varies in the duration of the lecture, and it also depends on when the lecture take place in a day (Raviv & Low, 1990). Raviv and Low (1990) pointed out that the main influence on students' concentration is the time of day, and the quality of concentration seems increased towards the end of the lecture. The quality of concentration can also be amplified through gamification in classrooms (Premarathne, 2017).

The paper discusses the different engagement methods that have been used in large second and third year engineering courses. Methods used varied depending on the class starting time and the instructor. Some activities were course-related and others were not course-related. The main objective was to help with student attention and increase their engagement in the course material.

Implementation and Different Methods Used

I) Course-related Kahoot! game in an early morning class

One Implementation was in a second year civil engineering solid mechanics course with 165 students enrolled. The fact that the class was offered at 8:30 a.m. in the morning caused the instructor to think of methods will cause students to arrive to class on time and start the class with high energy. This was the starting objective behind initiating the mechanics games. During the first month of class, the instructor started with physical activity games, where three to four groups were asked to participate. The group names were picked up at random. The games normally start at 8:20 a.m. so as not to take time from class. When the course material taught in class was related to centroid and center of mass, the games were focusing on balance, examples include stacking apples with a limited time, or stacking nuts or balancing a coke can on its edge. When talking about moment of inertia, building the highest tower with a stack of paper was introduced. They were able to fold the paper into any shape they want to increase its stiffness and allow them to aim for taller towers. When the section for reviewing Shear force diagrams (SFD) and bending moment diagrams (BMD) came, the game was related to SFD and BMD. Three groups were asked to come to the front, each using one board, and they were given a sheet with two sets of loading to draw the SFD and BMD on the board. The team that finished first and had all correct answers was the winning team. Later on in the term, the instructor started online games using "Kahoot!". This allowed the whole class to participate instead of just few picked groups. Students had to come early at 8:20 a.m. to be able to participate. The "Kahoot!" games consisted between 5 and 10 questions related to mechanics concepts taught in the course. Mainly it would be reviewing concepts covered in the previous session. Examples include concepts of shear stress, shear flow, torsion, etc. The advantages of using "Kahoot!" is that it informs the class who are in the top five after every question. The top 5 normally changed after each set, keeping the competition and the energy high in the room. The winners in each game were normally given small rewards, which could be candy, puzzles or any sort of small gifts. These games helped ensure the class start on time, but not only that, the energy level was high allowing students to engage with the mechanics concepts. Students commented that when finding it hard to wake up in the morning to come to class, they would think of the games and that would push them to come to class on time. During the end of the term the students were asked to answer the following questions while commenting on their course evaluations: "How effective or not were the mini-games in engaging you in the class? Comment!"

The positive feedback from the students was overwhelming. Examples of these comments include:

"The games and music in the morning keep us engaged and are a good way to grasp our attention in the morning"

"Kahoot … is a nice start to an 830 class to wake up"

“Her Kahoot games are good way to relax and relieve stress while still learning and having fun”

“The games in the morning are really motivational”

“Mini games were awesome”

Although all the students who responded enjoyed the games, there are some students who commented that it took some of class time, as in a couple of cases the games took 10 minutes of class. Reinforcing that these games will help them review the concepts could have helped these students not be worried about the time the games cut into class.

II) Course-unrelated anecdotes and course-related EPs

Another implementation was in a third year mechanical engineering course, Mechanical Design I, with 114 students enrolled. Two sets of EPs had been considered to keep the students engaged. One set was some anecdotes unrelated to the topics of the course, while the other set of EPs was related to the course subjects. In this course the instructor received the score of 95.4% for the quality of teaching and the average of 93.3% in nine other fields (such as organization, clarity, explanations, enthusiasm, class relationship, etc.), which makes an overall score of 94.2% (in fall 2017). A term before (winter 2017), the instructor intentionally didn’t use any of the EPs and he received the overall score of 84.2%. It’s very difficult to show that the 10% increase was just because of Eps, but they definitely played a very important role. In the fall 2017 the average grade of 113 students was 76.8%, while in winter 2017 the average grade of 93 students was 70.4%, which shows a significant increase of 6.4%.

In the following both sets of above mentioned EPs are explained separately:

II-a) course-unrelated anecdotes

Five to ten-minute anecdotes were prepared on different topics, which were chosen not to be related to the mechanical engineering content. The anecdotes were used by the instructor whenever the lecture became so intense or very rich in formula and the students lost their attention. One of the anecdotes was about the history of the letters, the origin of them, and why Greek letters have names; for example why they are called, alpha, beta, gamma, etc. It was a short linguistic lecture on Semitic Phoenician Abjad, Greek, and Roman letters which are adopted in English language. The other anecdote was about global warming and what happens if all the ice caps get melted. A hypothetical map of the world showed what the world would look like if all the ice melted. It was shown that almost all major cities will be drowned under water. In another anecdote the southwestern Ontario was compared with other parts of the northern hemisphere latitude-wise. It was shown to the students that the very southern part of Ontario has the same latitude as Nevada desert and north of California or the same latitude as Rome, then it was explained why southwestern Ontario is much colder.

The students were asked to leave comments on the evaluation forms about both sets of EPs. 83 students out of 114 (72.8%) filled out the forms and all of these 83 students left positive comments on instructor's teaching style and EPs. Based on the comments, all of the students enjoyed the anecdotes and they found them very engaging and help them to grasp their attention. But two students mentioned the anecdotes were not relevant to the subject, although they wrote positive comments:

"Anecdotes were catchy and cute in class but not really useful for studying purposes."

"Some anecdotes were effective but only when they relate to the course content. […] In the past the one on global warming was interesting but not relevant to course content."

In the following I copied four of the students' supportive comments (out of 81):

"Really enjoyed the extra snippets of information or videos that he showed and talked about. Most of them related to the course and contributed to my interest in this course. And the topics not related to this course, global warming etc. were also really interesting and showed me that the prof is really passionate about students learning, learning more than just what's required of the course."

"Prof Ghavam is enthusiastic about teaching this course and it really shows in his teaching style. The anecdotes/videos were very engaging when it came to grasping my attention. It really showed how MODS [Mechanics of Deformable Solids] can be related to everyday life. I especially enjoyed Kamyar's explanation about the origin of Greek letters!"

"Keeps us engaged with other content/mini lectures into stuff that may not be 100% course relevant but regains our attention and ultimately keeps the course interesting."

"Professor, I believe your use of anecdotes was effective in drawing the attention of the class and throwing in a different element to the general engineering theory that was refreshing. I appreciate the effort you put into engaging the students. […]"

II-b) course-related EPs

Some course-related activities were used to make the lectures more interesting and rich of context, and keep the students engaged. As an example, a guest speaker was invited to give a mini lecture on a real-life design problems on fatigue (one of the subjects of the course). The guest speaker talked about a mining factory and the fatigue problem in the exhaust fans and how they could solved the problem. It was so interesting to the students to see the equations they have just learned, were used in a real-life engineering problem. In the following you can see some of the comments regarding the guest speaker.

"It was really neat when Leif [Mr. Leif Falk the guest speaker from WATiMake lab at the University of Waterloo, Mechanical and Mechatronics Engineering (MME) department] came in

to talk about his time in the mining facility working on the exhaust fans there. More of those speakers would be really nice to have in the course."

"The guest speaker was also extremely interesting, and a very, very valuable addition to the course. It's really exciting to see the actual application of what we're learning."

"The lecture given by the guest speaker regarding fatigue in fan blades was extremely well done and I believe the entire class was talking about how cool it was to see that concept play out in a real world scenario."

In the MME department at the University of Waterloo, there is no lab associated with the Mechanical Design course. If the students could see a real fatigue test they would have learned the subject much better. This is the reason why throughout the term some course-related videos (10 to 20 minutes) were played for the student to learn the concepts better.

Moreover, some hands-on demos were made for the students to understand the stress distribution in a bolted joint. In the textbook it is just explained that a photo-elasticity method and a bi-refractive material is used to plot the stress distribution in a bolted joint. A bolted connection was made at WATiMake lab using two polycarbonate sheets (which are bi-refractive) and a set of a bolt, a nut, and two washers were used to join the sheets. A pair of 3D glasses and two wrenches were given to the students. By keeping the sheets in front of a polarized light, like a tablet or mobile phone screen, and tightening the nuts the students could see that the stress distribution in the polycarbonate sheets has a semi-conical (frustum) shape. In the following some of the comment are listed about the course-related EPs.

"The videos relating to the subject being discussed in class provides an immediate relation which helps to grasp concepts. Personally, as a visual person, I feel videos / photos are useful"

"The anecdotes and videos in class were incredibly effective in getting our attention and helping understand the course concepts. You went above and beyond what was required to keep us engaged."

"Videos etc. Were very useful to visualize the concepts we are studying. I thought the anecdotes/videos helped in keeping interest during the lectures. They provided a very nice change of pace as compared to the usual lecture format that professors follow. Additionally, the videos offered visual ways of observing the theory and concepts that are learnt during lectures. This helped in my personal understanding and I would encourage professor Kamyar to continue his great habits in teaching."

At the end this comment shows how both sets of EPs can be effective in increasing students' interest toward the course, and even can help the students get along outside the classroom:

"The anecdotes are actually incredibly interesting and thought provoking. In a class such as mechanical design where its more so of just following steps, it's hard to get the entire class to

engage in conversations but the Professor did a remarkable job at combining course concepts with the fields of art, language/literature and other fields of engineering which helps to get people with different mindsets to [get] interested to listen. This actually helped improve the in class relationship of the students in the class as well as people could observe fellow classmates have a spark ignited for a certain story (example: the anecdote about the sculptor using metals got quite a few people who never talked before to actually discuss about what they saw). All in all, I really hope more professors can do the same and relate broader concepts to their own courses to engage students."

Conclusion

Engagement methods used in the above classes were essential for student concentration and interaction with class material. The methods used varied with class time: some were used in the beginning of the class and others at the middle of the class time. The time when the course was offered was a major influence on when to add these engagement pieces. For early morning classes, for example 8:30 a.m., it was essential to engage the students at the beginning of the class. For courses happening at mid-day, engagement pieces were more essential at the middle of the course to keep the students attentive. In general, the students reacted positively to these engagement pieces, although some of them showed concerns about cutting into the class time.

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