Effects of Lightboard Usage on Circuit Problem Skills

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***Abstract*—While assessing electric circuit homework assignments in an Electrical Engineering program at West Virginia University, it is sometimes difficult to follow students' logic and thinking process. When instructors grade homework assignments, they only see what is written down on paper. Most students neglect to write out their thoughts, which can cause difficulty in comprehending why they choose a particular method to solve the problem, or the point where they experienced difficulty. A class of twenty-two students in a 200-level undergraduate Digital Electronics course that was offered at West Virginia University were asked to conduct several of their assigned homework problems using a Lightboard, a lecture recording tool that allows the user to face the camera while writing on a transparent surface. The intent of these exercises was to gain a better understanding of the students' thought process and see the effect on their self-confidence in circuit solving skills. While conducting the assignments, students would narrate how they were solving the circuit problem on the Lightboard, as if they were teaching the problem to their peers. These recorded sessions were assessed for problem-solving skills using a rubric with the following performance indicators: defining the problem, determining the strategy and procedure, evaluating the outcomes, creating diagrams and sketches, using neatness and organization, and referencing terminology and notation. Students were also asked to complete a survey prior to and after the Lightboard sessions using a five-point Likert scale to gauge their self-confidence. This data, in correlation with the students' course performance, was analyzed to determine if this approach to problem-solving techniques impacted the students' course grades and competency in problem-solving skills.**

Keywords—self-confidence; Lightboard; problem-solving skills;

I. Introduction

Engineering practice seems to revolve around the skill of problem-solving [1], [2]. Engineering uses science, math, and technology to create an idea, system, process, or product to discover a solution in real-world applications.

Students tend to rely on algorithms to solve problems even though the problem requires a conceptual understanding to solve [3]. Many of the topics in eengineering are algorithmic based, but require a conceptual understanding to fully understand the problem.

Several colleges and institutions are using various creative solutions to better engage students to learn/teach the material. The Lightboard is a multimedia teaching method that allows the professor to write on a clear surface while being recorded. It is captured in a dark room. LED strip lighting wraps around the edges of the Lightboard, illuminating and displaying the writing and the professor. The professor stands behind the surface, facing the camera, and uses a neon or fluorescent marker to write. It appears as though the professor is writing backwards, however, the camera flips the image of the written content so that the viewer can see exactly what the professor writes and sees.

In science, technology, engineering, mathematics (STEM) lectures, the professor provides many visual aids such as formulas, equations, graphs, and other illustrations. Typically the back of the professor faces the students as they prepare their visual aid. When students raise their hands, the professor does not notice it immediately. Both the student and the professor would benefit from the Lightboard as it does not block a student's view, and does not require a professor to turn around to answer a question [4].

The Lightboard technology has proven itself a useful tool for instructors to provide students with a digital copy of a lecture segment. The tool has been used for recording lectures for flipped and distance learning classes, as well as massive open online courses (MOOC). Instructors can answer students' questions with video responses, record homework solutions, and hold live online review sessions. Using this technology with other proven educational methods, peer learning and think-aloud problem-solving may help create more ways for students to learn how to solve problems. Research has shown that the cognitive process of explaining solutions and dealing with misunderstandings will help enhance understanding of the subject. It has been indicated in research that peer learning activities usually result in greater self-esteem, foster prosocial behavior, and higher achievement and greater productivity in terms of enhanced learning outcomes [5]. The Lightboard allows a student to teach more than one student at a time and could potentially hit a wider range audience. Evaluating the problem-solving skills of the students allows an assessment of the circuit curriculum to see where students might be having issues. Once these issues can be identified, plans can be made to correct the issues.

II. Course Context

EE 251, or Digital Electronics, is a three-credit course lecture developed for sophomore electrical/computer engineering students. The course teaches students about logic gates/circuits, applying bipolar junction transistors (BJTs) and field effect transistors (FETs) in complex circuit problems, and circuit design. Students should come out having a basic

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understanding of semiconductor physics when using BJTs, FETs, and diodes, how to analyze and comprehend data using the software PSPICE, and how to design and understand transistor circuits. The fall semester holds one section with about 20 seats. In comparison, the spring semester holds one section with a maximum of 100 seats.

A. Description of Participants

During the fall semester, 22 sophomore electrical/computer engineering students enrolled in the class. Of the 22 students in the class, 17 students consented to participate in the study (77% participation). Among the 22 students, 19 students completed at least two Lightboard sessions; five students completed two homework (HW) assignments on the Lightboard, seven students completed three HW assignments, and seven completed all four HW assignments. Among the 17 consenting students, nine participated in the self-confidence pre/post surveys.

III. METHODS

A. Lightboard Sessions

Of the four assigned homework assignments, one problem was chosen for the students to solve using the Lightboard while thinking aloud their thought process. These sessions were recorded and then assessed for specific performance indicators of problem-solving, as seen in Fig. 1.

B. Circuit Self-confidence Survey

The pre and post survey consisted of 24 questions, and was given to observe the students' beliefs of their own self-confidence about solving and displaying their knowledge of circuit problems. Three of the 24 questions, particularly questions one, 13 and 16, were programmed for circuit self-confidence. The survey questions used a 5-point Likert scale and consisted of the following questions:

1. I always approach circuit problems with assurance
2. I would never take more than 18 hours of class
3. I always know the answers to class questions
4. I am not an extremely confident person
5. I am comfortable with extra work or activities
6. I am always very sure of myself before an exam
7. I remain sure of myself after exams
8. I read The Athenaeum every day
9. I think that WVU students are too apathetic
10. I never expect high grades
11. I am always apprehensive about graded work
12. I can be anything that I want to be
13. I always know how to approach a circuit problem
14. I feel comfortable leading academic groups
15. I feel that voting is a very important duty in society
16. I feel comfortable solving circuit problems I have never seen before
17. It doesn't bother me to be wrong if I answer a question in class
18. Some people would say that I am egotistical
19. Having high grades makes me feel good about myself

Performance Indicators	Developing	Meets expectations	Exceeds expectations
Define Problem	Demonstrates a limited ability in identifying a problem statement or related contextual factors.	Demonstrates the ability to construct a problem statement with evidence of most relevant contextual factors.	Demonstrates the ability to construct a clear and insightful problem statement with evidence of all relevant contextual factors.
Strategy and Procedure	Procedure is hard to follow and no reasoning is explained.	Procedure is adaquete and brief insight on reasoning is shown for each step.	Every step of the procedure is shown with thorough reasoning.
Evaluate Outcomes	Reviews results superficially in terms of the problem defined with no consideration of need for further work or validation of answer.	Reviews results relative to the problem defined with some validations of the answer.	Reviews results relative to the problem defined with thorough, specifically validates answer within context of the problem.
Diagrams and Sketches	Diagrams and/or sketches are difficult to understand or are not used.	Diagrams and/or sketches are clear and easy to understand.	Diagrams and/or sketches are clear and greatly add to the reader's understanding of the procedure(s).
Neatness and Organization	The work appears sloppy and unorganized. It is hard to know what information goes together.	The work is presented in a neat and organized fashion that is usually easy to read.	The work is presented in a neat, clear, organized fashion that is easy to read.
Terminology and Notation	There is little use, or a lot of inappropiate use, of terminology, notation and units.	Correct terminology, notation and units are usually used, making it fairly easy to understand what was done.	Correct terminology, notations and units are always used, making it easy to understand what was done.

Fig. 1. Problem Solving Rubric

20. I never skip class
21. I enjoy offering answers in class discussions
22. I always try to participate openly in class
23. If I don't agree with a grade I have received, I always talk to the professor about it
24. I second guessed my answers on this survey

IV. DATA ANALYSIS

Problem-solving requires a multi-facet approach to truly understand the process. The rubric used to analyze the thought process of the students looks at multiple smaller aspects to get an overall picture. With each performance indicator being assessed, it allows a professor to understand more specifically what the underlying issue is with their students.

The performance indicators: Problem defining, Strategy and procedure, Terminology and notation were not significantly affected by using the Lightboard technology. However, as indicated below the Outcome evaluation, diagrams and Sketches as well as Neatness and organization were significantly impacted by using the Lightboard.

A. Outcome Evaluation

The results indicate that there was a significant improvement in the student's ability to evaluate outcomes.

TABLE I. SUMMARY RESULTS

Groups	*Count*	*Sum*	*Average*	*Variance*
HW1	14	17	1.214	0.1813
HW2	12	18	1.6154	0.2727
HW3	13	23	1.7692	0.1923
HW4	12	13	1.0833	0.9924

TABLE II. ANOVA SUMMARY RESULTS

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3.5754	3	1.1918	3.0145	0.0392	2.8024
Within Groups	18.5815	47	0.3954			
Total	22.1569	50				

B. Diagrams and Sketches

A one-way between subject ANOVA was conducted to compare the effect of the use of the Lightboard on the preparation of diagrams and sketches. There was a significant level of improvement between the first iteration and the second. This improvement was sustained during the 3 iterations of using the Lightboard.

TABLE III. SUMMARY RESULTS

Groups	*Count*	*Sum*	*Average*	*Variance*
HW 1	18	21	1.1667	0.1471
HW 2	13	21	1.6154	0.4231

TABLE IV. ANOVA SUMMARY RESULTS

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1.5192	1	1.520	5.7171	0.0224	4.1827
Within Groups	7.5770	29	0.2313			
Total	9.0968	30				

C. Neatness and Organization

Additionally, we tested the effectiveness of the Lightboard on the neatness of the diagram. A between subject' ANOVA was conducted and we found a significant improvement

TABLE V. SUMMARY RESULTS

Groups	*Count*	*Sum*	*Average*	*Variance*
HW 1	18	26	1.4444	0.2614
HW 2	13	26	2	0.3333

TABLE VI. ANOVA SUMMARY RESULTS

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.3297	1	2.3297	8.0008	0.0084	4.1830
Within Groups	8.4444	29	0.2912			
Total	10.7742	30				

D. Self-Confidence

The three responses programmed for self-confidence all had an increase, but none with significance. Students felt they could approach circuit problems with assurance 10.34% more at the end of the semester but p=0.326, while students felt more comfortable solving circuit problems that have never seen before 15% more with a p=0.422.

V. LIMITATIONS

The Lightboard provides many benefits to both the students and instructors, but there are some drawbacks with the device and this method. The Lightboard requires a decent sized room furnished with filming equipment. Along with the basic setup, time is required to spend post-processing to cut

out unnecessary pieces of the video, such as mishaps while speaking/working out problems that must be started over.

Most students found that the location of the Lightboard was inconvenient. The students had to find time from their already busy workload to record this assignment, frustrating several students. Occasionally, some students expected to finish in a certain amount of time, however, may not expect to go over. Also, the Lightboard was only accessible during University hours of 8am – 5pm, further limiting students' schedules. This was part of the cause for the number of no-shows and incomplete Lightboard assignments.

The Lightboard can be integrated into smaller classes with a few logistical fixes, but trying to implement this on a larger scale could be a more difficult task. Trying to organize scheduling with larger classes and potentially other courses would require too much work where it could be a full-time job alone.

VI. Discussion

VII. Conclusions and future work

Overall, this method of instruction allows professors to get a better understanding of where their class may have difficulty when solving problems. As many of the students tend to copy the solutions from the book without thinking, it can be hard for a professor to truly gauge where students stand in understanding a problem until it is too late.

Having a Lightboard dedicated for the department would make scheduling a little easier as it would be dedicated for department use rather than one for the entire University.

To compare each students' progression of knowledge and confidence, instructors could view the raw, or pre-processed, videos to see the time duration it takes for the student to complete a problem. The instructor could also compare their first Lightboard video, to their most recent video.

It has been recommended that students explain their mathematical thinking, but more research is needed to determine where students struggle with solving circuit based problems, which goes beyond the basic math skills. But from the initial data, significant levels of improvement were made, both in terms of neatness and organization, as well as diagrams and sketches. The improvement was sustained during the 3 iterations of using the Lightboard. This is a step towards better understanding the students' mindset when approaching circuit problems.

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