PREPARATORY DISCUSSION AND PROJECT AUGMENTED STUDENT LEARNING VIA STUDENT PRESENTATION BASED EFFECTIVE TEACHING (SPET) APPROACH

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Abstract

Instructor-led presentation-based teaching mainly focuses on delivering content. Whereas student active presentations-based teaching approaches require students to take leadership in learning actions. Many teaching and learning strategies were adopted to foster active student participation during in-class learning activities. We developed the student presentation-based effective teaching (SPET) approach in 2014 to make student presentation activity the central element of learning challenging concepts. We have developed several versions to meet the need for teaching small classes (P. Tyagi, "Student Presentation Based Effective Teaching (SPET) Approach for Advanced Courses," in ASME IMECE 2016-66029, V005T06A026), large enrolment classes (P. Tyagi, "Student Presentation Based Teaching (SPET) Approach for Classes With Higher Enrolment," ASME IMECE 2018-88463, V005T07A035), and online teaching during COVID-19. (P. Tyagi, "Second Modified Student Presentation Based Effective Teaching (SPET) Method Tested in COVID-19 Affected Senior Level Mechanical Engineering Course," in ASME IMECE 2020-23615, V009T09A026). The SPET approach has successfully engaged students with varied interests and competence levels in the learning process. SPET approach has also made it possible to cover new topics such as training engineering students about positive intelligence skills to foster lifelong learning aptitude and doing engineering projects in a group setting. However, it was noted that many students who were overwhelmed with parallel academic demands in other courses and different activities were underperforming via SPET-based learning strategies.

SPET core functioning depends on the following steps:

Step 1: Provide a set of conceptual and topical questions for students to answer individually after self-education from the recommended textbook or course material,

Step-2: Group presentations are prepared by the prepared students for in-class discussion,

Step-3: Group makes a presentation in class 1-2 weeks after the day of the assignment to seek instructor feedback and to do peer discussion.

The instructor noted that students unfamiliar with the new concepts and terminologies in the SPET assignment struggled to respond to questions individually and contribute to the group discussion based on their presentation. Several motivated students who invested time in familiarizing new concepts and terminologies met or exceeded the expectations. However, a significant student population struggled. To alleviate this issue author has implemented a further improvement in SPET approach. This paper reports teaching experiments conducted in MECH 487 Photovoltaic Cells and Solar Thermal Energy System and MECH 462 Design of Energy Systems course. This improvement requires augmenting SPET with instructor-led concept familiarization discussion on the day of issuing the assignment or close to that; for this step instructor utilized exemplary student work from prior SPET-based teaching of the same course. In the survey, many students expressed their views about the improvement and reported introductory discussions were helpful and addressed several reservations and impediments students encountered. This paper will discuss the structure of the new improvement strategy and outcomes-including student feedback and comments.

Keywords: SPET, active student teaching,

1 INTRODUCTION

Research studies on student learning show that the audience's attention in lectures starts to decline after 10-20 minutes [1-4]. Next-generation scholars' development requires proper attention to effective and smart teaching methods[5]. Figure 1 shows the research-based seven principles of smart teaching (Fig.1). Figure 1 also underscores the fact that smart teaching is heavily dependent on

student activities. Incorporating active learning techniques encourage student engagement throughout the class and enhance student learning [6]. Active learning approaches also strengthens course contents, concepts, and skills and their long-term retention and recalling [4]. During student active learning-based education in courses, learners get more frequent and immediate feedback about the depth and accuracy of the material they are focusing on [7]. An active learning approach can effectively address students' stereotypes and different student learning styles [8]. Student active education can effectively create personal connections between students and the course material, which strongly increases the student's motivation to learn proactively [9].

Unfortunately, the efforts and time required may be a limiting factor in spreading and adopting active teaching methodologies by college and university's busy faculty. Some active teaching methods may also suffer from concerns related to insufficient course coverage-especially in science and engineering. Another important limiting factor may arise due to insufficient faculty engagement in the understanding complex phenomenon and smart teaching methods via formal training. Tyagi et al. developed a student presentation-based effective teaching approach (SPET) [10]. The SPET approach is a kind of flip classroom approach and includes the features of the peer interaction approach initiated by the Prof Eric Mazur of Harvard University [3]. Under SPET approach, students are given topics for a class session 1-2 two weeks before the date decided for in-class discussion for students to understand the upcoming content discussion by self-reading. After self-preparation, students prepare a coherent group presentation for 10-15 minutes. The students subsequently present these presentations during a designated class discussion day in front of the class and instructor. During and after the presentations instructor and peers provided feedback or asked questions to increase the impact and value of the presentation's content or topic under discussion. Encouraged by the success of the course instructor developed several versions of SPET [11-14]. However, SPET is an evolving teaching method with high potential to effectively address seven principles of smart teaching (Fig.1).

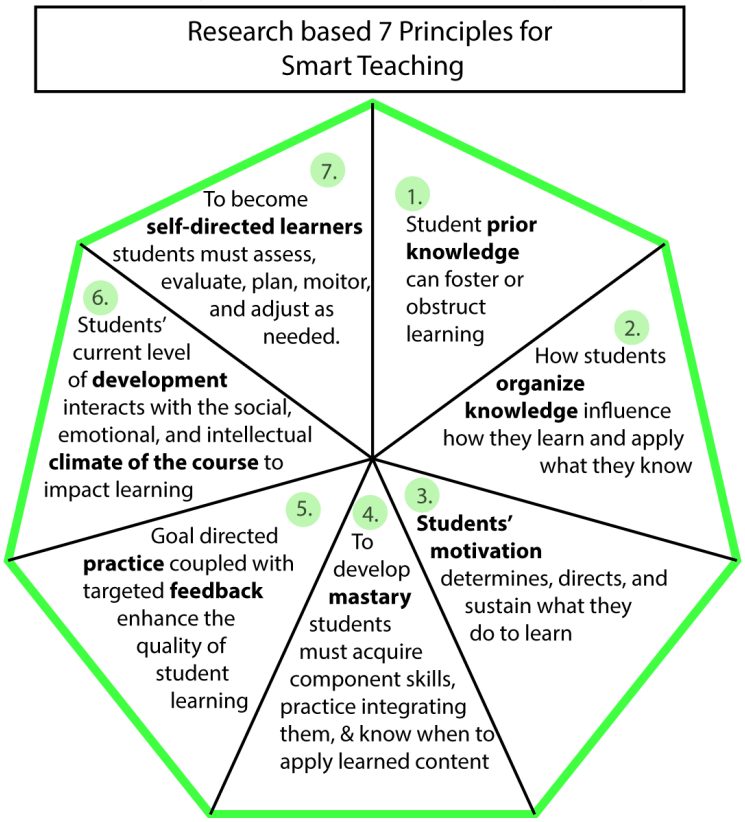

Figure 1. Research based seven principles of smart teaching.

The author noted that many students who were overwhelmed with parallel academic demands in other courses and different activities were underperforming via SPET-based learning strategies. This paper produces details of the author's experiment of including multiple introductory and preparatory units to strengthen SPET approach for motivating students. These introductory sessions are designed and interjected to help students keep a sharp focus on the relevance of component skills covered in a course taught by SPET method (Fig.2).

2 METHODOLOGY

SPET is a structured student active teaching method. The steps of SPET method are arranged in the flow chart shown in Figure 2. SPET's steps are designed to address the core concepts of seven smart teaching principles discussed elsewhere [5]. We further advanced the impact of SPET by especially focusing on principles 2, 5, and 7 (Fig. 3). Student motivation is the prime factor in determining student learning trajectories. To enhance student motivation under SPET method, two improvements were introduced. Right after Step-2, two introductory sessions were introduced (Fig. 4). Students were assigned a SPET assignment on the application of course topic and component skills

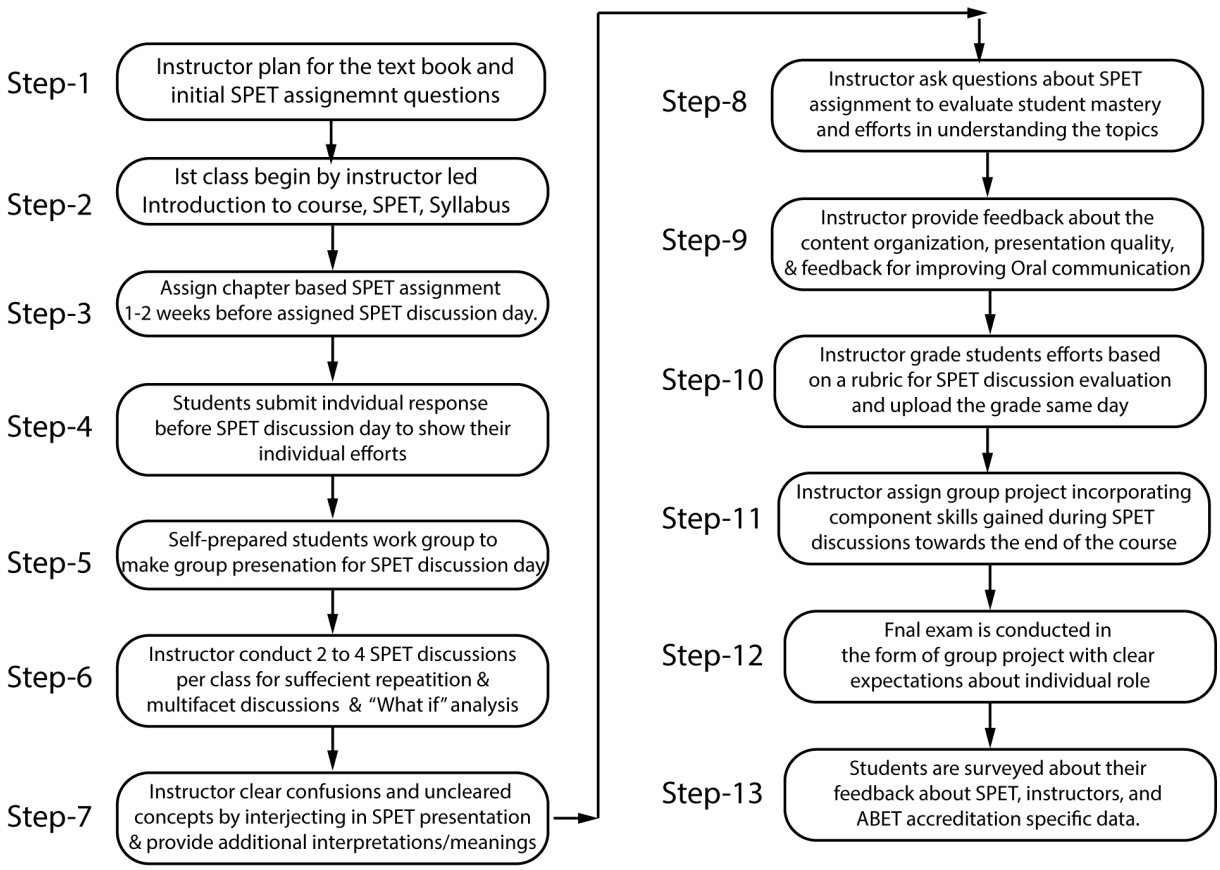

Figure 2. SPET Flow chart delineating various steps from beginning to the end of the course

one week before an assigned class discussion day. This introductory assignment was added with the intention of having students explore the application and value of the course. By this mechanism, they are expected to get a high level of motivation and engage in course activities with a higher-level self-motivation. To sustain students' motivation and to enable them to see the actual applications of the course content firsthand, they were given a semester-long group project. This project was designed to include the component skills they were to obtain from the course.

The second principle focuses on the organization of knowledge. In the prior SPET version, students were given a set of questions to prepare group presentations for in-class discussions. The instructor gave feedback after students' initial presentations. However, many students struggle to figure out the best way to organize the content of the discussion, and a significant part of the course passes by. As an improvement, the author has tried to introduce the expected content organization when assigning the SPET assignment. The author has utilized the prior year's exemplary SPET presentation prepared by the students. Prior year SPET presentations were shown to the students to advise them about the best practices. During this introductory session, students were also introduced to the core concepts of the topic of the discussion.

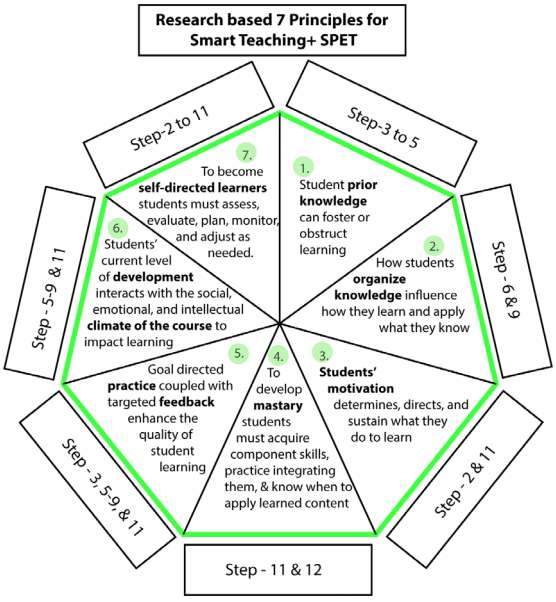

Figure 3. SPET steps are associated with the research based seven principles of smart teaching.

3 RESULTS

The author has observed remarkable improvement in keeping students motivated and engaged throughout the course. It is noteworthy that the SPET approach creates a very transparent feedback system involving the whole class and instructor. Even a least motivated student must make tangible efforts to participate in SPET activities that account for ~40% of the course grade. This paper mainly focuses on introductory sessions that are designed to kindle students' genuine interest without making them feel compelled to learn course content.

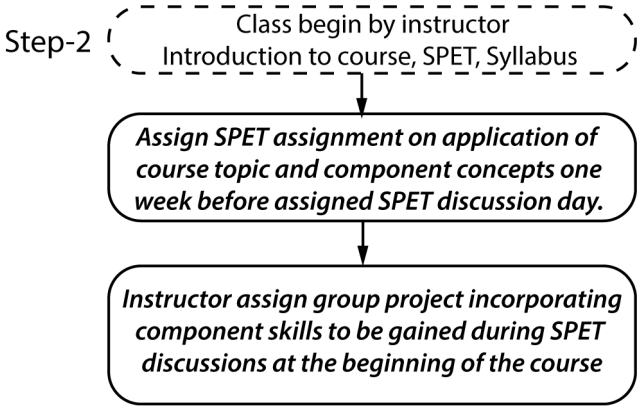

Figure. 4. Introducing value and application of course via introductory assignment and long-term group projects.

Despite being engaged in senior capstone projects, more than 90% of students were doing SPET assignments regularly. Most of the students appear to enthusiastically explore various methods of constructing intricate heat exchangers with internal features (Fig.4). More than 80% of students consistently made efforts to grasp the core concepts, and many went beyond the call of duty in exploring the several analysis strategies applicable to the course. Undoubtedly, few students were still less engaged and repeatedly gave reasons based on their struggle in senior capstone projects, research projects, and personnel challenges. Hence, SPET approach with the inclusion of several introductory sessions throughout the course appears to help in improving student focus significantly -but it is not a panacea that works for every student.

Twelve students were surveyed via an anonymous Google form to learn student feedback about new introductory sessions and improvements. Students were asked to give their input on a 1 to 5 scale. One (1) was assigned to low rating or poor experience, whereas five (5) were attributed to high rating or excellent experience.

Question 1: Was the initial session at the beginning of the course discussing the application of design of energy systems in different areas like the human body, geothermal energy systems, nuclear power plants, etc., helpful in seeing the importance of the application of Design of Energy system importance.?

Response: Almost all the students gave a high rating. This response reflects that the initial introductory session served the purpose of showing the course's value and wide applicability. During in-class discussion majority of the class was able to identify the presence of fluid flow happening in a biological system to nuclear power production etc. They also brought many examples from the internet for in-class discussion in response to the introductory SPET assignment.

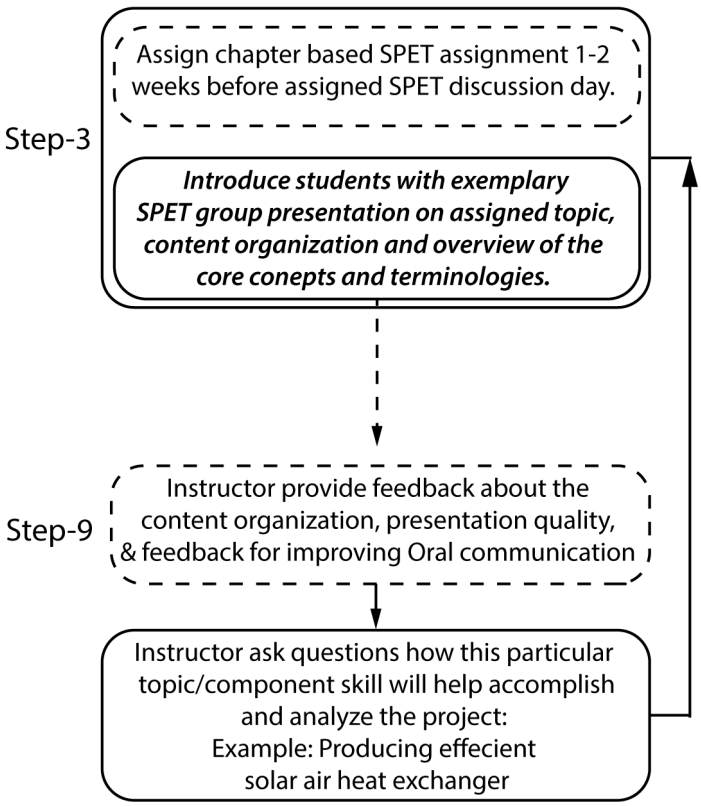

Figure 5. Introducing exemplary knowledge organization and core concepts in the scheduled

Question 2: Give your feedback about the usefulness of assigning a project on the design of a heat exchanger for the solar thermal air heater. Was it helpful to see the application of energy systems design throughout this course?

Response: 92.3%(12 out of 13 respondents) gave a 4 and 5 rating for having the class project assigned at the beginning of the semester. The assigned project served as lighthouse for steering attention in the right direction throughout the course. With the availability of the project upfront, students' endeavors to grasp component skills were purpose-driven. With repeated reinforcement and discussion during each SPET discussion, students developed an intuitive understanding of the project and also continuously evaluated various analysis approaches suitable for analyzing heat exchangers they were to make.

Question 3: Give your feedback on how clearly you saw the application of fluid flow through the concept of the pipe in the solar thermal air heater heat exchanger project.

Response: The majority of (91.3%) students had excellent experience connecting component skills with the heat exchanger project.

Question 4: Give your feedback on how clearly you experienced the application of design of heat exchanger concepts(LMTD or NTU) in developing a novel solar thermal air heat exchanger which does not exist?

Response: Eight students gave excellent ratings, and three students gave a good rating for this question. They were tasks to evaluate core concepts of two heat exchanger designing approaches taught in this course (LMTD vs.NTU method). Most of the class asserted their confidence and applied for the design program.

Question 5: Introduction to SPET assignment on fluid flow through pipes. Give your feedback about the importance of discussing prior exemplary SPET around the time of giving your SPET assignment on the same topic. The instructor showed a previous year's assignment to guide you about expected format end key concepts to look for as you prepare your SPET presentation. Was that introduction helpful?

Response: Introductory session at the time of SPET assignment allotment was welcomed and embraced by the students. Many students benefited from the clear discussion about the SPET format and related component skills and concepts.

Question 6: During your SPET presentations, the instructor provided feedback and initiated a discussion of how fluid flows through pipes and the heat exchanger design associated with your final project(Solar air heat exchanger). Was this discussion helpful in understanding the proper strategy to complete/attempt your final project and see the value of particular chapters towards the actual application?

Response: Many students responded with high ratings in response to the question about intermediate discussions about the connection between heat exchanger projects and components concept-specific SPET. Twelve students responded with a good or excellent rating.

We also consider the evaluation of the cumulative score of all the six questions/students to measure students' views towards improvement in the SPET method. Figure 6 presents the cumulative score of each student. It is noteworthy that the maximum cumulative score is 6x6=36. How close As data suggests, most of the cumulative scores are between 30 and 36. 10 out of 12 students gave these results suggesting that most of the students liked the modified SPET approach. The average score for each student was ~4.8.

We also asked students to provide general feedback. Students produced the following comments.

Comment-1 An effective means of learning the material

Comment-2 It helps to understand the concepts.
Comment-3 It's good practice for presentation skills.
Comment-4 Great class like the applied aspect maybe could have aid for help with generating code.
Comment-5 Amazing way to learn. Also enjoyed the ability to conceptualize and create a design.
Comment-6 Team projects should be supervised by the teacher.
Comment-7 I really love this method. Instead of sitting and cramming for exams, I was able to research different media to learn and come up with my own idea as to how to present the topic, and it is also fun to see how others have interpreted the topic.
Comment-8 This method was effective in allowing the students to learn more about the course, as the research was done mostly by the students. The class was extremely helpful.

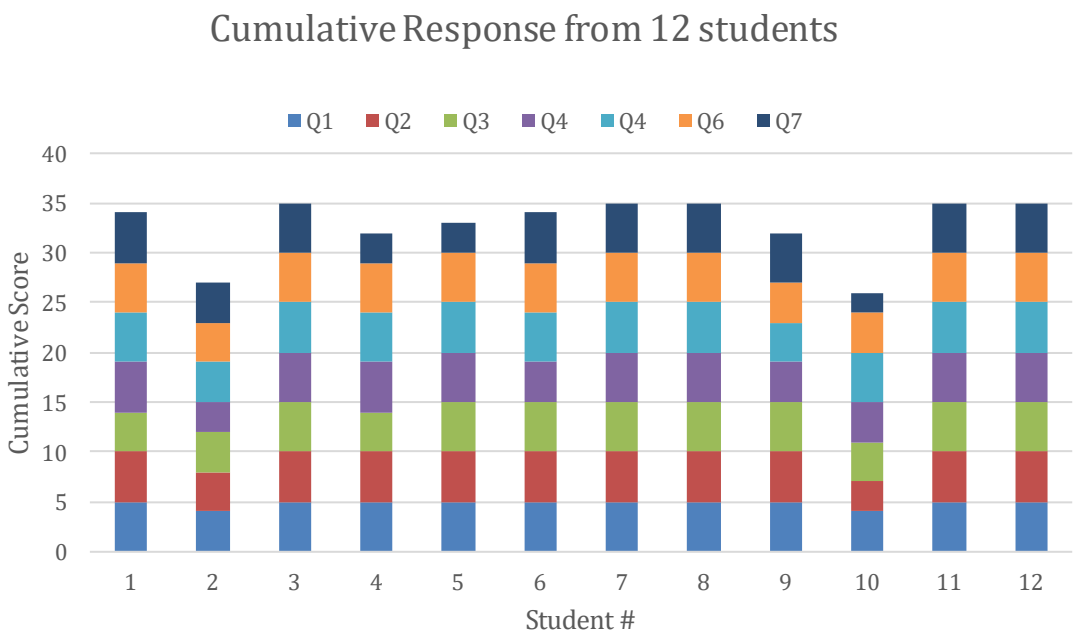

Figure 6. Cumulative response of 12 students for six survey questions.

4 CONCLUSIONS

This paper reported the importance of including an introductory and preparatory SPET discussion to connect students with the Design of Energy system course contents. Learning efficacy from SPET approach was enhanced with a project-based learning component. Introductory sessions were strategically distributed throughout the course to keep students focused on connecting the component theme and the big picture. This SPET version continues to be highly appropriate for reducing the extensive grading overload. It is because of the fact that a major portion of the feedback is provided during the class. The SPET teaching method is also a great tool for the instructor to develop mastery over some time by engaging in discussions with diverse student groups. Over the last eight years, the instructor found that students brought new insights and explaination about the course content that is either not available in the book or beyond the instructor's knowledge domain. The instructor made all possible efforts to offer direct and prompt feedback to fuel their performance and motivation.

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