

TEACHING A COURSE WITH ACTIVE LEARNING APPROACHES AND TRAINING OTHER TEACHERS ABOUT DEEP LEARNING STRATEGIES

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ABSTRACT

This paper describes different stages of teaching a course using active learning approaches. For this study author has utilized MECH 488 Fuel Cell Science and Technology course. This paper describes the strategies for developing a student active teaching approach that relies on promising syllabus, conceptual quizzes, peer interaction, self-reflection through an after class feedback form. This paper will elaborate on the structure and effectiveness of the feedback form aiming to improving the student attention and participation in the class discussions. To promote active teaching at university campus author have started conducting workshops on deep learning strategies. Content of these workshops are based the author's experience during active learning driven teaching.

1. INTRODUCTION

An active learning approach is considered a better means to teach course concepts more effectively than traditional lecture based teaching (Hake, 1998). Active learning is any activity that involves students in doing things and thinking about the things they are doing. Felder & Brent describe active learning as "anything courserelated that all students in a class session are called upon to do other than simply watching, listening and taking notes" (Felder & Brent, 2009). There are several strong reasons to advocate the selection of an active learning based class room teaching. An active learning approach can encompass both isolated and highly structured activities to motivate students to take charge of their deep learning (Prince, 2004). Active learning can be applied to both small (Prince, 2004) and big (Crouch & Mazur, 2001) classes; active learning was found to produce long lasting student learning as compared to the traditional lecture format based teaching (Thacker, Kim, Trefz, & Lea, 1994). Research studies show that the audience's attention in lectures starts to decline after 10-20 minutes (Crouch & Mazur, 2001; Johnstone & Percival, 1976; McDermott, 1991; Prince, 2004). Incorporating active learning techniques encourage student engagement throughout the class (Smith, Wood, Krauter, & Knight, 2011). Active learning also reinforces long term retention of course contents and concepts (Prince, 2004). During active learning students get more frequent and immediate feedback about the depth and accuracy of the material they are focusing (Hufnagel, 2011). An active learning approach is very effective in addressing students' stereotypes and different learning styles (Bain, 2012); a lecture based teaching may give nil to negligible consideration to these crucial factors in the student learning (Bain, 2004). Active learning can be very effective in creating personal connections between students and the course material, which strongly increases the student's motivation to learn proactively (Bain, 2004). In addition to the course content, active learning develops life skills like improving with others feedback, collaboration, and brainstorming to reach the

rational answers. An active learning approach also promotes a sense of community in the classroom by augmenting student-student and instructor-student interaction.

After realizing the aforementioned advantages author started learning various active learning approaches. To learn about various aspects of active learning he attended several workshops by a number of active learning proponents like Dr. Erik Mazur, Dr. Dee Fink, Dr. Prince, and Dr. Ken Bain. This paper discusses different approaches author have adopted for his class room teaching. Here author mainly focus on ‘MECH 488 Fuel Cell Science and Technology’ course which is an elective course and generally has a small enrollment. Effectiveness of various active teaching strategies was assessed by the means of surveys. These surveys were designed to keep responders unidentifiable and forms were filled in the absence of class instructor. Survey questions were to be rated on 1(ineffective) to 5(very effective) scale.

2. TEACHING STRATEGY

Before the commencement of this course in spring 2013, author explored the answers to the following questions: What are his student learning objectives for this course? How to understand student’s negative stereotypes and learning styles? How to connect students to the course topic early on to motivate them to learn

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course material? How to ensure students are present in the class? How to continuously motivate students to do their best without blackmailing them for grade? How to make learning fun in the class? How to effectively access and measure depth of their learning? The rest of this paper is organized as per the answers to these questions and the final outcome.

2.1 What are my student learning objectives for this course?

After completing this course author expects that students should be able to (1) understand global warming issues and how to address it by using renewable energy technologies like fuel cells, (2) understand the basic components and various types of fuel cells systems and have the ability to decide the suitability of these fuel cells for different applications, (3) understand the thermodynamics concepts behind converting chemical energy into electrical voltage, (4) understand the electrode kinetics concepts behind converting fuel into electrical current, (5) ability to design fuel cell components like electrodes and electrolytes to improve fuel cells, (6) characterize fuel cell systems and electrodes experimentally, and (7) communicate in writing and orally, the science and engineering concepts. After defining the course objectives author focused on the following question.

2.2 How to understand student’s negative stereotypes and learning style?

To understand students mentality and their level of preparedness author conduct a pre-course survey and ask questions, which directly or indirectly gauge students’ familiarity with the topic. Other questions focus on how they learn best, what is their primary motivation to attend this course etc. Author also asked about the students’ hobbies and their most cherished moments; discussing nontechnical points enable students to connect with other students and start becoming comfortable in communication. This survey contains direct or subtle questions to understand the students’ motivation and aptitude. In future author plans do icebreaker activity about course theme.

2.3 How to connect students to the course topic and learning objectives in the beginning of the class?

The Maslow chart is widely acknowledged to describe a hierarchy of needs which motivate humans to do any activity. The first three categories are considered basic needs and the last two categories are considered as higher level needs. Every student is different and presumably influenced by one or more categories of the motivations described in Table 1.

Table 1: Maslow chart of hierarchy of needs providing motivation for human action.

Order of motivation	Category of needs	Action
1	Physiological	Breathing, food, water, sleep,
2	Safety	Security of body, family, employment, health, property
3	Love and belongingness	Friendship, family, community.
4	Esteem	recognition by others Selfesteem, confidence,
5	Selfactualization	Inner bliss from own work, creativity, lack of prejudice

To connect students with the course content author start the first class by telling a motivational story that encompasses a wide range of the motivations categories mentioned in Table 1. This story is also known as ‘promising syllabus’ (Bain, 2004) and basically designed to boost student’s interest in the subject matter. The sample story that author used in spring 2013 and 2014 is the following:

Promising syllabus story for the first day of the class:

Question [1] Do you know about a special energy production technology that can power small appliances like laptops as well as giant industries; Do you know about a special energy production technology that can power simple automobiles to space exploring systems?

After responding to students answers collectively author steered students’ focus on the course topic and tell a vivid story.

Let me share one story of a struggling engineer who saw a new hope for his life and society in the fuel cell technology that you will learn from this course

Recently I met an engineer named John. After two years of service in a coal power plant, John lost his job in 2008. Actually, this coal power plant was a major culprit in polluting air and water and was no longer operational as per the new environmental regulations and economic reasons. John tried hard to get a sustainable and exciting job for the next six months. According to his credentials, he qualified for the job in a nuclear power plant. In spite of his unwillingness he had to accept the offer to serve as a process engineer in the nuclear power plant. Unfortunately, only after three months of working on the job this nuclear power plant started emitting radioactive pollutants due to a crack in the reactor. John was forced to quit the job with a small compensation.

Question#2: What will you do if you are in John's situation?

After commenting on students' responses I started telling the next phase of the story on what John did.

John started looking for a sustainable job once again. During this uncertain phase, John attended an open house about renewable energy and their social and economic benefits. However, John was suspicious about the fickleness of the renewable energy resources like solar and wind etc. But he decided anyway to explore career opportunities in renewable energy because this field is good for the environment and is rapidly growing.

Question#3: What are the main renewable energy technologies and what are their advantages? After commenting on students responses story progresses. Like you, John got impressed with the undeniable importance of renewable energy resources and technology.

John realized a new passion for becoming an expert in the renewable energy production. However, John wanted to make sure that his chosen area in the renewable energy field has robust and sustainable career prospects.

Question #4: If you were in John's place, what would you like to know about different renewable technologies before choosing one of them as your career?

After taking students' comments author steers their attention towards the unique advantages of Fuel cell technologies-the topic of this course.

For expert advice, he planned to visit the Mechanical Engineering department at University of the District of Columbia (UDC). One fine day John took a bus. From an informal discussion with the bus driver he came to know that this bus was using hydrogen as a fuel and emitted water, instead of carbon di-oxide that causes global warming. This water was so clean that he could fill it in a bottle and use it for different purposes. While travelling in this special bus he observed that a neighboring female passenger was working on a fancy laptop, which was powered by a fuel cell battery. John could not confine his curiosity about the fuel cell battery and he asked the lady about the advantages of fuel cell battery. John discovered that unlike a conventional battery, you can keep using a fuel cell battery endlessly, and hence they don't produce battery waste and heavy metal pollution. One only needs to refill hydrogen canister. Then, John arrived at the bus stop and walked across the street to catch a connecting bus. Right behind the bus stop was a superstore. Its signboard said that this superstore produces all the electricity within the store by a fuel cell generator. John really got pleasantly surprised that the same fuel cell technology that was powering a laptop was also powering a big superstore. Even before getting to UDC, John made up his mind to become an expert of this amazing technology, which is not only full of career prospects, but is also sustainable, and environmentally friendly.

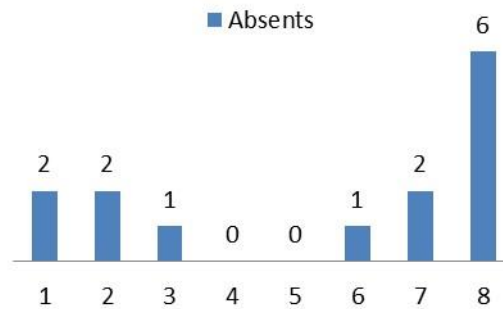


Fig. 1: Number of absents during MECH 488: Fuel Cell Science and Technology course, spring 2013.

Question #5: What will you do next if you are so excited about the career prospects of the fuel cell technology and its uniqueness?

Author steers students' attention towards understanding the fundamentals of this technology to become familiar with the key concepts.

Now dear students you have the opportunity to learn the core principles of the amazing fuel cell technology, which may empower you to solve some of the most pressing problems USA and global community is facing. I invite you to deeply understand the science and technology of Fuel Cells by actively participating in this semester long course.

In an after course survey five students, enrolled in 2014 spring, were asked to rate the effectiveness of promising syllabus in enhancing their interest in the course material. Students gave 4.4 ± 0.6 rating on the 1 to 5 scale. This data is in agreement with the previous research the 'promising syllabus' activity plays a pivotal role in connecting students to the course's mission. (Bain, 2004).

2.4 How to ensure that students are present in the class?

At UDC many engineering students work full time or part time. It is sometimes a challenging task to ensure their presence in the classes on regular basis. Active teaching strategies can only be effective if students are present in the class. To increase students' active presence author asked students to fill out a five minute survey form after every class; this survey form is given to students within the first 10 minutes of the class and is filled out in the presence of instructor. This survey has three questions. (i) What were the main concepts we discussed today, (ii) where can you apply these concepts, and (iii) do you have any questions about the concepts we discussed today. These after-class surveys are graded after each class and account for 10% marks counted toward their grade. Before author started using these surveys students typically missed ~10 classes/semester. These surveys helped reduce the absence (Fig. 1). Figure 1 indicates that only one student missed more than two classes. Average absents per student in the MECH 488 Fuel Cell Science and Technology during 2013 spring course was 1.75. In 2014 spring offering of the same course five students enrolled and were asked to keep responding to feedback form. It was noted that these students exhibited consistent result with regards to attendance. They demonstrated low tendency of missing classes without prior notice. However, one possible reason for the higher attendance may be students' sincerity and self-motivation. More studies are being planned to investigate the effect of end-of the class feedback forms.

In the after course survey student were asked to rate the effectiveness of feedback forms in motivating them to attend the classes and paying attention on the course content (Fig. 2a). On the 1(ineffective)-5 (very effective) scale students gave 4.0 ± 0.9 rating to feedback form. Author is attempting to adopt the feedback form for bigger classes with 20+ students. To reduce the grading burden a teaching assistance has been employed. This scheme is very effective for smaller classes. However, one can tweak with the content of the feedback form and employ

Blackboard® and other online resources to grade them effectively. Students may be asked to answer brief conceptual questions related to the topics covered in a class. At the end of the class students can go to assessment section on blackboard and answer those questions in the last 5-10 minutes of the class. Author is planning to adopt this format to keep employing feedback forms on a sustainable basis. It is important to realize that feedback form conform with the central doctrine of deep learning that students better learn by reflecting of their experience in learning activities rather than simply doing them (Bain, 2004).

2.5 How to continuously motivate students to do their best to learn the course concepts?

Author's teaching strategy is mainly based on conceptual questions on the major topics. For every chapter or module, key concepts are identified and a number of original conceptual questions are framed. Conceptual questions are generally multiple answers type questions and arranged in terms of a pre-class quiz; however, recently author started asking students to write few lines or sketch about the theme of conceptual questions as necessary. This pre-class quiz and associated reading assignments are prescribed to students before the commencement of the class. Answers to these pre-class quizzes are required to be submitted before the discussion in the class and are also used for grading purposes. These conceptual quizzes ensure that students make themselves prepared for the module to be discussed and become well qualified to grasp the content and concepts during the class discussion.

During the class, conceptual quizzes were used to guide the flow of discussion. Every question on the quiz was first discussed by a small group of students; subsequently students shared their views or argued with each other about the conceptual questions. After the group discussion author invite one representative from each group to share their cumulative or mutually agreed solution and underlying reason with the whole class. Author elaborates on student groups' responses and generally adds missing reasoning, logic, and information to complete the discussion about the conceptual question of interest. At the end of the after the course survey in spring 2013 and spring 2014 students gave high rating to the overall active teaching approach on 1(ineffective) to 5 (highly effective) scale (Fig. 2b). The average student rating to the teaching approach over a period of two semesters was 4.4 ± 0.8 . Surveys and direct student feedback strongly suggested that students favored active teaching approach.

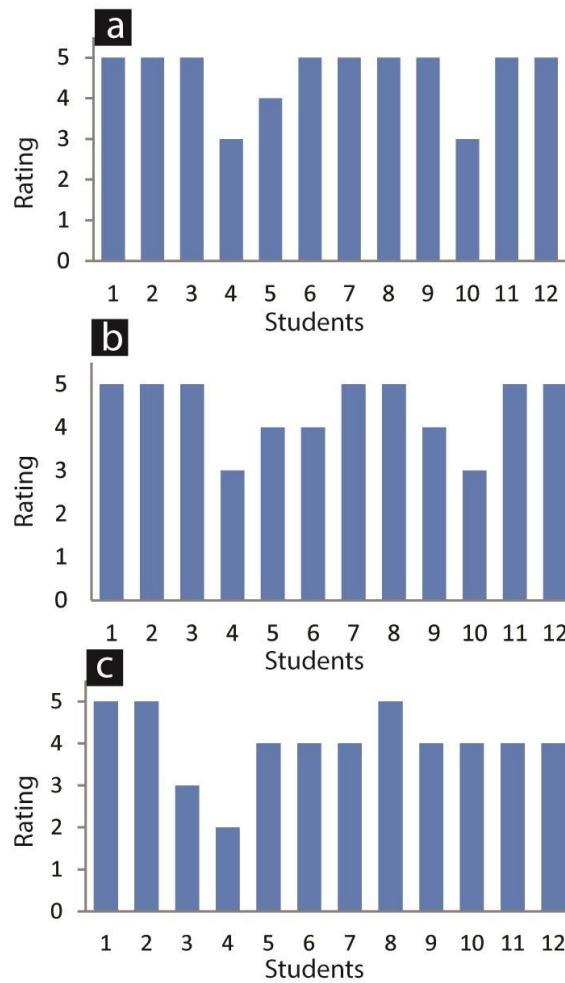


Fig. 2: Students rating for the (a) effectiveness of the after class feedback form in motivating them to pay attention to in class discussions and attend the classes (b) effectiveness of the conceptual quiz based active teaching strategy, (c) effectiveness of the active teaching strategy over lecture based teaching. Data collected after MECH 488: Fuel Cell Science and Technology course in spring 2013 and 2014.

Author also noticed that sometimes a module or math intensive topic may be quite challenging for students to grasp themselves by independent reading. For such modules author ask students to do timed reading and comprehension and share their understanding with the group members. The one representative from the group summarizes the cumulative group understanding. For such difficult topics no gradable pre-class quiz is asked to be completed. However, a reading assignment is given. For such difficult or heavy math based concepts author turn to semi-interactive lecturing about that topic. However, I tried to incorporate multiple interactive strategies to keep students engaged during the class.

In an after course survey students were also asked to rate active teaching as compared to lecture based teaching. These students are in a better position to comment as they have mainly observed lecture based teaching strategy in other courses. Figure 2c exhibits the response from individual students attending the MECH 488 Fuel Cell Science and Technology courses in springs of 2013 and 2014. Average student rating for favoring active teaching over lecture based teaching was 4.6 ± 0.79 .

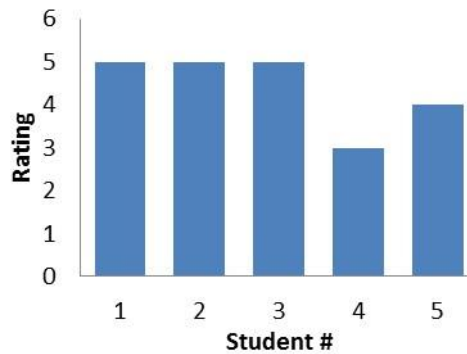


Fig. 3: Student rating the degree of liking for skits event during spring 2014.

2.6 How to make learning fun in the class?

To ensure that students are actively learning, a number of students' activities are set up for them. Since most of the important concepts of this course are dynamic in nature and students are highly likely to benefit by actively participating in it. Occasionally author asks students to design and play small skits about the key course concepts. Wherever possible, author also plays a role in the educational skit. On 1-5 scale students rated this active learning initiative (Fig. 3); average student rating was 4.4 ± 0.9 .

Author frequently used YouTube videos to aid the comprehension of complicated concepts. To keep the class discussion dynamic author frequently ask students to present whatever they understand about the concept of interest. Author also bring commercial components/products and organize industrial visits to industries. For instance, in spring 2013 an industrial tour was organized to visit the fuel cell application. To further deepen the understanding of key concepts, author include a number of experiments to provide experiential learning such as a fuel cell trainer, Versastat electrochemical setup, hydrogen fueling station, fuel cell car etc. To cover a number of important and interesting topics associated with the course theme, students are asked to write a term paper on related topics.

2.7 How to effectively assess and measure student learning?

In order to assess student learning a number of means were employed. The student's response to the preclass quizzes before and during the class is one direct measure to do so. The five minute feedback form after the class is another effective means to determine the students' understanding and address any questions they have about the discussion on concepts. Traditional home assignments are also assigned to promote collaboration and extensive understanding about the underlying principles of main concepts. Authors have made significant modifications in the method of giving midterm and final exams. Nearly 60% marks of an exam are based on the quality and depth of the written solutions. In addition, 40% of the marks are based on in class presentation pertaining to the exam questions. For example if a midterm or final exam is 20 marks in total, then 12 marks (60% of total 20 marks) will be assigned for the written answers and 8 marks (40% of total 20 marks) will be assigned for the student presentation and discussion on the exam questions. Typically two randomly selected questions are asked for the in-class discussion.

3. Fostering active learning among other teachers:

Author has been trained in active learning strategy by Dr. Ken Bain through a yearlong Myrtilla Miner Faculty fellowship (MMFF) from 2012-2013. One primary objective of this fellowship was to train a cohort of faculties

in research based active learning approaches and creating a sustainable faculty community who can keep educating other faculties and educators in future. Author has started conducting active learning workshops for the university faculties. In the two recent workshops he focused on (a) showing the difference in the effectiveness of student activities based teaching over traditional lecture based teaching, (b) different strategies to conduct student active learnings, (c) approached to monitor and assess student progress. These workshops were convened and independently evaluated by the Research Academy for Integrated Learning (RAIL) at University of the District of Columbia. After the workshop RAIL staff surveyed faculty participants about their perception of workshop effectiveness and utility. Two workshops were attended by the 12 faculties and various aspects of it were rated on 1 (poor or ineffective) to 5 (excellent or very effective). Participants were asked if the workshop session were well organized and well run; their response is summarized in Fig. 4a. The average rating for this question was 4.0 ± 1.3 .

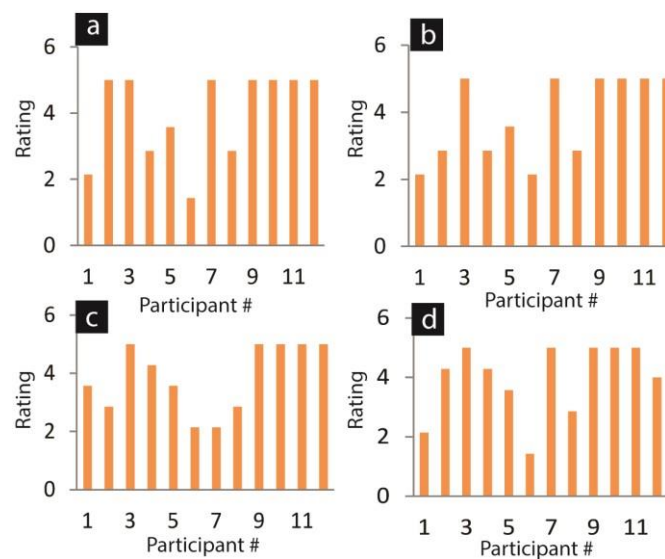


Fig. 4: Faculty participants rating the workshops on easily adoptable active teaching approaches on 1 (poor) to 5

(excellent or very effective) scale to the following sections:

- (a) the session was well organized and well run
- (b) my expectation for this session were met
- (c) the content of this session increased my knowledge,
- (d) the presenter was Knowledgeable and has sufficient knowledge about active teaching.

More than 90% faculty participants were practicing traditional lecture based approach. They expressed interest in knowing the advantages of active learning and practical strategies to quickly adopt in their teaching. Faculty participants attended this workshop with an expectation to explore components of active learning. Fig. 3b indicates that participant’s response to the question “if their expectations were met” was 3.9 ± 1.2 . The content of the workshop included review of research on active teaching approach. Author also included the details of surveys, course planning, assessment methods and practical insights. Response from the faculty participants for a question “if workshop content increased my knowledge” was 3.9 ± 1.2 . Faculty participants, who have been in teaching profession from few years to three decades, rated the knowledge of author as a workshop presenter (Fig.4d). Participants gave 3.3 ± 1.4 average rating.

In the survey workshop attendees were asked few questions. In the response to the question that what components of the session engaged you? 50% participant mentioned that content of the workshop was most engaging. However, other participants responded that interaction with other attendees and pedagogy was engaging for them. In the response to the question that what did you find most valuable in the session?

Participants responded that “learning that you lose 1/2 of the class after 20 minutes of straight lecture”, “very instructive methods of teaching, “very strong application of MMFF program's insights”, and “This session really demonstrated how to turn a lecture course into a more interactive course”.

CONCLUSION

This paper discussed the active learning approaches used in MECH 488 Fuel Cell Science and Technology course at the University of the District of Columbia (UDC). Promising syllabus, peer interactions, end of the class feedback forms, skits, and experiential learning were employed to deepen students' understanding and make learning enjoyable. According to the end of the course survey students enrolled in spring 2013 and 2014 courses gave high ratings to the active learning approach. The author has also organized two workshops about active teaching approaches at UDC as a part of faculties' professional development event. Both workshops were independently evaluated and found to be highly effective in catalyzing interest in active teaching at UDC.

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