A Blended Learning Approach to Enhance Student Learning for an Introductory Power Systems Course

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***Abstract*— This Innovation Practice Category Work-in-Progress Paper presents the implementation and results of a blended learning approach to design an introductory Power System Course to enhance student learning and pique their interest. The focus of this research is to develop a blended learning framework that converts the student from a passive listener to an active learner. Firstly, the lectures were moved online but instead of covering one topic and all the sub-topics in one video we covered each sub-topic in a separate video. This resulted in four to five videos a week between five to ten minutes. The shorter videos ensure that students learn the individual sub-topics before their attention gets divided. The classroom time was spent in relating the theory taught in the videos to practical real-life applications, live demonstrations of the concepts as well as solving mathematical tutorials. Secondly, a graded online quiz is conducted every two or three weeks that tests students on the video's contents. Thirdly, quizzes with a competitive element built in are conducted during the classroom time to revise and reiterate the concepts covered that week. Quantitative and qualitative analysis show promising results on the implementation of blended learning in power systems.**

KEYWORDS: Blended learning, game-based formative assessment, student response systems, power systems education, curriculum design

I. INTRODUCTION

Power Systems engineering is a fundamental discipline of electrical engineering. The introductory power systems course covers a wide array of topics ranging from phasors, AC circuit analysis, power generation, transmission, and distribution. These topics are extensively theoretical as well as mathematical in nature. The traditional delivery of this module was through two-hour classroom lectures and one-hour tutorials.

Blended learning combines digital content with traditional classroom teaching wherein online videos are used to deliver lecture content [1]. Griffiths proposed a blended approach to support modern learners post lecture using technology and investigated different online tools for the same [2]. The flip-side to that is if the videos are long and cover multiple sub-topics then the issue of attention span crops up again [3]. Another downside of online videos is that the student has to actually view the video to learn the content.

There are a few studies that outline the implementation of blended learning in power engineering modules. Broadmeadow et.al. studied the effectiveness of using digital tablets as a tool for enabling blended learning in a power engineering course. They outlined the different use case scenarios for the tablet and concluded that the majority of students preferred using delivery with digital tablets [4]. Pena et.al implemented blended learning in a virtual laboratory setting using the PSPICE simulation environment to teach students photovoltaic systems. Different PV parameters were obtained using the simulation environment for comparison with real measurements[5]. These studies focus on implementing blended learning in individual aspects of the module and not to the whole module holistically.

Student response systems (SRS) form the basis of converting a passive classroom to an active classroom. The use of SRS in classroom promotes participation and engagement of students, enables interaction and discussions in the classroom and provides an avenue for formative assessment and feedback [6]. Klinkenberg studied the role of formative assessment in a blended learning course and found that the validity of the assessment can be used for remedial teaching [7]. Wood et.al. studied the effect of SRS on student learning and attitude and realized that students are more engaged in the classroom with SRS [8]. Caldwell analyzed different peer reviewed articles focusing on the rationale for using audience response systems(ARS) and exploring questioning strategies with ARS [9]. Jones et.al concluded that the use of classroom response systems influenced the grade of the student if they knew it was for course credit vis--vis no credit and proposed their use to increase student accountability[10].

To address some of these challenges a blended learning approach to the introductory power systems course albeit with a few modifications is implemented. Since, there is a gap in literature with regards to a holistic application of blended learning in power engineering education, the current work can provide insights into their effectiveness.

II. DESIGN OF THE BLENDED LEARNING FRAMEWORK

The blended learning framework is divided into online activities and face-to-face (F2F) activities as follows:

A. Online Activities

1) Short Videos: The lectures are online but instead of covering one topic and all the sub-topics in one video, each sub-topic was covered in a separate video. This resulted in four to five videos a week but each video was between

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five to ten minutes long. The shorter videos ensure that the student learns individual sub-topics before their attention is divided. The topics of Transformers & Per Unit Analysis, Renewable Energy and Generators were selected for online delivery resulting in seventeen short videos.

2) Online Graded Quiz: An increase in the number of videos could result in students getting fatigued by the sheer number and avoid watching them. A graded online quiz is proposed as a scaffold for the students to view these videos. The quiz will have an equal distribution of theoretical and numerical problems. To prevent overdoing the number of these online graded quizzes, it is proposed to be conducted once every two to three weeks. For this module, only one online graded quiz was designed for the topic of Per Unit Analysis. The remaining topics were used as a control to observe if having the online graded quiz had an effect on student engagement.

3) Simulation Models: Simulation models for analyzing and estimating theoretical parameters of different sub-systems will be provided for the students to execute before coming to the class or laboratory sessions

B. Face-to-face Activities

1) Application-based Review and Discussion: The face-to-face session will use application based learning methodology to review and relate theory taught in videos to practical real life situations and applications. This will be promoted using whole class discussions on relevant topics or sub-topics of that week's content. To further link theory to practice and application, live demonstrations of the concepts will be shown in the F2F sessions.

2) In-Class Quiz: Kahoot! is a game-based student response system that provides tools for creating quizzes. When playing Kahoot! in the classroom, the instructor launches Kahoot! in a web browser connected to screens visible to all students. The students launch the URL *kahoot.it* on their own devices, enter a game pin and a nickname to join the game.

Once the students sign up, the instructor starts the game. The questions along with the answers are shown on the screen while the students device show them different colors and symbols representing the different options for that question as shown in Fig. 1. The students can choose the color/symbol they feel is the correct answer. There is an on-screen timer that counts down to zero as well along with the number of students that have answered the question. During the quiz, Kahoot plays music and sounds similar to a game show to give a competitive atmosphere in the class.

At the end of each question, a distribution shows the student responses and a leaderboard with the top 5 students is shown on the screen. The students are given feedback on the correctness of their responses and individual scores. Kahoot! differs from other SRS in using a time component to grade and mark the students. The faster a student responds with the correct answer, the higher they scores relative to their peers. At the end of each quiz, the top three students are identified and given *rewards* for their performance in the quiz.

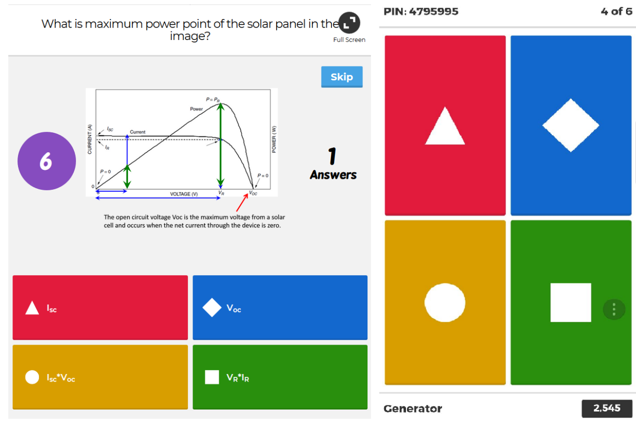

Fig. 1. Kahoot displaying a sample question on the screens (Left) and the options screen for the students (Right)

The Kahoot! quizzes were administered once or twice in-class during the seminar sessions for a total of nine quizzes. They tested the concepts covered in preceding hour as well as their applications in numerical problems.

3) Tutorial: Power systems is a mathematically heavy module with numerous calculations relating theory to parameter estimation of real equipment. A tutorial session is proposed to analyze and evaluate hands-on problem solving techniques for these numerical problems. Common misconceptions and mistakes will be also be covered in this session.

4) Laboratory : Laboratory sessions are proposed for the students to experiment and estimate practical parameters of different sub-systems. The students can compare theoretical simulation models with practical laboratory sessions and contrast the differences between them.

A sample weekly plan for the topic on transformers is provided in Table I

III. Results and Discussion

A. Student Engagement

Fig. 2 shows that on average, 47% of the class viewed the different short videos each week. The average views per video is 1.7 views per student who has watched the video. There is a slight increase in the average views and the % student views for the topic on per unit which will be explored in later sections.

B. In-class Quiz

It can be inferred from Fig. 3 that around 70% of the students got the answers correct. Their response time on average for the correct answers for both numerical and theoretical questions was around 8 seconds. It is interesting to note from Fig. 4 that the average response times for the incorrect answers was much less (5.9 seconds) compared to to the correct answers. On further investigation during the in-class quiz, it was revealed that most of these students in the hurry to be the fastest, click the wrong answer by mistake.

After the completion of each question, the correct answers were discussed and each wrong answer was justified to/by

TABLE I
SAMPLE WEEKLY PLAN FOR THE TOPIC ON TRANSFORMERS

Week	Learning Outcomes	Online Activities	Face-to-face Activities	Assignments/ Assessments
8	By the end of the topic on transformers, learners should be able to 1) describe the operating principle of a transformer 2) compare and contrast ideal transformers and real transformers 3) analyze and estimate transformer parameters using open circuit and short circuit test 4) differentiate wye and delta transformer connections and recognize their respective importance in the power system	• 4-6 **short lecture videos** of 8-10 minutes each covering different sub-topics of the topic on Transformers • A discussion forum where a relevant application scenario is posted and responses from the learners is solicited. The consolidated responses will be discussed during the F2F session • Simulation models for analysing and estimating transformer parameters. Learners to analyse and estimate the theoretical models before F2F lab session	**Seminar Session:** • Review and demonstration of key concepts in the lecture videos. • Whole class discussions on ideal and real transformers • Whole class discussion on delta and wye transformer **Tutorial Session:** Hands-on problem solving techniques discussed to analyze and evaluate numerical problems in transformers **Laboratory Session:** • Experiment and estimate the transformer parameters using short circuit and open circuit tests. • Whole class discussion on the variability of the estimated parameters and the simulated parameters.	• **Online Graded Quiz** after the F2F session evaluating the comprehension and understanding of learners on the topic • **In-class quiz (Kahoot!)** evaluating the comprehension and understanding of learners on the topic. • Submission of lab report following the experiment on transformers

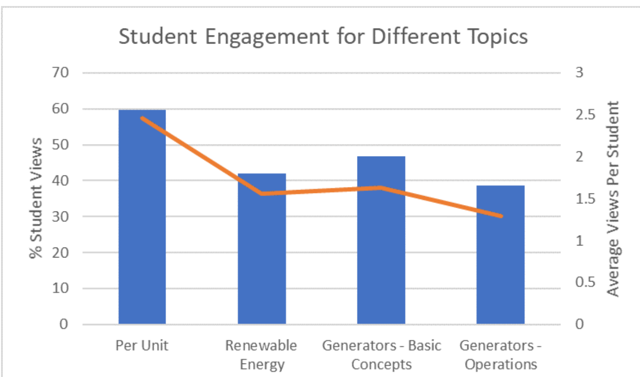

Fig. 2. Student engagement for different topics with the average views per student per video

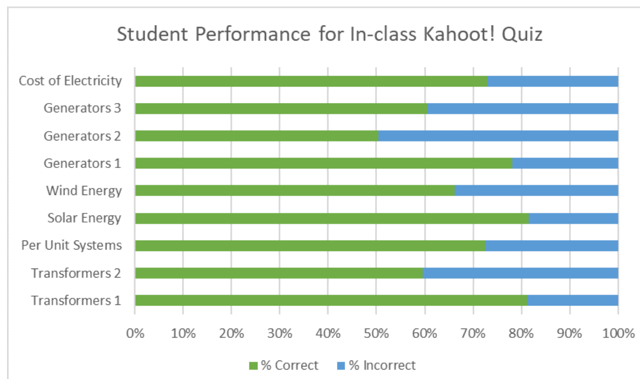

Fig. 3. Student Performance for the In-class Kahoot! quiz

the students to effectively scaffold them in their learning journey.

C. Online Graded Quiz

The online graded quiz was opened after the completion of topics on transformers and per unit analysis. It is evident from Fig. 5 that the average is high (97%). The students did equally well in theoretical and numerical based questions.

Looking back at Fig. 2, it can be concluded that the higher percentage of student views and average views per videos for the topic on 'Per Unit' can be attributed to the online graded quiz.

D. Survey Results

An end of semester survey was conducted to get the student's feedback on the blended learning mode of conducting this module. Twenty five students took part in the survey. A webcast is the recorded video of the whole seminar session that is uploaded after every seminar session typically 3 hours long. The survey had two sections as follows:

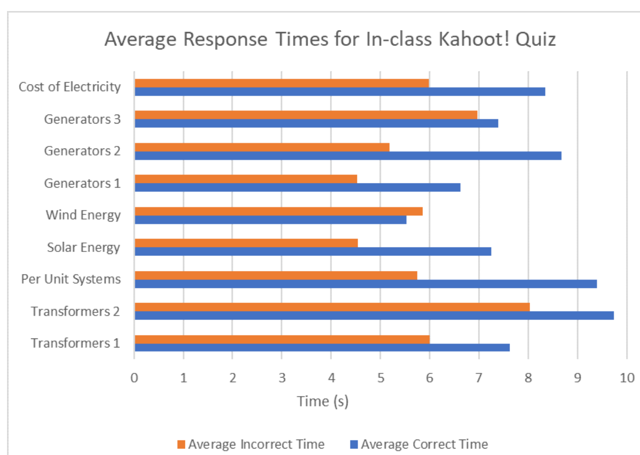

Fig. 4. Average response times for the In-class Kahoot! quiz

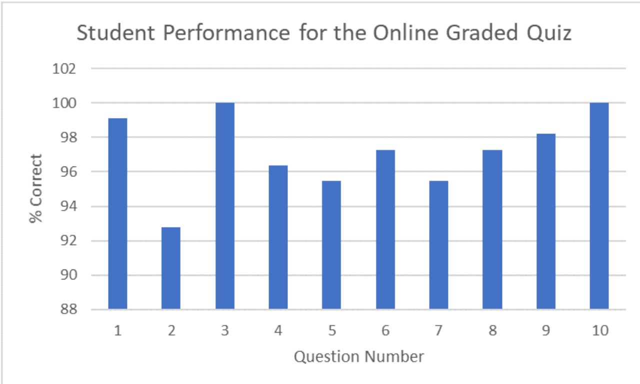

Fig. 5. Student Performance for the Online Graded Quiz

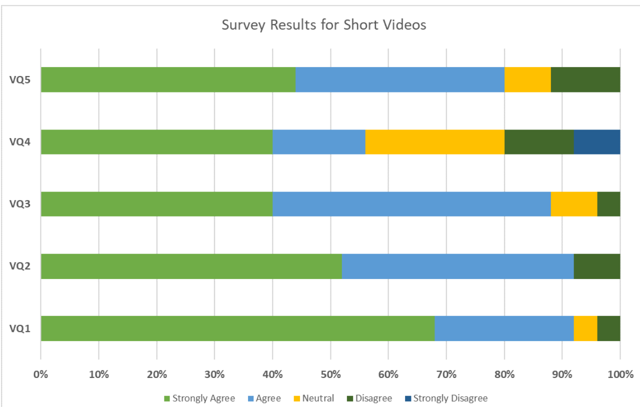

Fig. 6. Survey Results for the Short Videos

- *Section 1: Feedback on Short Videos* with the following questions:
  - **VQ1**: The short videos are the ideal length (5-10 mins) to watch
  - **VQ2**: My attention is not diverted during the short videos
  - **VQ3**: Each short video cover a sub topic throughly
  - **VQ4**: I prefer watching the short videos over the webcast
  - **VQ5**: The number of weekly short videos (4-5) is optimum
- *Section 2: Feedback on In-class Kahoot! Quiz* with the following questions
  - **KQ1**: Do you think Kahoot quizzes helped you to understand concepts during lectures?
  - **KQ2**: Do you think Kahoot quizzes helped you to apply concepts during lectures to solve problems?
  - **KQ3**: Did the prizes awarded for the Kahoot quizzes performance motivate your learning?
  - **KQ4**: Did Kahoot quizzes help you reflect on the quality of your learning?
  - **KQ5**: Did Kahoot quizzes help you learn with your peers?

Analyzing the first survey in Fig. 6, it can be concluded that the number of weekly videos and their length is op-

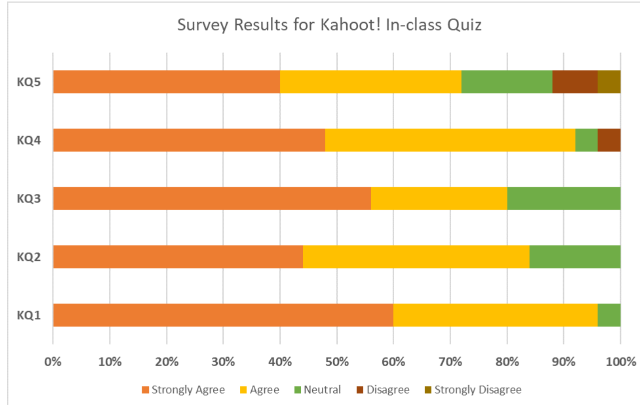

Fig. 7. Survey Results for Kahoot! In-class Quiz

timum. Majority ($> \mathbf{90\%}$) of the students' feel that their attention is not diverted during the short videos which is one of the aims of this study. The students also preferred watching the short videos over the long webcasts.

The second survey results show the popularity of the in-class quiz. A high percentage ($> 90\%$) of students felt that the Kahoot quizzes helped them understand the concepts during lectures and reflect on the quality of their learning. This builds on providing them with a scaffold in their learning journey. The prizes and rewards awarded at the end of each in-class quiz motivated the students in their learning. The current format did not provide ample opportunities for student's to learn form their peers but it provided an insight that peer activities would be popular especially with Kahoot! as the medium to facilitate the activity.

IV. Conclusion and Future Works

This study focused on establishing a framework for designing a blended learning approach for an introductory power systems course. Different strategies including shorter videos times, in-class quizzes and online graded quizzes were implemented and their effectiveness was evaluated. Student feedback was extremely positive for both the short videos and the in-class Kahoot! quizzes. It was also concluded that graded online quizzes can be a good motivating factor for students to watch the videos.

The next steps would be to expand this framework by implementing the blended learning methodology for the whole module and redesign the traditional classroom lectures as short videos with online and face-to-face activities. More graded online quizzes need to be planned but it has to be also ensured that students do not encounter grading fatigue.

References

[1] Guzer, Bayram; Caner, Hamit; "The Past, Present and Future of Blended Learning: An in Depth Analysis of Literature," Procedia - Social and Behavioral Sciences, Vol. 116, Pages 4596-4603, 2014

[2] L. Griffiths, "Flexible Learning Support in an Inflexible Society," 2011 IEEE 11th International Conference on Advanced Learning Technologies, Athens, GA, 2011, pp. 274-276.

[3] Bruff, Derek O; Fisher, Douglas H; McEwen, Kathryn E; Smith, Blaine E."Wrapping a MOOC: Student Perceptions of an Experiment in Blended Learning", Journal of Online Learning and Teaching; Long Beach Vol. 9, Iss. 2, (Mar 2013): 187.

[4] M. Broadmeadow, Y. Mishra and G. Ledwich, “Digital tablets as a tool for blended learning in power engineering education,” 2013 Australasian Universities Power Engineering Conference (AUPEC), Hobart, TAS, 2013, pp. 1-5.
[5] J. D. Aguilar-Pea, F. J. Muoz-Rodrguez, C. Rus-Casas and J. I. Fernndez-Carrasco, “Blended learning for photovoltaic systems: Virtual laboratory with PSPICE,” 2016 Technologies Applied to Electronics Teaching (TAEE), Seville, 2016, pp. 1-6.
[6] Kay, Robin H and LeSage, Ann, “Examining the benefits and challenges of using audience response systems: A review of the literature,” Computers & Education, Volume 53, Issue 3, Pages 819-827,2 009
[7] Klinkenberg S. “The Role of Formative Assessment in a Blended Learning Course”. In: Joosten-ten Brinke D., Laanpere M. (eds) Technology Enhanced Assessment. TEA 2016. Communications in Computer and Information Science, vol 653. Springer, Cham, 2017
[8] Wood, Fortner Cheryl; Armistead, Leigh; Marchang Anna; and Morris, Benjamin M“The Effects of Student Response Systems on Student Learning and Attitudes in Undergraduate Psychology Courses,” Teaching of Psychology, Vol.40, No 1, pages 26-30, 2013
[9] Caldwell, J. E. “Clickers in the large classroom: Current research and best-practice tips.” Life Sciences Education, Vol. 6 No.1, 920, 2007
[10] Jones, Sara J. Crandall, Jason; Vogler, Jane S“Classroom Response Systems Facilitate Student Accountability, Readiness, and Learning” Journal of Educational Computing research, Vol. 49, No.2, Pages 155-171, 2013