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Second Modified Student Presentation Based Effective Teaching (SPET) Method Tested in COVID-19 Affected Senior Level Mechanical Engineering Course

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ABSTRACT

Student presentation based effective teaching (SPET) approach was designed to engage students with different mindsets and academic preparation levels meaningfully and meet several ABET student learning outcomes. SPET method requires that students prepare themselves by guided self-study before coming to the class and make presentations to teach the whole class by (a) presenting complex concepts and systems appealingly and engagingly, and most importantly (b) serving as the discussion platform for the instructor to emphasize on complex concepts from multiple angles during different presentations. In class, SPET presentations address the conceptual questions that are assigned 1-2 weeks before the presentation day. However, the SPET approach becomes impractical for large class sizes because (i) during one class period all the students can not present, (ii) many students do not make their sincere efforts. This paper focuses on the second modification of SPET to make it practical for large classes. The method reported in this paper was tested on MECH 462 Design of Energy System Course. Unlike the first modified approach, all the students were expected to submit the response to the preassigned questions before coming to the class. In class, SPET group presentations were prepared by the group of 3-6 students, who prepared themselves by doing SPET conceptual questions individually. Students communicated with each other to make a cohesive presentation for ~30 min. In two classes per week, we covered 5-6 group presentations to do enough discussions and repetition of the core concepts for a more in-depth understanding of the content. During the presentation, each student was evaluated for (a) their depth of understanding, (b) understanding other parts of the presentation covered by other teammates, and (c) quality of presentation and content. The student who appeared unprepared in the class group presentation were provided direct feedback and resources to address concerning areas. SPET approach was applied in the online mode during the campus shut down due to COVID-19. SPET was immensely effective and helped to complete the course learning outcomes without interruptions. SPET could be customized for the online version without any additional preparation on the instructor part.

Keywords: SPET; Effective Teaching; COVID-19; Online Engineering Teaching.

1. INTRODUCTION

Student active learning techniques engage students during the instruction stage in the classes. Active teaching methods also require students to prepare the foundation by their self-study of the concepts throughout the course [1]. Student multilevel participation reinforces efficient learning and long-term retention while making learning a highly dynamic process [2]. During active learning, an instructor spends more time as a facilitator and fills the knowledge gap as per individual student requirements instead of giving the same content coverage to the whole class. A teacher practicing student active teaching approach has various occasions to gauge the level of content mastery and provide frequent and immediate feedback to students [3].

Student presentation based effective teaching (SPET) approach was designed to engage students with different mindsets and academic preparation levels meaningfully and meet several ABET student learning outcomes. The SPET approach adopts an unprecedented methodology to address the seven research-based principles of effective teaching [4] for the advanced science and engineering courses. The seven key principles are discussed in detail by Ambrose et. al. [4]. These seven principles are (1) Students' prior knowledge can assist or impede learning. (2) Students' approach to organizing knowledge impact their learning skills and ability to apply what

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they know. (3) “Students’ motivation determines, directs, sustains what they do to learn” [4] (4) To develop mastery, students must obtain constituent skills, exercise integrating them, and identify when to apply what they have learned. (5) Goal-directed practice, coupled with targeted feedback enhances the quality of students’ learning (6) Students’ current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning. (7) To become self-directed learners, students must learn to monitor and adjust their approaches to learning.

SPET method requires that students prepare themselves by (a) do self-study to answer the conceptual questions provided by the instructors for a specific topic before coming to the class and (b) make presentations to teach the whole class by presenting complex concepts and systems, (c) make their presentation appealing and clear by doing what-if analysis, (d) incorporate animations, sketches, and complementary materials from different online resources to demonstrate and develop mastery[5, 6].

SPET presentations are intended to address the conceptual questions that are assigned 1-2 weeks before the presentation day. However, the SPET approach becomes impractical for large class sizes due to the reasons that (i) during one class period all the students can not present, (ii) many students do not make their sincere efforts. Some students were inclined to take credit from others’ work. In prior work [5], we published the original SPET concept. Afterward, in the follow-up work[6] we reported the first modified SPET approach to address the limitations. However, the first modified SPET approach for the 20+ senior-level enrollment suffered from the following limitations. (1) All the students did not make a significant effort to understand the course content to answer the assigned questions for in-class presentations because they were not required to answer all the questions assigned before the class. (2) All the students in a group did not understand the content assigned to other members in their group and frequently showed ignorance about the portion covered by other members.

2. TEACHING STRATEGY

This paper focuses on the second modification of SPET to make it practical for large classes. The method reported in this paper was tested for two years on the MECH 462 Design of Energy System Course. Under the recently modified scheme, SPET based sessions are conducted twice a week. Students were assigned the conceptual questions about the target content or chapter 1-2 weeks before the intended in-class discussion. Unlike the first modified approach, under the second modified approach, all the students were expected to submit the response to the preassigned questions before coming to the class for the group presentation. In class, SPET group presentations were prepared by the group of 3-6 students who prepared themselves by doing SPET conceptual questions individually. Students communicated with each other to make a cohesive presentation for ~30 min. In two classes per week, we covered 5-6 group presentations to do enough discussions and repetition of the core concepts for a more in-depth understanding of the content. In the class, students gave a group presentation. During the presentation, each student was evaluated for (a) their depth of understanding, (b) understanding other parts of the presentation covered by other teammates, and (c) quality of presentation and content. These individual submissions were graded after the in-class presentation. The student who appeared unprepared in the class group presentation were given more attention during individual assignment grading. This second modified SPET approach carries most of the original attributes, such as enhancing student technical communication skills, quick feedback, and repeating the complex concepts 4-5 times from multiple perspectives to foster deep learning. During spring 2020, due to pandemic MECH, 462 was adopted for online teaching. In a few hours, MECH 462 became an online course as a student group kept presenting online in a similar fashion as they did in face-to-face classes. SPET based online teaching during the COVID-19 pandemic has even showed increased student participation and accountability. One can also record discussions and provide a link to students who missed the discussion session.

3. RESULTS AND DISCUSSION

The SPET strategy was applied for the senior level MECH 462 courses with 21 students in the Spring 2020 and 22 students during 2019. To measure the performance, the same conceptual questions or pre-class assignments were given. The very first assignment was designed to bring students’ attention to the omnipresence of energy systems e.g., within the human body, to Nuclear electricity plant, solar thermal water heater, etc. However, for this objective, the student was asked to understand five systems of their choice and then make line diagrams to highlight the essential components of the design of energy systems. This discussion quickly brought us to the conclusion that fluid flow through pipes, heat exchangers, and mechanical pumps are critical components of energy systems. To innovate and design new systems, we begin the in-depth coverage of designing the piping systems, heat exchangers, and mechanical pumps.

The first assignment was given to students nearly one week before the presentation.

Assignment #1 Design of Energy Systems and Fluid Flow Through Pipes (Chapter-1)

Please make a presentation. You can use online materials and chapter-1 Fluid flow through pipes to make your group presentations.

Question-1: 1 Show only the sketches (drawings) of 5 systems where the design of the energy system is observed.

Question-2: Describe fundamental equations of fluid mechanics and figure 1. (section# 1-2 in the textbook)

Question-3: Describe equations 1-5 to 1-19 and connections between them. (section# 1-2 in the textbook)

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Question-4: Describe how equations 1-8 and 1-9 can help you design an energy system. What terms represent pump power and losses? (section# 1-2)

Questions from the textbook section (1-3)

Question-5 What is the head loss? Describe the equations 1-10 and 1-12.
What is the difference between $f_{D\text{-}W}$ and Ff. Discuss the Moody chart in figure 1-4.
Question-6 Discuss figure 1-5 and explain relative roughness.
Question-7 Describe equations 1-14 to 1-17c. Describe the importance of this equation, parts of the equations.
Question-8 What are the hydraulic diameter and corresponding Reynolds number. (equation 18). Give an example where hydraulic diameters are useful.
Question-9 What are the minor head losses? Describe the difference in equations for major and minor head losses.
Question-10 Describe the minor losses in table 4 and page 15.
Question-11 Describe the equation 1-20 to 1-22 how these equations are different from the basic Bernoulli equation 1-16.

Each student was asked to complete the assignment one and future assignments in two steps:
Step-1: Answer all the questions individually and submit their response before the presentation by email. This part was graded out of 20 marks.

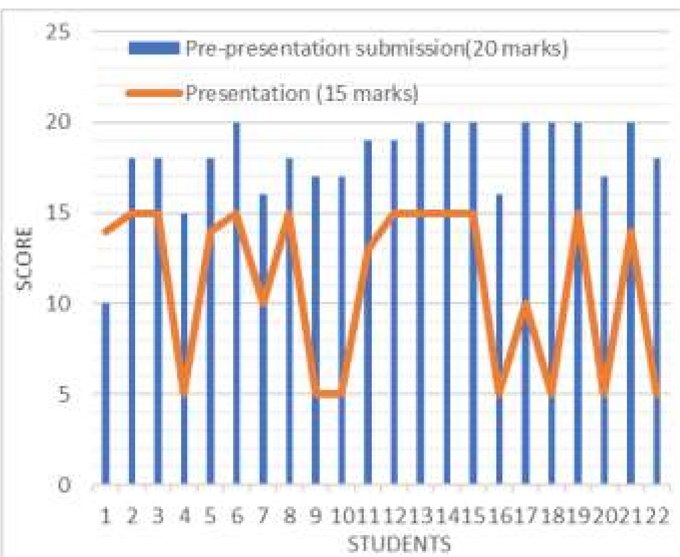

Figure 1: Students score for submitting individual assignment before coming to the class (blue bars). Score for presenting the assignment questions during class in the group.

Step-2: Work in the group to make a 25-minute presentation. To preparing a group presentation, the student was free to pick and choose sections. However, during the presentation, they were explicitly asked which part they contributed.

During the presentation, students were asked to explain selected portions and concepts randomly. The instructor also provided additional explanation and context to enhance the student understanding further. Even though a group made the presentation, but each student was graded out of 15 marks according to a rubric. In the rubric, five marks were assigned for student contribution in the group presentation, five marks for the quality of presentation, and five marks for answering the questions about the whole group presentation. Frequently, if one student was presenting his or her section, other students from the same group were asked to explain the concept further or answer a topical question or respond to "what if" analysis.
As shown in Figure 1, generally, most of the students did well in the individual part. It was mainly because questions were directly answered in the textbook chapters, and the student could easily spot them. However, a real knowledge check occurs during the presentation, which more like a discussion and by no means a monologue. Student presentation core (Fig.1) varied significantly, and this is understandable because every student did not care to understand the concepts deeply to apply them in a different context.

The first assignment also helps the student learn the SPET approach and clarify any doubt. The second assignment is focused on applying the science and engineering of fluid flow through pipes, covered in assignment 1, to practice the designing of systems. For this purpose, assignment#2 was selected from the textbook. However, parameters were changed for each group. Also, like assignment#1, students were asked to do individual work and then work in a group to make a single group presentation. The following is the description of assignment#2.

Assignment#2: Please make a program to solve one design problem. You can use a programming language you are comfortable with (python, C++, Java, etc.)

- All the students of each group are to solve the problem individually. All the students are expected to submit their program and results by email.
- Then, please summarize each group member's approach/program in the form of a presentation for the presentation on Monday 28 and Wednesday 30 January. All the group presentations should also be submitted before the class.
- Please go to page 23 on the Chapter-1 handout given to you and make a computer program to calculate the nominal diameter. Note I have slightly different numbers for each group. So, choose problem carefully.

Group-1 For the system illustrated in example 1-1, specify the nominal size of clean commercial pipes required for a flow rate of 0.2 ft3/sec if the following are given
Da=Db=Dc, La=200ft, Lb=20ft, Lc=80ft, H=75 ft

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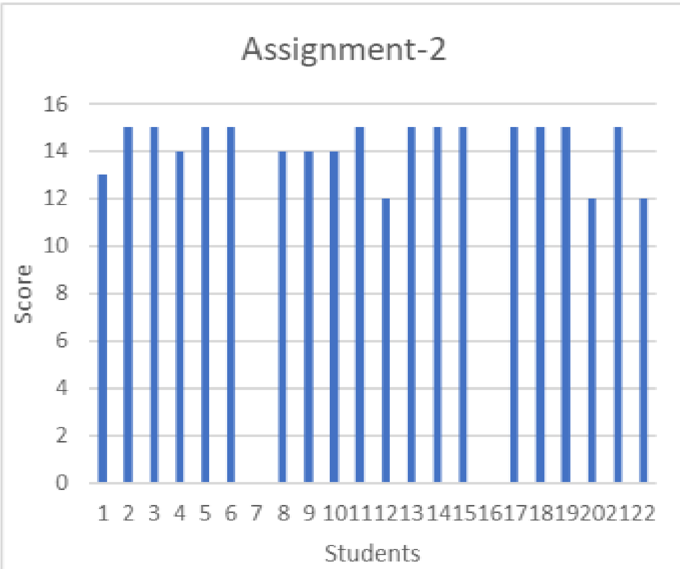

Figure 2: Students score for presenting the assignment questions during class in the group.

However, to reduce the grading load, students were encouraged to include their full individual work in the

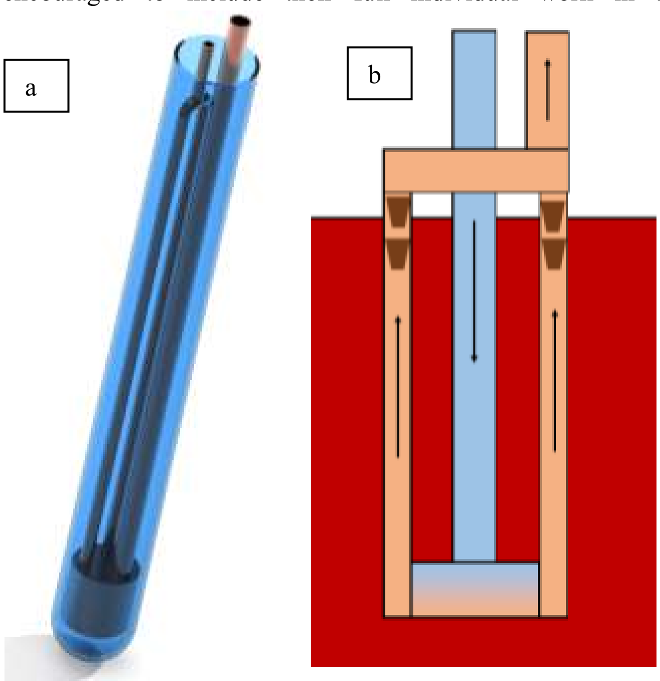

Figure 3: Group project: Compute the headloss and temperature of water coming out of the solar thermal heater (a). (b) Cross sectional view of heat exchanger showing various features inserted in the path of fluid flow to enhance heat exchanger properties.

presentation for assignment-2. However, they were expected to be informed of group member work and were asked questions related to other student work in that group. All the group presentations were also asked to include a summary slide to include the results obtained by different students. In the end, each group discussed potential reasons why their design approach produced different results with respect to other students in the same group.

SPET approach also encourages students to self-learn complementary skills, such as the scientific program. Each student was asked to develop (a) a Clear line diagram of the energy system they want to design. (b) a block diagram clearly explaining the engineering equations and assumptions made to make design process practice, (c) develop a computer program

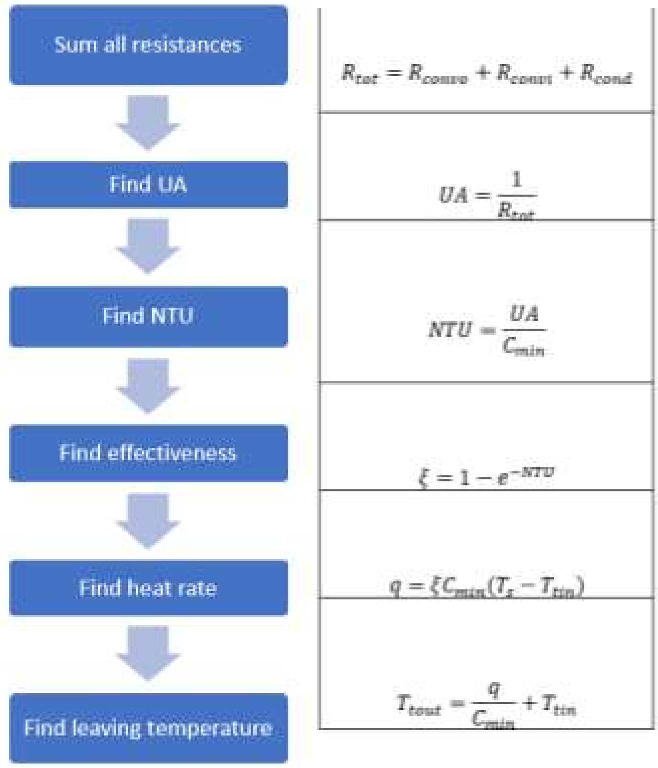

Figure 4: Flow chart and design equations associated with each step.

using python or C++ like basic languages.

This class covered the heat exchanger design principle and methodology. Students followed a similar assignment pattern as described for the fluid flow through the pipe. It is noteworthy that each topic was covered twice a week during the five group presentations. SPET approach is designed to enable to conduct of multi-angle discussions for an optimum length of period. Repetitions are required to make each student presenter and listener. Cumulatively a student has three distinct opportunities to learn the course content and associated fundamentals. (1) Preparing answers to the questions to prepare individual responses, (2) Collaborating with a group member to make and do presentations and discussion. (3) listening to 3-4 group presentations and associated discussions (Fig.3).

Subsequently, students were challenged to design a new heat exchanger. Under this design project, students were

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tasked to analyze the properties of the heat exchanger (Fig.3). Similar to assignment#2, students were asked to produce a clear flow chart to define their design strategies (Fig. 4). Afterward, each student prepares the computer program to enable the variation of several geometrical parameters.

Table1: Common parameters used by the four members of a group to check the difference in their output for the same heat exchanger geometry**.**

Inlet Flow Rate (cfh) @77°F	32.127
Inlet Mass Flow Rate (lb/h)	2000
Inlet Pipe ID	0.375”
Inlet Pipe OD	0.5”
Outlet Pipe ID	0.25”
Outlet Pipe OD	0.375”
Branch Pipe ID	0.25”
Branch Pipe OD	0.375”
Length of each pipe	16”
Cone thickness	0.0625”
Small diameter of conical feature:	.075”
Shell Temperature (°F)	212
Entering Temperature (°F)	77

The results obtained by the four students with their approach are shown in Table 2. After getting the data, all the students were asked to make a single presentation to demonstrate their strategies. Each student was responsible for showing a 3D engineering drawing, and 2D cross-sectional view to define the interior features of the heat exchangers. Each student also presented a flow chart like Fig.4. And finally, students discuss the output of their computer program designed to simulate and iterate various dimensions. Finally, a student compared the output of their design of the energy systems approach. However, as a requirement, all the students of the group were to check the output of their program. Table1 shows the example of the common set of parameters used by the four members of a group to calculate the heat exchanger properties depicted in Fig.3. Table 2 shows the output obtained by different students. According to the instructor, the current version of SPET is very useful in focusing on the performance of each student and provide them timely feedback for continuous improvement. According to the author's past ten years in teaching this course, teaching the design of the energy system is now fully based on student activities. Instructor roles are (a) design the pre-class assignment, (b) provide feedback to the student during the presentation, (c) grade student in the blackboard after each class session. This aspect is vital to assure the student that the instructor is serious about this approach, and their activities are indispensable to progress in this course. As a result, students became alert toward frequently posted class participation grades and regularly participated in the individual and group assignments. Due to the high visibility of student work, some students find this approach quite demanding.

Table 2: Various parameters calculated for the same input by four members of a group.

# of Outlet Pipes	2	
# of Conical Features	0	
Head Loss without ΔT (ft)	16.1	1
Exit Temperature (°F)	88.14	
Head Loss with ΔT (ft)	14.99	
Head Loss without ΔT (ft)	39.25	2
Exit Temperature (°F)	80.04	
Head Loss with ΔT (ft)	39.24	
Head Loss without ΔT (ft)	20.23	3
Exit Temperature (°F)	73.4	
Head Loss with ΔT (ft)	20.21	
Head Loss without ΔT (ft)	15.36	4
Exit Temperature (°F)	77.01	
Head Loss with ΔT (ft)	15.36	

After the course, students were asked to give annoymous feedback about their perceptions in Google Suvey. Students listed the following SPET aspects as the major strengths.

1. Working with others
2. Design a program that calculate both heat transfer and fluid mechanics of the system.
3. The presentation is new way of learning
4. Integration of programming & numerical solutions
5. Constant oral presentations with active feedback.
6. Training on how to present.
7. The subject matter was interesting
8. Learn from other students
9. The instructor

Some significant comments from students are quoted below:

“ I believe it's good that we have to present every week because I used to have fear but now fear doesn't exist no more” . “It allowed one to step outside of their comfort zone.”

“High emphasis on communication skills, and training our abilities to communicate very complex concepts. Also, it was a great combination of concepts & tools - it was great how we were really challenged to put the concepts to practice through coding.”

“This class prepared me to how present my final senior capstone a lot taught me the design process and how to present it.”

We also asked students to express concern andor weakness of this course. Students gave the following feedback.

1. “Some lecture material would be useful at the beginning of the course”
2. “Provide more explaining from the instructor instead of the students present”

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3. “A bit more time spent ensuring that we grasped the concepts would have made this course even better.”
4. “Less presentations”
5. “More in-house teaching vs strictly students teaching other students”
6. Offer this course in Fall semester.
7. “Found some group members difficult to work with and hard to manage”
8. “Short turnover time for each assignment”
9. “Too frequent presentations slowed us down”
10. “I think it would have been helpful to receive a bit more feedback on what parts of projects were done incorrectly. I think I would have more confidence in understanding the concepts better if we had some time in class devoted specifically to student questions or if it was identified when there was a misunderstanding in the concept, rather than let any student continue presenting while explaining something incorrectly (I think it was sometimes confusing whether the presenting students got it right or not).”

One remarkable achievement of the SPET approach is that it can be seamlessly conducted online. After the shut down of the on-campus classes, the author was able to reschedule all the SPET sessions online, and students started presenting their work. During the online SPET session, student attendance increased, and we were able to complete all the course activities decided for the course.

After completeing the course almost 50% online (Due to COVID-19) and 50% face to face students were asked the following question. Do you feel the SPET presentation assignments fairly assessed your knowledge of the Design of Energy Syestem? 15 students out 17 respondants said yes. One student commnted about COVID-19 effect “**COVID-19 interfere a little bit on the presentation but still it was doable.”**

4. CONCLUSION

This paper discussed the 2nd version of the SPET method. In the current version, significant modifications were made to ensure the active participation of the whole class. For that, all the students were required to submit the individual response for the SPET assignment to gain foundational knowledge to contribute in making the group presentation. During the group presentation, all the members were responsible for the group presentation. This SPET version is highly suitable for reducing the extensive grading load because most of the feedback is done during the class. Most importantly, the student gets direct feedback. There is also peer support in completing the individual assignment. Indeed, this approach can be perceived as a great learning opportunity for motivated students. However, strategic learners who conditioned themselves to keep getting a good grade by responding to traditional assignments and exams, find it demanding. SPET was easily transformed for online engineering education without missing major course activities. Fundamentally, SPET is based on student presentations developed to respond to preassigned topical questions.

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