Perceptions of Lightboard Videos on Engineering Students' Engagement for Learning: A Mixed-Methods Case Study

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Purpose. Researchers have recommended using comprehensive visual materials in engineering courses, as visuals instill more information in students than auditory information and they have the ability to engage students more effectively than other types of content and to convey the nuances of non-verbal communication. The purpose of this study was to explore the perceptions of engineering students on incorporating technologically advanced video course materials (TAVCM) created with lightboard technology on their engagement in learning.

Theoretical Framework. The theoretical framework was based upon an integrative learning environment that incorporated many theories of cognitive learning. The Cognitive Theory of Multimedia Learning (CTML) was the most pertinent learning theory to take into account while analyzing the characteristics and efficacy of lightboard technology. The Cognitive Load theory (CLT) was the next hypothesis on which the lightboard technology was built. Finally, the other learning theory that was pertinent to examine the potential of lightboard was Social Agency Theory (SAT).

Methodology. A mixed-methods case study design was employed and for the purpose, a case was identified where the perspectives of both faculty and student were equally important to
establish the research findings. The case, included every faculty participant and the entire engineering student population that participated in this research (student, n=191; faculty, n=5). The process of convenient sampling was used to select the participants. Multiple forms of data were collected for the case and the data were analyzed within and across the data collected from faculty and student participants.

Findings and Conclusions. The major findings emerged from analyzing both quantitative and qualitative data collected from the faculty and student participants were that lightboard videos help students to be engaged in studies, faculty’s body gesture and facial expression help students follow the content, lightboard videos offer a traditional classroom experience, lightboard videos made content easier to understand, short duration lightboard videos were more useful, recording requires intelligent use of color contrast and recording lightboard videos were easy and required no additional training.

The findings clearly showed that engineering students' learning engagement was stimulated by lightboard videos. The lightboard videos were deemed relatively easy to view and comprehend by the participants. It made studying new subjects easier by summarizing key ideas and providing information visualization to complement them. One of the best ways to get students engaged and participating in the classroom was to use visually appealing and functional technology. It was simpler to pay attention because of the faculty's handwritten notes, facial expressions, and body language.

Recommendations. This study recommended the following to enhance the application of lightboard videos.

- Create shorter length videos.
• Pay attention to the color contrast while recording lightboard videos.
• Avoid recording lightboard videos for text savvy courses.
• Select the attire carefully and marker color so that the text does not blend with presenter’s image.
• Provide some kind of marked boundary for writing on the glass board.
• Integrate software to digitally wipe the glass board off.

Future research should be conducted to investigate if adding lightboard videos to the course materials can help students perform better academically and compare the learning engagement of lightboard videos with other methods of producing audio-video course materials.

*Keywords*: Body gesture, Case study, Cognitive load, Facial expression, Faculty, Learning engagement, Lightboard, Mixed-methods, Qualitative data, Quantitative data, Student, Traditional classroom
PERCEPTIONS OF LIGHTBOARD VIDEOS ON ENGINEERING
STUDENTS’ ENGAGEMENT FOR LEARNING:
A MIXED-METHODS CASE STUDY

BY
RANA SANYAL
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A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE
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Dr. Jason Rhode
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Achieving this pinnacle of academic success, completing my Doctor of Philosophy, was only in my wildest dreams and will be cherished ever as the proudest moment of my career. After spending a major part of life working for reputed organizations, I never imagined of pursuing a research endeavor to attain a doctoral degree. My heartfelt gratitude is for the people around me without whose unwavering support I could not have accomplished this.

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see her children become scholarly individuals has always supported my educational journey. The love and support of two individuals in my life have been the most crucial and last things that made all of this possible. First and foremost, my wife Indrani, who has been a crucial source of support for me during this incredible journey toward my PhD. It would not have been possible in the slightest without her dedication and her belief in me that "I can do it" during this difficult journey. The other individual is our princess, Angelica, who, despite her busy schedule, never failed to inquire on my progress throughout my PhD. That sweet question itself, was an inspiration for me to accomplish the job.
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## Chapter

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

Engineering education suffers greatly from a lack of student engagement (Chen et al., 2008; Simmons et al., 2019). According to numerous studies (Bedard et al., 2012; Cady et al., 2009; Chang et al., 2011; Chen et al., 2008; Heller et al., 2010; Willmot & Perkin, 2011), "student engagement" can be defined as the time and effort students invest in meaningful academic activities. Additionally, the Accreditation Board for Engineering and Technology (ABET) changed the focus of engineering education to outcomes in the late 1990s (Froyd et al., 2012). As a result, engineering institutions were held responsible for ensuring that students in their programs of study obtained the necessary knowledge, abilities, and professional growth (Hardre & Siddique, 2013; Natarajarathinam et al., 2021). Hence, in order to encourage students' learning engagement, it is now crucial to maintain a focus on student engagement and offer ongoing support at all stages of engineering education (Chang et al., 2011; Craft & Capraro, 2017).

Student engagement is a significant concern as it is essential for academic success in engineering education (Adams et al., 2011; Craft & Capraro, 2017; Hadgraft & Kolmos, 2020). Additionally, engineering is a practicing profession, according to Feisel and Rosa (2005); it mobilizes materials, energy, and technical resources, necessitating students' active participation in the learning process. Other researchers (Felder et al., 2000; Kearsley & Shneiderman, 1998)
advocated that students should be involved in worthwhile educational activities that require cognitive processes like reasoning, problem-solving, or decision-making. Also, student disengagement compromises the availability of future engineers who are qualified (Chen et al., 2008; Simmons et al., 2019) and results in poor academic performance, mediocre program outcomes, and alarmingly high academic attrition rates for engineering institutions (Chang et al., 2011; Chen et al., 2008; Craft & Capraro, 2017; Simmons et al., 2019). In this context, Ohland et al. (2008) conducted research using datasets from major universities and supported the idea that undergraduate engineering student engagement was trending downward. As a result, it is now crucial for teachers to find ways to increase student engagement (Craft & Capraro, 2017).

Educators are essential in improving the learning environment at the program level and encouraging student engagement (Chen et al., 2008). According to them, various degrees of learners’ engagement is essential for the cognitive model created by the faculty to carry out its features to inspire student engagement. Consistent with the view, Hardre and Siddique (2013) stated that learning engagement requires explicit attention by the faculty for the purpose of instructional designing. Additionally, practitioners noticed that there is a shift away from traditional in-class lectures toward a more student-centered learning process in the delivery of engineering education, which encompasses every aspect of overall development and growth to encourage student engagement in the academic curriculum (Felder et al., 2000; Hadgraft & Kolmos, 2020; Litzinger et al., 2011). In order to increase student engagement in learning, researchers are currently pursuing an open learning approach that includes student-centered learning, project-based learning, collaborative learning, and active learning (Lee & Mentzer, 2021). As a result, researchers advised exploring various engineering education strategies with a
focus on the function of different educational environments in fostering student engagement (Chen et al., 2008; Simmons et al., 2019).

Background of the Study

Problem-based learning (PBL) environment with its innovative curricula puts engineering students’ perseverance on test and thereby increase their engagement (Bedard et al., 2012). PBL is the technique of having students work in teams to solve challenging real-world problems while the faculty serves as a facilitator (Galand et al., 2010; Graaff & Kolmos, 2003). Researchers have suggested using PBL to inspire student engagement in learning because engineering education involves complex and multi-disciplinary processes to solve problems (Bedard et al., 2010; Figueiredo, 2021; Graaff & Kolmos, 2003; Hadgraft & Kolmos, 2020; Jones et al., 2013; Litzinger et al., 2011; Matusovich et al., 2012; Moore et al., 2017). The main idea of PBL is that students learn on their own, and researchers have found that engagement plays a significant part when going through the PBL process for a project (Brown et al., 2015; Figueiredo, 2021; Galand et al., 2010; Hadgraft et al., 2018). Consequently, studies where PBL has been implemented for engineering education have found that students become more engaged when the project is initiated by the students as they realize that their involvement is directly influencing the project direction (Felder et al., 2000; Figueiredo, 2021; Graaff & Kolmos, 2003; Hadgraft & Kolmos, 2020; Jones et al., 2013; Matusovich et al., 2012; Mills and Treagust, 2003). The issue with PBL is that different students have varying levels of pedagogical knowledge and inspiration for engagement, which causes them to contribute to projects in different ways. As a result, when a
student feels that their contribution is undervalued, their engagement declines and they become reliant on the other team members (Lee & Mentzer, 2021).

However, the impact of the collaborative learning (CL) environment on students' learning engagement was mixed because few systematic strategies incorporating collaboration among students have been implemented into place (Qiu, 2019). The term "collaborative learning" refers to an instructional technique whereby students collaborate in groups to achieve a common objective (Felder et al., 2000; Saterbak & Wettergreen, 2016). According to Froyd et al. (2012), this is the most prevalent way faculty ensure student engagement. In order to ensure student engagement, some researchers planned the collaboration process; their findings suggested that the collaboration process had a positive impact on students' learning engagement (Felder et al., 2000; Kearsley & Shneiderman, 1998; Saterbak & Wettergreen, 2016). While other investigations (Froyd et al., 2012; Oakley et al., 2004) concluded that CL improves learning engagement because it increased information retention, academic performance, and critical thinking and problem-solving skills. In contrast to this perspective, according to Lee and Mentzer (2021), there is a phenomenon known as "social loafing" whereby students may put in less effort on a group project than they would on an independent endeavor. This phenomenon occurs when the individual contribution to a project is not acknowledged. In order to effectively increase student participation, Oakley et al. (2004) emphasized that teachers must take the proper procedures for the adoption of CL.

In addition, few researchers implemented the virtual technology environment and remarked that the application of virtual technology still has limited application in the educational domain and so its full potential to improve student engagement can’t be verified (Gutierrez et al.,
Virtual reality (VR) refers to a combination of computerized systems to perform a simulated reality that gives a realistic immersive experience whereas, augmented reality (AR) makes it possible to superimpose elements, contents, or text data on real-life images thereby increasing the user interaction (Gutierrez et al., 2017). Some practitioners created an environment that allowed engineering students to work with Virtual technology and observed that students became engaged in the active learning process; the enriched instructional delivery facilitated student understanding of the subject by creating a realistic learning experience (Gutierrez et al., 2017; Liarokapis et al., 2004). Consistent with the view, Tuttle et al. (2019) commented that VR possesses characteristics of a lively, dynamic, and realistic learning environment that encourages students to engage in learning. In contrast, some studies discovered that while virtual technology has the ability to boost student engagement through its interactive and realistic environment, it still did not contribute to superior academic results (Tuttle et al., 2019). Moreover, because it is expensive and causes physical discomfort in certain students, such as nausea, there is still little use of virtual technology in the educational setting (Gutierrez et al., 2017; Tuttle et al., 2019; Vries et al., 2018).

Nowadays, online courses make up a significant portion of engineering education, in contrast to the conventional face-to-face (F2F) learning setting where learning methodologies like PBL, CL, and virtual technologies are mostly employed (Prince et al., 2020). Therefore, the crucial question became apparent was how to implement and maintain student engagement in an e-learning environment or in other settings where e-learning tools are applied, such as for blended learning (where online learning aspects are combined with off-line or F2F curriculum), flipped classroom, and virtual/ remote lab (Chang et al., 2011).
It is much harder to maintain student engagement in an e-learning environment than it is in a conventional F2F context (Prince et al., 2020). According to Chang et al. (2011), e-learning is a collection of many teaching strategies that use digital technologies to enable, disseminate, and support learning. Additionally, for engineering education, e-learning has been implemented with the emphasis on specific interventions and effective mechanisms to leverage learning engagements (Chang et al., 2011; Qiu, 2019). E-learning, according to Gudimetla and Iyre (2006), is a cost-effective way to reach a larger audience, but it is still unclear if it can be fully utilized in engineering education due to the program's unique structure, which calls for hands-on practical experience because online instructional material is insufficient. As a result, it is more difficult to maintain student engagement in an online learning environment due to the technological needs and interpersonal difficulties (Prince et al., 2020). To encourage student engagement, e-learning initiatives have been established in accordance with the needs of particular e-learning environments (Chang et al., 2011).

Flipped classrooms are an effective way of enhancing students’ learning engagement (Abeysekera and Dawson, 2014; Herried & Schiller, 2013; Prince and Felder, 2006; Roehl et al., 2013; Saterbak & Wettergreen, 2016). The flipped classroom has been defined by researchers as a comprehensive approach to learning with two components: in-class and outside-of-class activities, where the outside-of-class component includes rich media content to engage the learners and the in-class lectures are replaced by learning activities related to the content where students actively participate individually or in groups (Abeysekera and Dawson, 2014; Prince and Felder, 2006; Saterbak & Wettergreen, 2016). Researchers commented that the flipped classroom has undeniable appeal to the modern-day engineering students (Roehl et al., 2013;
Several researchers employed the flipped classroom approach for engineering courses and investigated its impact for students’ learning engagement and found that the flipped classroom inspires learners to keep themselves engaged in studies (Abeysekera and Dawson, 2014; Herried & Schiller, 2013; Prince and Felder, 2006; Roehl et al., 2013; Saterbak & Wettergreen, 2016).

Blended learning (BL) did not, however, show much promise for raising student engagement (Geng et al., 2019; Garrison & Kanuka, 2004) as it depends upon other factors as well. Learning outside the classroom is made possible by BL, which can take many different forms (Erdem & Kibar, 2014; Geng et al., 2019; Lim et al., 2007). Sometimes, BL mixes the traditional classroom with technology-driven online learning activities. Other researchers added that the full potential of blended course quality is achieved with constructive integration of traditional and online parts of the course (Garrison & Kanuka, 2004; Geng et al., 2019). A blended learning environment was used, and Lim et al. (2007) discovered that it had a favorable impact on student engagement. Geng et al. (2019), in contrast, discovered that engagement depends on how well each student performs in their learning activities, with engaged students being more involved in their studies. They contend that students' technological aptitude is essential to their performance in a BL setting. Garrison and Kanuka (2004) emphasized that the BL learning process should be examined prior to adoption depending on the desired learning outcomes, which lends support to the viewpoint.

Engineering students associated with the remote/virtual lab, however, were intensely engaged in their learning because it reflected in their practice (Chang et al., 2011). Computers have altered the course of engineering education through the use of virtual/remote labs because
they give much-needed impetus for activities like data collection and analysis, running engineering software for simulation, and sharing information via the internet in ways that are almost identical to physical labs (Feisel & Rosa, 2005; Koretsky & Magana, 2019). The virtual/remote lab concept altered the engineering students' learning engagement with the laboratory (Chang et al., 2011; Koretsky & Magana, 2019). In addition, computer simulations have the unique feature of providing the solutions to a variety of tests in a matter of seconds as opposed to taking several days in a physical laboratory setup. The benefits of a virtual lab, according to Koretsky and Magana (2019), include less resource requirements, minimal scheduling commitments, and quick feedback for trials. Practitioners have developed virtual labs for engineering students based upon a combination of logically associated components that provide a virtual simulation model (VSM) for students to enter parameters for processing, and furnished the operating and learning results; their reflections showed that student engagement was expanded and deepened through the virtual/remote experimentation (Babich & Mavrommatis, 2004; Chang et al., 2011; Froyd et al., 2012; Gillet et al., 2005; Jong et al., 2013) however, unstable network connectivity was an issue (Babich & Mavrommatis, 2004; Jong et al., 2013).

According to Babich and Mavrommatis (2004), Chang et al. (2011), and Jong et al. (2013), the use of various e-learning tools in various learning contexts has evidently been successful in affecting student involvement to some extent. The potential of e-learning technologies for various learning contexts has led to active student participation, according to practitioners (Chang et al., 20011; Prince et al., 2020). However, keeping students engaged in an e-learning environment requires much more concentration on instructional strategies and
The researchers claimed that the concept of student engagement is similar regardless of the learning environment, whether traditional F2F or e-learning (Chang et al., 2011; Prince et al., 2020). Furthermore, Chang et al. (2011) given a warning that the increased autonomy connected to the e-learning environment may invite some unintentional activities, such as students engaging in unrelated activities during class or beginning to experiment with something that would have been harmful if done in a traditional F2F learning environment.

Statement of the Problem

Exploring various learning environments has shown that the trend in engineering education is toward student-centered active learning using digital tools to increase productivity in the classroom and where the learning environment influences better student engagement (Hadgraft & Kolmos, 2020; Koretsky & Magana, 2019). Despite implementing these improvement techniques, in different learning environments, Felder et al. (2000) claimed that there hasn't been much of an impact on engineering students' engagement in study. According to Adams et al. (2011), who shared this opinion, a variety of strategies have been used and significant funds have been invested in engineering education to make it more engaging for students, but the outcomes to date have not been satisfactory.

Vries et al. (2018) observed that engineering schools have lagged behind in catching up to technological change at an equivalent development rate due to the exponential expansion of technology innovations and digital transformation. Therefore, the researchers stated that we need to learn more about emerging technologies, their perceived relevance, and what is required for
them to function in relation to the significance of emerging technologies for education, learning innovation, and industry demands (Vries et al., 2018).

According to Wilson (2020) to improve academic performance, numerous public and private educational institutions are integrating cutting-edge technological tools and programs into their curricula (U.S. Department of Education, 2015). Such integration is frequently utilized to increase academic productivity, broaden course content and experiences, provide ongoing support, and have extra materials for students with different learning styles. The educational industry is advancing toward implementing these innovations by utilizing a variety of contemporary media and technical tools to support student learning and make them competitive job applicants.

In order to encourage an enriching learning experience for the engineering students to boost up their engagement into learning, more resources need to be explored (Simmons et al., 2019). To a large extent, the prevailing rule for engineering instruction consists of words in the form of written or oral and stepwise illustration for solving a problem (Cady et al., 2009). Other types of instruction involving external stimuli like pictures, videos and learning activities to arouse interest in engineering students should be explored and that can be easily accomplished with few changes in the instructional design (Cady et al., 2009). According to Gudimetla and Iyre (2006), the learning materials for engineering courses should be designed pragmatically to grab students' attention and keep them engaged with the subject matter. Additionally, according to Cadena et al. (2019), course content is one area in which faculty continually work to improve in order to ensure that the course materials have the ability to keep students engaged because everything depends on the students' responsiveness to the instructional material. Other
researchers have recommended using comprehensive visual materials in engineering courses, as visuals instill more information in students than auditory information (Babich & Mavrommatis, 2004; Felder et al., 2000). Confirming this view, Liarokapis et al. (2004) commented that the quality of a traditional engineering class instruction can be augmented by integrating multimedia content into the course structure. This observation was further supported by Gudimetla and Iyre (2006), who argued that interactive and informative learning materials displayed on a computer screen pique students' engagement in learning. As a result, visually appealing learning materials naturally keep students interested in what they are learning. Consequently, due to their ability to engage students more effectively than other types of content and to convey the nuances of non-verbal communication, researchers have also noted that the use of video in the application of diverse media for course content has become widespread (Cadena et al., 2019; Fung, 2017; VanderMolen et al., 2018). The need has been identified but still a void is noticed that high quality video content has limited or almost no application in engineering education. As a result, Cadena et al. (2019) suggested using cutting-edge multimedia-technology tools to create and incorporate technologically advanced video content for engineering education in order to keep students engaged in learning.

Purpose of the Study

The purpose of this study was to explore the perceptions of engineering students on incorporating technologically advanced video course materials (TAVCM) created with multimedia technology on their engagement in learning. That is, this research was concerned with the perceptions of student engagement towards learning as a result of designing the course
material with the application of advanced multimedia technology. For the research, I used the lightboard technology tool to produce TAVCM for five engineering courses, including them into the curriculum for the students. Lightboard is a low-cost technology that can be applied as a creative presentation tool that allows faculty to record visually captivating videos involving drawing sketches, diagrams or explaining equations of the course material on an illuminated glass board with dry erase markers while facing towards the viewers (Cadena et al., 2019; Rosasco, 2018; Rulino & Fabriana, 2022). The unique features of the lightboard technology are explained in detail in chapter 2 of this dissertation paper.

Rationale

The New Media Consortium's (NMC's) Emerging Technology Initiative produces a Horizon Report every year in an effort to identify and comprehend emerging technologies that have the potential to have a positive impact on learning, creative inquiry, and education as well as those that promise to have a significant global impact on various sectors (Yuen et al., 2011). This decision-making process for the teaching and learning environments, to a considerable extent, is influenced by the primary users, students. It is clear that during the past ten years, technology and tools have permeated our society as a whole, including education, and have had a significant impact on our way of life (World Economic Forum, 2016). This applies to the academic community also. Hence, it requires a particular level of understanding in order to determine if a technology might be helpful or not for the students and accordingly, in facilitating learning (Vries et al., 2018).
The instructional skills gap in digital engineering served as a significant impetus for this exploratory study into the utilization of new technologies for teaching and learning (Kiss, 2017). Considering the progress gained, it appears to be a problem that needs continual attention because it is closely tied to the social changes that are always taking place. When the necessary skills are lacking, there is a general scarcity that prevents students from being engaged in learning. Education is under a lot of strain due to the rapidly evolving demand, but emerging technologies have the potential to make engineering instruction easier.

Educational technology constitutes a little part of the technology sector and hence, technical upgradation for the educational sector does not happen simultaneously with the advancement in the technological sector. Education seems to be a follower and advancement lags behind. However, the promise of technology is that it will have a profound impact on education, including how we teach and how students learn (Adams Becker et al., 2017; Carlton, 2017). It will therefore matter how well technology is used to advance teaching and learning (Brinson, 2015; Janssen et al., 2016, King et al., 2017).

Saterbak et al. (2016) experienced that students found it difficult to transition from hearing about a subject for the first 30 minutes of class to using it in their design project right away. After some thought about how to best promote student learning, they started having students watch videos related to the course content before class to ensure they were familiar with the material. The faculty’s goal for using videos with a maximum of 11 minutes’ duration was to move important information from the lecture format used in the classroom to rich media that can be viewed outside of the classroom. Guo et al. (2014) expressed a similar opinion, arguing that shorter videos are more engaging. By far, the most important engagement metric was video
length. They discovered that viewer engagement was strongest for short videos (0–3 minutes). Additionally, students were less likely to participate in assessment exercises that came after lengthy videos. Lightboard videos fit into this perfectly.

There hasn't been enough research to determine whether lightboards are more effective at helping students comprehend the material than other media-based teaching techniques, despite the fact that they combine the parts of more widely used gadgets and educational software while incorporating newer aspects. The goal of the current study is to comprehend the application of lightboards techniques in terms of how engineering students engaged with their academic work. This study will shed light on how various aspects of this modern technology affect students' engagement on course material, either positively or negatively, and it will provide educational institutions with information about media resources they may use to better serve their students. This study will increase our knowledge and awareness of the potential influence that lightboard technology may have on students' learning habits.

In addition, despite some study on technology-enhanced learning, the findings are not universally accepted. Investigating the relationship between technically sophisticated video content and individual students' academic engagement is crucial to close this gap (Geng et al., 2019). Due to its major influence on learner attitudes and learning behavior (Fairchild et al., 2005), engagement is one of the success elements for learning (Lim, 2004). Students may have excellent possibilities and abilities to be self-directed in their learning in a learning environment that provides highly technologically sophisticated video contents (Fahnoe & Mishra, 2013).
Research Questions

This study seeks to investigate the perceptions of engineering students on captivating video course materials created by applying lightboard technology on their learning engagement. The following primary research questions are used for the purpose of data collection and analysis:

**Quantitative**

1. What are engineering students’ perceptions of learning engagement with video course materials created with lightboard technology?

**Qualitative**

2. How do engineering faculty perceive the use of video course materials created with lightboard technology would influence student learning engagement?
3. How do engineering students perceive the use of video course materials created with lightboard technology would influence student learning engagement?

**Mixed**

4. How does student data and faculty data help understand the effectiveness of video course materials created with lightboard technology?
Significance of the Study

These study topics are important to the field of higher education since it has been demonstrated that greater student engagement increases online student retention (Craig, 2018). Institutions can incorporate inspiring instructional design into their curriculum with the help of a better understanding of what drives engineering students for learning engagement. Additionally, knowing why students do what they do will help more students complete their coursework and graduate (Beluce & Oliveira, 2015; Chen & Jang, 2010; David & Glore, 2010). In the US, it's still difficult to retain and graduate students who have begun college. According to Shapiro et al. (2014), "over the past 20 years, more than 31 million students have enrolled in college and left without receiving a degree or certificate". Even though there has been improvement, there is still a lot of work to be done to enhance college enrollment. Furthermore, non-graduating students waste time, money, and confidence, all of which have a detrimental effect. Engaging instructional design might not seem important at first glance; however, enhancing retention and graduation rates for students depends on developing an instructional design that engages students to persevere.

This study will also aid in identifying the real-world issues that teachers and students run into while putting ideas into practice. When taken into account, the study's findings can assist in identifying their areas of weakness and recommending solutions to strengthen their performance and instructional methods. Finally, research in this field may improve students' knowledge by raising faculty awareness of the pedagogical alternatives to teacher-centered instruction.

Every student should have the chance to be successful in a postsecondary setting. These institutions of learning have a duty to offer opportunity to students who have had inadequate
educational experiences in the past (Johnson, 2014). However, it is necessary to look into the
efficiency and value of those services. The results of this study could be used to inform faculty
about cutting-edge video technologies for providing academic support to the students.

This new creativity environment can be utilized to spark original ideas and raise
important theoretical and practical queries. The term "engaging characteristics" can be used to
discuss identity development, cognitive, socio-technical, and affective aspects of deep learning,
as well as the effectiveness of learning settings and perseverance in engineering (Adams et al.,
2011). This will open up new avenues for research and innovation, including (1) examining how
learners' understanding of and identification with engineering is influenced by socio-technical
engineering experiences, (2) developing and evaluating methods for teaching students to control
their own affect, and (3) figuring out the connections between engagement, deep learning,
affective outcomes, and identity formation, (4) designing and evaluating case-based materials of
heterogeneous engineering projects to develop capacities to see and notice socio-technical
aspects of engineering work and shape successful engineering projects, and (5) comprehending
the relationship between engagement and future learning or transfer.

In literature, still not many observations are available with regards to the application of
lightboard technology for creating cutting edge video course materials to engage students for
learning. There still exists insufficient information about the implementation and uncertainty
about the outcomes of those implementations, how faculty’s and students’ characteristics affect
the outcomes. Engineering is one of the disciplines that has merely adapted any advanced
multimedia technology enriched curriculum based on the gaps of conventional instruction
(Ozlem, 2009). Teaching the concepts and practices of the profession in isolation is not enough
to educate future engineers. This study will evaluate the usage of lightboard, a cutting-edge multimedia tool for producing captivating video course materials, and explores how it affects engineering students' learning engagement and use of study techniques. The findings of this study can help university curriculum developers and faculty to evaluate their current program for betterment. Additionally, this data can assist decision-makers in creating better designed instructional materials and moving the curriculum design process forward.

The findings of this study will open up avenues for research on lightboard technology for producing captivating video course materials and offer recommendations that administrators and faculty may use to: a) assess the effectiveness of current instructional design in engineering education to identify strengths, weaknesses, and areas for improvement; b) set priorities when creating new instructional programs; and c) create strategies that will improve and institutionalize current practices.

The study's findings will indicate crucial elements that enhance the durability of the instructional design and have positive ramifications for schools looking to incorporate engaging video course contents produced using cutting-edge multimedia technology: Collaboration on planning, execution, and assessment between administrators and faculty is prioritized, as is communication between professors and students to accommodate various teaching and learning philosophies and to foster student engagement.

These innovations have had a major impact on how faculty instruct, and this is particularly true in higher education, where lecturing is still the most popular method of instruction and still takes up the majority of instructional time (Slavich & Zimbardo, 2012). On
the other hand, improvements in lecturing methods only make up a small portion of the overall pedagogical gains that have been realized (Mazur 2009; Ueckert et al. 2011).

Definition of Terms

The following terms are defined to facilitate the study.

*Active learning.* Using debates, problem-solving, case studies, role plays, and other techniques, active learning includes actively involving students in the course material. Compared to passive methods like lectures, active learning approaches lay more responsibility on the learner, although in an active learning setting, faculty direction is still essential. Active learning exercises can last anywhere from a few minutes to an entire class period, or they can span numerous class periods.

*Asynchronous learning.* Online instruction frequently employs the student-centered teaching strategy known as asynchronous learning. Its fundamental tenet is that learning can take place at various times and places that are unique to each learner. A learning route is typically established by teachers for asynchronous learning, which students follow at their own speed.

*Blended learning.* A teaching strategy known as blended learning combines online or digital components with in-person instruction. Because computers and other connected devices are now so essential to communication and business, integrating technology into education helps prepare students for success in the future. Students that learn in a blended learning environment not only master the subject being studied, but also the usage of technology. A teacher-led classroom setting is necessary for the blended learning strategy. In addition to visual and kinesthetic skills, listening skills should also be developed in students.
Cognitive load. The amount of working memory resources employed is referred to as cognitive load in cognitive psychology. It is crucial to differentiate it from the true Cognitive Load (CL) or Mental Workload (MWL), which is extensively researched across several fields. According to research in the fields of instructional design and pedagogy, there are three different types of cognitive load: intrinsic cognitive load that can be referred as the inherent difficulty of the course content; germane cognitive load, which refers to the effort put into developing a permanent store of knowledge (a schema); and extraneous cognitive load, which refers to how information or tasks are presented to a learner.

Collaborative learning. The educational strategy known as "collaborative learning" uses groups to improve learning through cooperation. Learners collaborate in groups of two or more to solve issues, finish assignments, or pick up new ideas. Rather than having students memorize facts and figures by heart, this method actively engages them in the processing and synthesis of information and concepts. Students cooperate with one another on projects where they must grasp the principles being taught as a group. Learners will acquire greater comprehension as a group than they might as individuals through clarifying their points, listening to opposing views, defending their positions, and reframing concepts.

Computer simulation. Computer simulation is the practice of mathematical modeling carried out on a computer and intended to forecast the behavior or result of a physical or real-world system. By contrasting the results of some mathematical models with the outcomes they hope to predict in the actual world, one can establish how reliable they are. Many natural systems in physics (computational physics), astronomy, climatology, chemistry, biology, and manufacturing, as well as human systems in economics, psychology, social science, health care,
and engineering, may now be mathematically modeled using computer simulations. Running the system's model is how a simulation of a system is described. It can be used to investigate and get fresh perspectives on emerging technologies, as well as to gauge the performance of systems that are too sophisticated for analytical solutions.

Distance education. Distance education (DE) is a style of education that delivers instruction to students who are geographically separated from the teacher while still facilitating regular, meaningful interaction between the students and the faculty, either synchronously or asynchronously. The internet, satellite or wireless connection, as well as audio and video conferencing, are the technological kinds that can be employed for distance education.

Educators/ Faculty. A person who imparts knowledge or instruction; a teacher.

e-Learning. E-learning is a formalized teaching-based learning system that makes use of electronic resources. E-learning is primarily based on using computers and the Internet, while teaching can also take place in or outside of formal classroom settings. The delivery of education to many recipients at once or at different times is known as e-learning, which is also known as a network-enabled transfer of skills and knowledge.

Flipped classroom. The premise of a flipped classroom is that lectures and direct instruction are not the most effective uses of class time. Instead, students receive material outside of class, freeing up class time for higher order thinking exercises. This instructional approach brings activities into the classroom, including ones that might have previously been regarded as homework. In a flipped classroom, students actively engage with subjects in the classroom while also watching online lectures, participating in online conversations, or conducting research at home under the supervision of a mentor.
Learning environment. The term "learning environment" describes the various settings, situations, and cultural contexts in which students learn. The term is frequently used as a more accurate or preferred substitute for the classroom, which has more restricted and traditional connotations—a room with rows of desks and a chalkboard, for example—because students can learn in a wide variety of settings, including outside-of-school locations and outdoor settings.

Learning management system. A learning management system (LMS) is a piece of software or web-based technology used to organize, carry out, and evaluate a particular learning procedure. It is used for e-learning procedures and, in its most basic form, consists of two components: a server that handles the essential operations and a user interface (UI) that is controlled by teachers, pupils, and administrators. An LMS often gives faculty a tool to develop and deliver curriculum, track student involvement, and evaluate student performance. Additionally, it could give students access to interactive elements like discussion boards, video conferencing, and threaded discussions.

Mixed-Methods research. To capitalize on the advantages of each, mixed-methods strategically integrate or combine exacting quantitative and qualitative research techniques. By combining inductive and deductive thinking, mixed-methods approaches enable researchers to use a variety of techniques while overcoming the limitations of exclusively quantitative and qualitative research. This complementary strategy maximizes the strengths of each data type and enables a more thorough understanding of the issues and potential solutions. To provide a strong description and interpretation of the data, to make quantitative results more intelligible, or to comprehend the broader relevance of small-sample qualitative findings, mixed-methods may be used.
Online courses. An online course is one that is delivered through the Internet. They are typically performed using a learning management system, where students may access their course curriculum, track their academic progress, and interact with their peers and faculty. Online courses are typically self-paced, giving students more flexibility in how quickly they may finish their assignments.

Problem based learning. Instead of directly presenting facts and concepts to students, the teaching approach known as problem-based learning (PBL) uses complicated real-world issues to encourage student understanding of concepts and principles. PBL can help students enhance their critical thinking, problem-solving, and communication skills in addition to the course material. It may also present chances for group collaboration, locating and assessing sources for research, and lifelong learning. It is a student-centered approach in which students gain knowledge about a subject by working in groups to address an unrestricted problem. The motivation and learning are driven by this issue.

Qualitative data. The definition of qualitative data is information that approximates and characterizes. It is possible to observe and record qualitative data. The nature of this data type is not numerical. Focus groups, one-on-one interviews, observations, and other similar techniques are used to gather this kind of data. Data that may be categorized based on the characteristics and traits of an object or phenomena is referred to as qualitative data in statistics.

Quantitative data. Quantitative data is information that is expressed as counts or numbers, each of which has a specific numerical value. Data is any quantifiable information that may be used by academics for statistical analysis and mathematical computations so that they can derive practical conclusions.
Remote lab. With the use of these types of labs, faculty and students can conduct experiments and complete other laboratory work without physically being in the lab space. These tests employ actual parts or equipment in a different location than the one in which they are being managed or carried out.

Social loafing. The term 'Social loafing' is a term used in social psychology. It's what happens when someone works less efficiently when they feel like they're being judged as a member of a group. When compared to when the same person is working alone or being evaluated individually, this degree of effort is lower. Many people tend to work harder when working alone. But when teamwork is required, some people tend to lose focus.

Student. A student is someone who is not employed full-time but is registered full-time in a degree-granting program (undergraduate or graduate) at a higher education institution, as defined by his or her specific academic institution.

Student centered learning. The simplest definition of student-centered learning is an educational strategy in which students decide not just what to study but also how and why that subject could be interesting (Rogers, 1983). In contrast to the emphasis on faculty control and coverage of academic subjects seen in traditional, didactic teaching, the core of the learning environment is student responsibility and activity.

Student engagement/ Learning engagement. Student engagement is the level of focus, interest, optimism, and passion that students exhibit when studying or being taught. It also includes the degree of motivation they exhibit to learn and advance in their education. But it's not just limited to students. Student engagement may also refer to strategies used by administrators,
teachers, and other adults to "engage" youth more completely in governance and decision-making.

*Synchronous learning.* All forms of learning in which the learner and the faculty must be present at the same time and location are referred to as synchronous learning. This includes live online meetings for the entire class or smaller groups as well as in-person classes. In synchronous learning, students typically follow the learning path side by side with their faculty, who can offer assistance as they work through assignments and activities.

*Traditional learning.* In traditional learning, a teacher interacts with a group of pupils in a conventional brick and mortar classroom setting. The students attend the class for a set amount of time, learn about specific subjects, and frequently have practical work experience. Despite the widespread use of technology in schools and other institutions, the teaching-learning process still incorporates handwritten notes, assignments, tests, etc. The texts used in the curriculum are standardized and have been approved by the education board and the government. Additionally, the pupils' knowledge of the subject is entirely dependent on the teacher.

*Triangulation design.* In research, triangulation refers to the use of various datasets, methodologies, theories, and/or investigators to answer a topic. It's a research technique that can help the researcher improve the reliability and validity of their conclusions while minimizing the impact of any study biases. Although it is frequently employed in quantitative research, triangulation is mostly used in qualitative research. A study applying mixed-methods research will always use methodological triangulation.

*Virtual lab.* These laboratories imitate or virtualize actual experiments, which students can access online. Software is used to replicate the lab environment in a virtual lab. Although
they have other uses as well, virtual labs are frequently utilized for training and educational purposes. For instance, by removing many of the variables included in actual experiments, virtual laboratories may also help to increase the accuracy of traditional lab work.

*Virtual environment.* A networked application known as a virtual environment enables users to engage with both the computing environment and the work of other users. Virtual environments include email, chat, and web-based document sharing programs, for instance. It is a networked common operational space, to put it simply. Once the virtual environment's fidelity reaches a point where it induces a psychological state in which the person believes themselves to be a part of it. Virtual environments are interactive, computer-generated image displays that have been supplemented with sophisticated processing and nonvisual display modalities, like aural and haptic, to give viewers the impression that they are actually inside a manufactured location.

*Virtual reality.* Virtual reality is the computer-generated simulation of a three-dimensional image or environment that may be manipulated in a way that appears real or physical by a person using specialized electronic equipment, such as a helmet with an internal screen or gloves connected with sensors. It lets users engage and explore a virtual environment in a way that simulates reality as it is experienced by the users physically. Hardware and software for computers are used to construct the environment. Users are better able to suspend disbelief and treat a VR experience as real, even if it is fanciful, the more fully they can immerse themselves in it and block out their physical surroundings.

*Wiki.* A wiki is a collaboratively edited and controlled online hypertext publication that is accessed using a web browser. A typical wiki has multiple pages for the project's topics or scope,
and it may be accessible to the general public or restricted for usage only within an organization to preserve its internal knowledge base.

Assumptions and Limitations

Assumptions

This exploratory study was conducted under the presumption that new technology could enhance teaching. Overall, the forty years of research on how digital technologies affect learning have consistently shown beneficial outcomes. It is obvious, however, that the variety of contexts and situations as well as the many techniques made it challenging to pinpoint precise and clear consequences for educational practices. Effective schools appeared to be more adept at utilizing technology in some situations than less effective ones, but is this always the case? The quality of how technology was used to support teaching and learning practices, how well it was aligned with what was to be learned, and how well it was in line with the teacher's underlying pedagogical assumptions, instead of the use of technology itself, appeared to make the difference in most cases.

Additionally, the student participants were anticipated to be relatively diverse and comparable. Students were not accepted or rejected based on their age, race, or gender; nevertheless, this data was obtained to look into any potential variances in response patterns. Also, different students were equipped with different levels of pedagogical knowledge and possess various levels of learning engagements and therefore, contribute differently to the project. Finally, honesty was assumed on part of the participants while answering the questions.
Limitations

Regardless of the methodology used, limitations always exist and must be taken into consideration when doing scientific research. Because the researcher has extensive contact with both the study's environment and its participants (McMillan & Schumacher, 2006; Merriam, 1998), bias, reliability, and validity issues must be addressed. The following list contains a number of variables that could have influenced the study's findings.

1. The student perception survey was distributed and responses were collected from students in the class. So, there always existed the possibility that student responses have been influenced by watching adjacent student’s answers. This possibility could have been limited had the survey been administered online.

2. The study's population may have an impact on the findings. Faculty and students who were also members of Region IV-E of the National Association of Student Personnel Administrators (NASPA) made up the full population, albeit they may not be entirely representative of it.

3. The social desirability of the responses might play a role. Respondents could want to give a more positive impression of their institutions or be reluctant to provide negative experiences.

4. The researcher's ability to gather and analyze the data could have limitations. The researcher may have introduced biases to the study even when participant observers were acknowledged as competent qualitative researchers (Rhode, 2008; Van Maanen et al., 1982).

5. The study's qualitative component sought to describe the specific facts in great detail in order to shed light on topics of interest or concern. Merriam (2009) contended that reliability need not be compromised by subjectivity. We'll look at emerging topics rather than preset notions.
6. The study included students from a public University's College of Engineering (henceforth referred to as the "research university"). The ability to generalize may not be justified due to the variety of courses given and the number of teachers who teach the courses. The study chose Keller's ARCS model as the implementation framework even though there were other instructional design models available, such as Gagne's nine events of instruction or Wlodkowski's approach to motivation.
CHAPTER 2. LITERATURE REVIEW

Introduction

The concept of students’ academic or learning engagement and its correlation with college success and results is becoming more widely recognized (Nayir, 2017; Nehme, 2010) in the engineering education and higher education domains. This is primarily because of initiatives like the National Survey of Student Engagement (NSSE) and the Academic Pathways Study (APS) task, which is funded by the National Science Foundation (NSF) (as cited in Chen et al., 2008). In addition, enhancing the learning environment and attracting and retaining engineering students depend heavily on student engagement (Heller et al., 2010). Various researchers have different takes on engagement and also applied different means to measure it like, time spent on a task by the students (Legendre, 2005, as cited in Bedard et al., 2012); ability to mobilize affective, cognitive, and metacognitive assets when completing a learning task is what Pirot and De Ketele (2000) defined as "academic engagement" (as cited in Bedard et al., 2012).

Elaborating the concept, Chen et al. (2008) stated that the amount of time students allocate engaging in learning-enhancing activities, such as studying independently, asking teachers for extra help, or studying in groups, is known as student engagement. It can also refer to actions that are generally linked to self-regulation, like time management and study techniques.

There are three aspects to student engagement: cognitive, behavioral, and emotional (as cited in Nayir, 2017). It is observed that students that demonstrate behavioral engagement attend
class regularly, participate in school events, and follow school policies. Students who engage emotionally feel like they belong in the classroom, are interested in what they are learning, and have either positive or negative feelings about the social and academic aspects of school. Cognitively engaged students are motivated to learn, take on difficult assignments head-on, are self-conscious and aware of their accomplishments, and can maintain self-control.

Accordingly, Nayir (2017) argued that an essential prerequisite for active learning is student engagement and involvement in the classroom. According to Craft and Capraro (2017), "student engagement" is the demonstrable effort that students make in connection to their academic performance. In order to become involved in studies and subsequently activate their learning process, researchers found that a minimal level of learning engagement is necessary on part of the students (Stiller et al., 2022). Accordingly, to increase student engagement, Huett et al. (2008) suggested using a student-centered learning strategy. Practitioners advised pragmatic instructional process design to improve the multimedia-based learning environment to have a beneficial impact on student engagement (Dousay, 2016). In this context, the technique this study introduced for learning engagement was to integrate technologically advanced video learning materials for engineering courses using lightboard technology. The associated learning theories for multimedia learning were outlined and combined with design principles to create the theoretical framework, which served as a solid foundation for the creation of video learning materials (Hurmuzan & Yahaya, 2015). As a result, an integrative learning environment that incorporates many theories of cognitive learning was necessary (Stiller et al., 2022).
Theoretical Framework

The Cognitive Theory of Multimedia Learning (CTML) by Mayer (2005) is the most pertinent learning theory to take into account while analyzing the characteristics and efficacy of lightboard technology. 'Generative processing' (Mayer, 2005) was the term used to describe how motivated students process information in their minds to understand what is being presented to them. According to the multimedia principle of CTML, a combination of pictures and words facilitate learning more than words alone (Kessler & Totino, n.d.; Mayer, 2017; Wilson, 2020). Lubrick et al. (2019) stated that it is obvious that lightboard videos adhere to this idea because lightboard permits the teachers to provide a lesson while outlining the diagram to explain it. Wilson (2020), a proponent of the idea, claimed that lightboard has the distinctive quality of fusing visual and audio elements. To avoid unnecessary processing, the CTML coherence principle advises removing extraneous materials (Mayer, 2014). This theory is particularly applicable to lightboard videos, and study by Lubrick et al. (2019) reinforced the idea by noting that instead of producing a split-attention effect or adding extraneous emotional nuances, lightboard videos actually result in a reduction in cognitive load due to the faculty's on-screen presence. According to Mayer (2017), signaling or cueing principle of CTML points towards the essential guidance provided by vocal attention and highlighting important portions to lessen the cognitive load. The horizon of this principle was broadened by Schneider et al. (2018) by stating that gesturing effects facilitate retention of knowledge, performance of knowledge transfer, and that color enhances the cue modes for the presentation environment leading to improved learning outcomes (as cited in Lubrick et al., 2019). Lubrick et al. (2019) asserted that lightboard videos can naturally facilitate the signaling and gesturing effects; in addition, it has the capacity to
Integrate multiple media, signaling cue is also enhanced by faculty's body gestures, and it emphasizes the important points with glowing colored texts and diagrams. According to the CTML principle of "spatial contiguity," words and their related images should be put next to one another in order to save unnecessary processing and give students guidance on where to look (Mayer, 2017). Faculty can easily follow this principle while creating the lightboard videos and in addition, application of different glowing colors enhances the signal to the learners (Lubrick et al., 2019). Moreover, Mayer (2017) proposed that narratives and their related images occur simultaneously in order to save unnecessary processing. This is known as the "temporal contiguity" principle of CTML. Needless to say, lightboard videos support this since teachers can converse while describing a diagram on the screen with pertinent annotations and other helpful hints (Lubrick et al., 2019). According to Mayer (2017), the 'modality principle' of CTML recommends the use of spoken words while explaining graphics in order to avoid the split attention effect between words and graphics simultaneously for the learners. This concept is ideally applicable for the lightboard, according to Lubrick et al. (2019), as teachers rely on spoken words when describing a diagram in order to make practical use of the available screen space. Additionally, because the faculty's gesture directs learners' attention, it does not result in split attention (Lubrick et al., 2019).

The next theory that the foundation for the theoretical framework of the lightboard technology is based upon Cognitive Load Theory (CLT) also, as stated by Lubrick et al. (2019), because instruction attempts to transmit knowledge into long term memory, which in turn drives human cognitive effort. Students learn by watching while making less cognitive efforts, according to CLT, which contends that the knowledge we have evolved to know is the biological
primary knowledge and that this aids in learning with the least amount of cognitive effort (Lubrick et al., 2019). In addition, poorly designed instruction creates extraneous cognitive load and hampers the acquisition of knowledge by decreasing the intrinsic cognitive load capacity (Kessler & Totino, n.d.; Lubrick et al., 2019; Wilson, 2020). Therefore, CLT recommends removing extraneous cognitive load by reducing the working load for short-term memory in order to facilitate long-term memory's ability to acquire knowledge (Wilson, 2020). The lightboard videos feature the faculty on the screen, which will aid with generative processing and speed up learning because seeing puts less cognitive strain on the brain than other forms of learning (Lubrick et al., 2019). Consistent with it, Wilson (2020) pronounced that potential distractions are eliminated by the lightboard feature of glowing colorful writings that grabs the learners’ focal attention.

Finally, the other learning theory that is pertinent to examine the potential of lightboard is Social Agency Theory (SAT) that prioritizes learning on the ground of social aspects and emphasizes that students learn better when they have a feeling of social bonding with the teacher, they put additional effort to learn (Kessler & Totino, n.d.; Mayer, 1997; Mayer, 2017; Wilson 2020). Hence, the researcher advocated for the importance of human voice while creating video course materials as that discerns a social presence (Mayer, 2017). Lightboard videos naturally fulfils this criterion as it includes faculty’s voice and in addition, the faculty’s presence on the screen looking towards the audience while lecturing conveys the feeling of social presence to the learners (Lubrick et al., 2019; Wilson, 2020). Consistent with this view, Wilson (2020) emphasized that there exists a reciprocal interaction among memory, motivation, and attention and therefore, students learn effectively by following the faculty and advocated that the onscreen
presence of faculty through lightboard technology will be successful for the reinforcement of social engagement between faculty and students. Moreover, SAT suggested that a conversational style presentation facilitate learning and that can be easily implemented for lightboard videos (Lubrick et al., 2019). Furthermore, Mayer (2005) stated that social cue is conveyed by gesturing, facial expressions, and eye contact and is considered as highly-embodied. Supporting the view, Pi et al. (2017) advocated that faculty’s guiding gestures utilizes lesser working memory, provides motoric information for faster processing, and the faculty’s presence positively impacts students’ attention (as cited in Lubrick et al., 2019). Faculty’s on screen presence, gesturing while discussing, facing towards the audience, and keeping eye contact for lightboard videos are clearly high-embodied (Lubrick et al., 2019). Reduced cognitive load and influential motivation for learning engagement are achieved with the proper integration of learning theories and design principles (Dolah et al., 2011; Hurmuzan & Yahaya, 2015).

Implementation Underpinnings

This study incorporated the illustration steps into an instructional design model based on ARCS (an acronym made up of attention, relevance, confidence, and satisfaction) to underpin the cognitive learning process (Stiller et al., 2022).

The ARCS model served as the foundation for the motivational theory suggested for motivational strategies, claimed Song and Keller (2001). Students' motivation for learning engagement was significantly increased by ARCS as a multimedia learning strategy (Li & Ren, 2018). Researchers frequently used the ARCS instructional design approach to improve the engaging elements of learners (Annamalai, 2016; Colakoglu & Akdemir, 2010), and it has also
been used for designing courseware materials (Suzuki et al., 2004). According to Suzuki et al. (2004), ARCS implementation makes instruction more engaging for students. Consistent with the view, Liao and Wang (2008) recommended that Keller's (1987) ARCS model should be used for both instructional design and in-class instruction. Huett et al. (2008) referred to the ARCS model as the amalgamation of different learning theories.

Motivation and student engagement, particularly cognitive-behavioral engagement, are intimately linked (Bear & Harris, 2018; Nayir, 2017). For learning to be effective in the classroom, students need to be engaged and demonstrate interest in the material. They need to be very motivated and engaged in the lessons in order to do this (Bear & Harris, 2018; Nayir, 2017). In most circumstances, when students are motivated, they are also engaged; in other words, when engagement is mentioned, it usually refers to both motivation and engagement (Bear & Harris, 2018). Hence, ARCS was the perfect choice for my research.

**ARCS in Research**

For their research, several researchers used the ARCS model in various ways. Through the use of various systematically designed strategies, research studies have introduced an integrated environment and examined how it affects student performance and motivation (Arora & Sharma, 2019; Colakoglu & Akdemir, 2010; Feng & Tuan, 2005; Hamada, 2008; Hamada & Hassan, 2016; Huett et al., 2008; Liao & Wang, 2008; Nehme, 2010; Song & Keller, 2001). The goal of some more research (Gunter, 2007; Keller & Suzuki, 2004; Kilgore et al., 2013) was to identify particular instructional strategies that have a favorable impact on student learning and motivation for an online course. A web application was created by Suzuki et al. (2004) to assess
the Instructional Material Motivational Scale (IMMS) questionnaire and provide users with recommendations on how to improve their instructional practices in order to increase student motivation. In order to deploy a flipped classroom, Shimamoto (2012) designed a web-based educational module. Annamalai (2016) wanted to motivate students to enhance their reading comprehension skill and for the purpose, she integrated multimedia to create an interactive mEbook and used the (IMMS) (Loorbach et al., 2015) developed by Keller to determine the effect. Hueng and Hew (2016) did a case study for massive open online courses (MOOCs) and investigated learner’s motivation. Mills and Sorensen (2018) described how the ARCS model was implemented in the Kid’s CollegeTM 2004 educational program in order to motivate learners. A study by Lajane et al. (2021) developed an online learning exercise and assessed nursing students' motivational growth. The following section described the ways that the different components of ARCS namely, attention, relevance, confidence and satisfaction were implemented in different research studies by various researchers.

**Researchers Implemented ARCS in Various Ways**

**Implementation of Attention**

Smaller educational segments, an easy-to-read screen interface, an interactive and adaptive screen, visual augmentation of the instructional material, and the use of alternative formatting to highlight essential points were all presented by Song and Keller (2001). Feng and Tuan (2005) designed different learning activities for students and during the learning process, the faculty questioned and encouraged students to find solutions themselves. For certain research investigations (Annamalai, 2016; Hamada, 2008; Hamada & Hassan, 2016; Liao & Wang, 2008;
Mills & Sorenson, 2018; Nehme, 2010), audio-visual examples were given to learners as a starting point. Liao and Wang (2008) introduced various instructional tools to serve as a stimulus in order to pique students' interest in and curiosity about the subject matter. Nehme (2010) recommended adding motivational scenarios to the discussion board, including online games, and incorporating a variety of creative activities that could draw in and motivate students to learn. To capture the students' initial attention, some researchers used narration, soft background sound, and animation (Annamalai, 2016; Lajane et al., 2021; Mills & Sorenson, 2018). The researchers then used several multimedia elements to present the content to maintain the students' attention (Annamalai, 2016). Other researchers (Arora & Sharma, 2019; Hamada and Hassan, 2016) used a variety of enticing materials including simulators and practical examples that were integrated into the learning environment. To stimulate the students' curiosity and subsequently capture their attention and motivation, Mills and Sorensen (2018) incorporated surprise aspects for the students as well as an unorthodox and creative atmosphere. Lajane et al. (2021) suggested formative assessment, a brief test, student self-evaluation, and the use of color to illustrate.

Implementation of Relevance

Song and Keller (2001) employed graphical representations of the material and used learners' names where applicable. By giving relevant examples and analogies, as well as by showing how the concepts could be applied in the actual world, Feng and Tuan (2005) connected the learners' interest with the course. Moreover, the researchers have set up lab projects to get students engaged and advance their own expertise. According to Hamada (2008), the visuals
were appealing in and of themselves and will draw students' attention to the subject matter. Researchers (Annamalai, 2016; Liao & Wang, 2008; Nehme, 2010) suggested that teachers should incorporate and integrate modern teaching strategies, engaging instructional materials, learning activities relevant to current and past knowledge, present interest, and future aspirations or career objectives. The content of the mE-book was created by Annamalai (2016) in a way that made it simple for students to relate it to their everyday activities and academic requirements. Hamada and Hassan (2016) developed active learning materials that adhere to the learning preferences of engineering students while maintaining familiarity and upholding the study's relevance. The Kidz College™ program, according to Mills and Sorensen (2018), offered unique questions gathered from a database by faculty for the students to stimulate their interest in the subject. For the research by Arora and Sharma (2019), relevance was created by real time experiments with the learned concepts. Preliminary quizzes that were pertinent to the subject matter, student discussion of the learning purpose, and feedback on the quiz with recommendations for further reading were all implemented by Lajane et al. in 2021.

Implementation of Confidence

Researchers employed different strategies to implement confidence among learners. To prevent cognitive overload, Song and Keller (2001) matched participants' past knowledge with the learning requirements. Some researchers established a collaborative learning environment for the students by creating learning activities that were pragmatically designed, had an appropriate level of difficulty, provided ample practice opportunities for the students to acquire the necessary skills, provided timely feedback and encouragement for the students' improvement (Feng &
Tuan, 2005; Nehme, 2010), and designed gradual lab skills activities. Other researchers arranged for a simple test so that students can gain confidence by taking that easy test and thereafter, the researchers went through the topics, used simulators, and then recommended the students for taking the appropriate level test to judge themselves to gain more self-confidence (Hamada, 2008; Hamada & Hassan, 2016; Nehme, 2010). Similar to this, Liao and Wang (2008) suggested that teachers should support and encourage individual student needs for technological tools or instructional assistance. They also suggested that teachers challenge the students with the appropriate level of difficulty so that students are encouraged to move to the next level as they anticipate the achievements. Other researchers (Annamalai, 2016; Song & Keller, 2001) gave the students complete control and self-navigation throughout the entire learning content and introduced the learning objectives at the beginning with the hope of keeping the students motivated and boosting their self-confidence. According to Mills and Sorensen (2018), the team logo served as a stimulant, making students feel at ease and familiar. Additionally, as students became aware that their performance is directly tied to their teams, it increased their confidence. For the research by Arora and Sharma (2019), students had to separate different components for the experiments provided by the faculty. A virtual lab was introduced for this reason to supplement the experience of an experimental lab. In order to encourage the students, Lajane et al. (2021) set up practical chapter-ending quizzes and supplied both the right and wrong answers.

Implementation of Satisfaction

In order to ensure satisfaction with learning, researchers vocally applauded students (Feng & Tuan, 2005; Liao & Wang, 2008; Nehme, 2010), provided rewards (Annamalai, 2016),
and let students present their work to other students (Feng & Tuan, 2005). In order to help the students feeling less anxious about their exams, Feng and Tuan (2005) organized a cooperative exam for them. Other researches advised teachers to address the issues of specific students, give quick feedback (Annamalai, 2016; Liao & Wang, 2008; Mills and Sorenson, 2018; Nehme, 2010), assist students in problem-solving, and clear up any confusion (Nehme, 2010) in order to satisfy them. Nehme (2010) also recommended that professors should pay attention to any existing discussions and contribute their own thoughts. The study setting developed by Hamada and Hassan (2016), which included a platform for simulation and an end-of-semester survey based on Keller's (1987) IMMS, gave the much-needed impetus about satisfaction. A completion certificate and brief enrichment quizzes were also arranged for by Annamalai (2016) for the end of the semester. According to Mills and Sorensen (2018), displaying the scorecard and rewards, which were the outcomes of students' labor, increased the satisfaction of students. After the lecture, Arora and Sharma (2019) asked the students to assess their overall satisfaction with the experience.

**Impact on Students**

**Student Motivation**

For their research, by following the methodically planned lessons, students' motivation was increased (Annamalai, 2016; Colakoglu & Akdemir, 2010; Huett et al., 2008; Keller & Suzuki, 2004; Song & Keller, 2001). Positive feedback was given to Suzuki et al. (2004)'s website for analyzing instructional needs, and they hypothesized that with the enrichment of the database, the website will serve as a crucial tool for the faculty to develop practical instructional strategies
for student motivation. According to research by Keller and Suzuki (2004), it was advised to support a learning environment that encourages students' intrinsic motivation, which will increase their confidence. In accordance, Feng & Tuan (2005) found that students' motivation can be increased by using ARCS, and they thrive to meet their learning objectives. Researchers discovered that discussions among online course participants increased student motivation and satisfaction, which in turn facilitated learning (Gunter, 2007; Rourke et al., 2001). According to several findings (Colakoglu & Akdemir, 2010; Hamada, 2008; Liao & Wang, 2008; Tseng & Walsh, 2016), strategically designed instructional aids including engaging learning activities and visualizations can affect and boost students' motivation. As a result of working on the task for a longer time, some researchers predicted that higher motivation scores were similar with better learning (Cook et al., 2009; Hueng & Hew, 2016). According to Nehme (2010), their strategy of ARCS inclusion will assist other lecturers in creating instructional tactics to affect students' motivation. Other researchers observed that adopting innovative instructional strategies that adhere to ARCS can systematically develop instructional design to engage online learners (Kilgore et al., 2013; Lajane et al., 2021). Additionally, Lajane et al. (2021) discovered that there exists a good correlation between the online learning activities and the measurement of motivation. Study findings by Hueng and Hew (2016) confirmed that the MOOC supplied instructional materials were satisfactory for the students and improved motivation for learners. When Tseng and Walsh (2016) compared and evaluated a blended learning course with a traditional course, they discovered that the blended learners were more positively motivated, had greater confidence, and that this was helping them learn. According to Mills and Sorensen (2018), the sports experience of the learners and their involvement in it worked as a great
motivator for the students. In addition, students participated in out of the class activities related to the game and that way their intrinsic motivation was also enhanced (Mills & Sorenson, 2018).

**Student Learning**

After implementing ARCS, students' performance significantly improved, they learned better time management skills, and they developed greater interest and engagement for learning, according to researchers' observations (Annamalai, 2016; Colakoglu & Akdemir, 2010; Feng & Tuan, 2005; Hamada & Hassan, 2016; Liao & Wang, 2008; Tseng & Walsh, 2016).

Additionally, Liao and Wang (2008) noted that the ARCS paradigm led to students becoming useful partners in the instructional process. Similar findings were made by Huett et al. (2008), who discovered that their pragmatically designed intervention increased the engagement of the treatment group and improved their performance in comparison to the control group.

Accordingly, Kilgore et al. (2013) observed that students' perceptions and attitudes toward various learning media had altered as a result, and they began exploring the advantages of active learning. This theory was backed by research results from Colakoglu and Akdemir (2010), which showed that all of the ARCS motivational components were encountered by students and had a favorable effect on their attitudes. Additionally, Hamada and Hassan (2016) found that after implementing their instructional method, students gained more self-assurance, had no reluctance about enrolling in a course, and most importantly, were engaging in all of the learning activities spontaneously. Furthermore, Tseng and Walsh (2016) noted that implementing blended learning with the aid of technology had advantages like improving communication between students, and between students and teachers, enhancing related other skills, and receiving immediate feedback.
All of these things led to cognitive learning as students benefited from the opportunities to combine significant information. Technology made it easy to achieve student engagement, which is usually difficult to obtain, according to Kearsley and Shneiderman (1998).

Technology and its Impact on Education

Schacter (1999) found that instructional technology helps students learn more quickly and develops a more positive attitude about classes. By stating that "Computer and Internet technology have the potential to provide highly interactive learning environments that are independent of time and space constraints," Kassim (2001) supported the viewpoint. According to Surry (2002), the educational sector began implementing technology to improve learning because all technological resources may be supplied in a way that makes them available to all stakeholders. Over the past ten years, technology and technical tools have had a dramatic impact on education in ways that would not have been possible without them (Vries et al., 2018). The idea was reinforced by Koretsky and Magana (2019), who referred to the twenty-first century as the "information age" and claimed that computer technology is now an integral element of the educational sector. Teaching and learning procedures are facilitated by technological inventions and improvements. Information and communication technology (ICT) is a crucial component of modern society, according to Yusuf (2005). Through its engaging, intuitive, and dynamic material, ICT has the ability to enhance the teaching and learning process. It can also provide real freedoms for personalized instruction. It may help students learn faster, better, and more effectively; encourage and engage them in their studies; help them connect their classroom learning to real-world situations; and contribute to beneficial improvements in the classroom.
Today's educational process is heavily reliant on computer-assisted instruction, claimed Patil and Abraham (2010). Students can learn at their own pace, individualized thinking is supported, instant feedback, audio-visual medium can be manipulated to achieve higher level of learning satisfaction, more effective methods for teaching and learning can be implemented, achievement on student analytics is facilitated, supplemental and open access resources can be easily provided, and complex issues can be easily addressed are just a few of the ways it positively impacts learning and teaching.

**Application of Technology for Engineering Education**

For the purpose of facilitating and promoting learning, computer technology has been used in engineering education. Kassim et al. (2001) introduced a web-based intelligent learning environment for digital systems (WILEDS) for an engineering course that used Internet and multimedia technologies to enhance student learning and problem-solving abilities. WILEDS was easily accessible online. The traditional lectures were combined with online learning resources by Ursulet and Giller (2002). Additionally, web-based tools were included to provide the students some sort of hands-on experience. In general, students valued the flexibility of the web-based learning environment, which enables managing one's workload over a lengthy period of time. Accordingly, Shahni et al. (2004) put in place an intelligent interactive tutoring system for an engineering course that gave students instructions on how to solve issues and keeps track of their progress. Babich and Mavrommatis (2004) asserted that acquiring practical skills like process interrelations and learning to apply theoretical knowledge into the real world job scenarios were of utmost importance for engineering students. Specifically, for the distance
learning students, they developed a virtual lab for metallurgical engineering and material science students based upon a combination of logically associated components that provided a virtual simulation model (VSM) for students to enter parameters for processing and supplied operating and learning results. Remote students and teachers communicated via a software interface throughout the procedure so that the teacher may watch over and guide them. The contribution attested to the fact that it raises students’ engagement with learning. For the engineering students to conduct lab experiments, Gillet et al. (2005) also implemented a flexible learning system that offered a collaborative Web-based experimentation environment. Additionally, sharing notes and research findings was permitted. Due to its simplicity and affordability, e-learning has become a crucial instrument for education and Gudimetla and Iyer (2006) presented guidelines for using it effectively. According to Patil and Abraham (2010), who agreed with this viewpoint, modern engineering education has significantly increased its effective use of computers for a variety of learning objectives, including distance learning, virtual modeling and simulation, and the development and widespread use of engineering software for learning. Erik (2010) gathered usage data, such as visits, hours spent, and the subject in question, using the TutorTrac software. Garcia et al. (2014) employed an online platform for math tutoring at first and held the tutoring sessions in a computer lab, but when the students struggled with the subject, they insisted on in-person teaching. Koretsky and Magana (2019) recommended three ways for application of computer technology for engineering education, “(a) learning innovations specifically developed around instructional design to foster deep thinking and meaningful learning, (b) computational tools used in engineering practice, and (c) Technology with a capital “T.” For more student engagement, Hadgraft and Kolmos (2020) designed a flipped classroom by fusing a traditional
classroom with a virtual classroom. The digital component for the classroom included audio-video and reading materials, tests, and online collaborative projects.

**Contribution to Instructional Technology**

According to Leidner and Jarvenpaa (1995), instructional technology (IT) was primarily utilized to facilitate the function of information delivery during class. Additionally, some learning models will undoubtedly be reflected in the usage of IT in the educational field. Surry (2002) asserted that the use of technology can improve educational objectives in three different ways: by incorporating pedagogical advantages and dynamic interaction opportunities between faculty and students to improve students' cognitive skills; by making educational resources easily accessible; and by offering financial advantages. Vries et al. (2018) supported the idea by pointing out that technology integration can only benefit the educational sector when the learning activity is precisely matched with the learning objective. So, according to the researchers, the important thing was not to check if technology was used for instructional purposes but to determine the best possible way to incorporate technology to benefit learning. The challenge is to ensure that technology contributes to improvement. Keeping all these factors in consideration and aiming to provide engaging video course materials for engineering students, this study employed sophisticated multimedia technology, specifically lightboard, and investigated engineering students’ perceptions if videos made with lightboard technology may positively impact their learning engagement.
Over time, using technology in the classroom has become standard practice. Different teaching strategies were used to excite students' interest in learning and to engage them. According to Nehme (2010), students' engagement in their coursework has a direct impact on how well they perform academically. Additionally, Pange and Pange (2011) said that students should visualize their learning objectives and referred to "engagement" as the key component of student involvement. Researchers pointed out that despite playing a crucial part in the instructional design process (Arora & Sharma, 2019; Keller, 1983; Nehme, 2010), it is frequently overlooked (Huett et al., 2008; Keller, 1983). Therefore, Lajane et al. (2021) argued that assessing engagement is essential to determining whether a scenario for instructional design that aims to increase student involvement is effective.

Technology used in the classroom and course delivery are both designed with student engagement in mind (Okere, 2022). The visible effort in connection with the level of attention and interest that students make in relation to their academic success is known as "student engagement" which requires body gestures, facial expressions and hand movements on part of the presenter (Craft & Capraro, 2017; Okere, 2022). Hence, researchers found that in order to engage students and thereby activate the learning process, there must be a minimal quantity of motivation (Stiller et al., 2022). Accordingly, Huett et al. (2008) recommended a student-centered learning process to boost up student engagement. Whereas, Rosasco (2018) believed that the main reason why students are disengaged with the content of online courses is a lack of connection between the teacher and the students. In addition, according to Cadena et al. (2019), course content is one area that faculty continually strive to improve as this is done to ensure that
the course materials have the ability to keep students engaged because everything depends on
their responsiveness to the instructional material.

A number of scholars argued in favor of employing video course materials because they
were more effective in engaging students to learn than other types of content (Babich &
Mavrommatis, 2004; Cadena et al., 2019; Felder et al., 2000; Fung, 2017; Gudimetla & Iyre,
2006; Liarokapis et al., 2004; Rulino & Fabriana, 2022; VanderMolen et al., 2018). Hence, to
keep students interested in and engaged to learn, particular technological requirements for the
incorporation of high-quality video content emerged (Cadena et al., 2019). Practitioners advised
enhancing the multimedia-based learning environment when creating the instructional process to
increase the learning engagement (Dousay, 2016). However, a void is noticed that high quality
video content has limited or almost no application in engineering education and hence, Cadena et
al. (2019) have recommended application of advanced multimedia-technology tools for the
creation and incorporation of technologically advanced video content for engineering education
to keep students engaged for learning. Therefore, it was important to ascertain the perceptions of
engineering students on using multimedia technology to generate cutting-edge video course
materials on their learning engagement. In this context, application of lightboard technology
could potentially have a significant impact as it was well known to produce technologically
sophisticated video course materials.

Lightboard

Lightboard can be expressed as a novel and innovative technology-friendly solution for
the faculty to create visually attractive video course materials with the main focus on writing or
drawing and that lightboard technology is the latest tool for capturing and recording instructional video materials (Fallas-Ramirez et al., 2022; McCorkle & Whitener, 2017). Lightboard is a low-cost technology that can be applied as a creative presentation tool which allows faculty to record videos involving drawing sketches, diagrams or explaining equations of the course material on an illuminated glass board with dry erase markers while facing towards the viewers (Cadena et al., 2019; Rosasco, 2018; Rulino & Fabriana, 2022). A clear glass board mounted inside an iron frame with an LED light strip along the inner edges, a camera, and a microphone make up the lightboard technology where the camera records the presenter's writing and illustrations from the opposite side of the glass board so that the presenter is facing the audience, and the resulting video is horizontally flipped to produce upload-ready video (Birdwell & Peshkin, 2015; Educause, 2014; Lubrick et al., 2019; McCorkle & Whitener, 2017; Okere, 2022; Rogers & Botnaru, 2019; Rosasco, 2018; Rulino & Fabriana, 2022; Skibinski et al., 2015; Ye, 2016). The glass board is lit evenly by the LED strip, and writing with dry erase markers glow to simulate writing in the air.

**Unique Features of Lightboard**

Researchers found some unique features of the lightboard videos. The presenter faces the audience while illustrating the instruction steps; look similar as if the teacher is instructing in a traditional classroom; the videos are visually attractive, post-production free, and upload ready; the presenter can have the presentation on the screen to facilitate the presentation; the faculty do not need to learn any new software and it does not require training; it has the capacity to easily integrate or superimpose PowerPoint presentations, multimedia materials, or graphics while
emphasizing, annotating the key points with the glowing markers; interpretations and diagram or equation illustrations can also be infused from a computer onto the screen (Birdwell & Peshkin, 2015; Educause, 2014; Lubrick et al., 2019; McCorkle & Whitener, 2017; Rogers & Botnaru, 2019; Rosasco, 2018; Rulino & Fabriana, 2022; Skibinski et al., 2015; Ye, 2016).

**Lightboard’s Effectiveness for the Purpose**

There aren't many studies available that investigated how video lectures or other course materials made with lightboard technology affect learning, but those researchers came to the conclusion that lightboard technology, with their distinctive qualities, had the ability to enhance students' learning and engagement. Moreover, very little research has been done to examine the impact of video lectures or course materials created by applying the lightboard technology for engineering education. Fung (2017) intended to examine the impact of lightboard videos for a flipped classroom. He did the enhancement of the online part of the active learning by incorporating visually appealing video materials created by applying lightboard technology. Rogers and Botnaru (2019) did a mixed-methods research to determine the effect of lightboard videos on student perception and learning for a flipped classroom for engineering students; lightboard videos were chosen over whiteboard owing to the dynamic feature of lightboard that allows presenters to have eye contact with the audience while illustrating the content without blocking the views and the lightboard videos were included in the online content for the course and provided sample computations and example problems while emphasizing key concepts for the course content. Lubrick et al. (2019) explored the pedagogical content and framework for the purpose of the lightboard videos. The researchers did a literature review and theoretical analysis
to find the evidence of application potential of lightboard regarding pedagogical framework.

After reviewing the relevant theoretical frameworks like, Cognitive Load Theory, Cognitive Theory of Multimedia Learning, and Social Learning Theory, the researchers came to the conclusion that lightboard videos have the potential to improve students learning and engagement with its unique feature of faculty’s presence throughout the video, facing the students and that students can follow the hand gestures during the illustration. The findings of the above mentioned research are thematically summarized in the following.

**Visually Attractive Instructional Videos can be Made with Lightboard Technology**

With the use of lightboard technology, faculty can produce post-production-free, ready-to-upload video lectures that are visually appealing as the writing glows in the air (Birdwell & Peshkin, 2015; Cadena et al., 2019; Fung, 2017; Rulino & Fabriana, 2022), and they can be promptly posted to a cloud service such, YouTube (Birdwell & Peshkin, 2015). Additionally, researchers discovered that lightboard technology was user-friendly and enabled the presenter to face the audience while illuminating the instruction steps; however, it was necessary to prepare ahead of time and begin the recording with prepared information in hand (Cadena et Al., 2019; Fung, 2017; Rosasco, 2018; Rulino & Fabriana, 2022; Ye, 2016). The videos were brief, engaging, and looked like they are being delivered in a traditional classroom (Educause, 2014; Fung, 2017; Rosasco, 2018; Rulino & Fabriana, 2022); the only difference was that there were no interruptions from the students and that lightboard videos were simpler to make than PowerPoint voice-over videos. This was another benefit of lightboard technology (Fung, 2017). Rosasco (2018) also observed that due to the lightboard videos' brief and condensed length,
faculty tend to produce them with high levels of intensity. Ye (2016) also mentioned that faculty can create aesthetically appealing educational videos with lightboard technology with little to no training. Consistent with the view, according to McCorkle and Whitener (2017), the faculty did not need to learn any new software in order to utilize the lightboard technology, which freed up their time to more effectively design the instructional process. Additionally, the use of lightboard technology made it simple to add online materials to a course, and the dynamic aspects of lightboard can motivate professors to enhance their teaching techniques (McCorkle & Whitener, 2017). Moreover, according to VanderMolen et al. (2018), lightboard videos promoted a consistent pedagogical foundation, improved the faculty's presence in online courses, and aided in student engagement because there was little opportunity for personal connection in online courses. According to Rosasco (2018), the presenter can receive immediate feedback on the audio-video quality of their presentation, which was another crucial aspect of the lightboard technology. Furthermore, Educause (2014) asserts that the creation of lightboard videos on the glass board using luminous dry erase markers by the faculty reduced the inhibition associated with taking part in a video production.

Other Educational Resources can be Easily Integrated or Connected

Researchers noted that lightboard can simply superimpose or merge PowerPoint presentations or graphics, as well as highlight the most important details and subtitle the material using illuminating markers (Birdwell & Peshkin, 2015; Educause, 2014; Ye, 2016). Fung (2017) further stated that computer-generated explanations and diagrams or mathematical drawings might also be integrated onto the lightboard screen. A document camera may also be
incorporated to support the demonstration while creating a lightboard presentation, according to McCorkle and Whitener (2017). This was confirmed by Lubrick et al. (2019), who proposed integrating multimedia components into the lightboard videos together with body gestures to illustrate them, making the content more visually pleasing and engaging for the learners. Additionally, the presenter was given the capacity to annotate using lightboard technology (Birdwell & Peshkin, 2015; Ye, 2016; McCorkle & Whitener, 2017), for example, by placing an object behind glass and describing it on the glass board (Educause, 2014). Other applications of lightboard were mentioned by Birdwell and Peshkin (2015), such as live online review sessions and responding to a student's question with a video response.

**Lightboard Videos Complement Traditional Classroom**

Researchers described the lightboard as a device that allows for the creation of high-quality video lectures where the presenter maintains eye contact with the audience while writing or illustrating with diagrams on the glass board, and the audience can observe the presenter's body language because the view is not obstructed in any way (Birdwell & Peshkin, 2015; Educause, 2014; Fung, 2017; Rosasco, 2018; Schweiker et al., 2020; VanderMolen et al., 2018; Ye, 2016). This dynamic aspect of the lightboard, according to Malyutina et al. (2021), resolved the difficulty of the faculty turning around the white or black board while lecturing in the classroom. According to Peshkin et al. (2014), lightboard technology enabled lecturers to use body language, which was crucial since audience members interpret body language to understand the lecture's content. Research found that lightboard videos complement traditional lectures in the classroom because faculty write with dry erase markers on a glass board, which
was recorded by the camera and reflected in a mirror (Birdwell & Peshkin, 2015; Fallas-Ramirez et al., 2022; McCorkle & Whitener, 2017; Ye, 2016). Additionally, faculty did not interact with computer software or hardware during this process (McCorkle & Whitener, 2017). All of these factors, according to Rosasco (2018), supported a teaching-centered environment. Other researchers observed that faculty can deliver visually engaging video materials for the students by writing glowing texts on the glass board, drawing diagrams, or writing equations (Schweiker et al., 2020; VanderMolen et al., 2018).

**Lightboard videos Provide Human Presence**

Compared to the presentation of PowerPoint slides and repeated turns around to face the students during a classroom lecture on a white or black board, lightboard videos have the special capacity to establish a direct connection between the faculty and the students (Fallas-Ramirez et al., 2022; Molen et al., 2018; Okere, 2022). Other researchers noted that the dynamic characteristic of faculty making eye contact with students while discussing course material let students experience the faculty's human presence, and that students can also follow the faculty's body language and facial emotions (Malyutina et al., 2021). This opinion was confirmed by the observation that lightboard technology enables faculty to more readily clarify subject matter while facing the camera during the procedure by illustrating the steps, adding notes, and incorporating other course materials, diagrams, or sketches (Educause, 2014). Additionally, Ye (2016) said that lightboard is a low-tech solution that helps even faculty who are not tech-savvy produce visually appealing and engaging videos for the students by enabling the faculty to discuss the topic while looking at the students. Supporting the view, Rosasco (2018) asserted that
lightboard video significantly improved online course content by equating it to conventional in-person lectures.

**Learning Benefits Associated with Lightboard Videos**

Rosasco (2018) asserted that the incorporation of non-verbal communication into the video materials produced by lightboard made the course content intuitive and consistent, which improved learning. With the aid of brief lightboard explanation videos and projects, researchers noticed considerable gains in in-class and homework assignments (Educause, 2014; Rogers & Botnaru, 2019), as well as enhanced grasp of the essential concepts and important themes (Rosasco, 2018). According to Cadena et al. (2019), who supported the theory, lightboard videos provided students with a more integrated and cogent experience throughout the courses. The lightboard videos made learning more interactive by adding the much-needed human element to the course material (Malyutina et al., 2021). Additionally, in order to meet the needs of all types of learners, lightboard videos gave students multiple opportunities to view the course material. For example, those who process information more slowly could pause the video and think (VanderMolen et al., 2018), those who struggle with reading comprehension could rely on auditory cues, those who have trouble with self-regulation could pause and walk away, and English language learners could listen repeatedly to strengthen their listening comprehension. According to some researchers, students preferred lightboard video lectures since they are more understandable than written lectures (Educause, 2014; VanderMolen et al., 2018). Moreover, because the students had access to those understandable and instructive lightboard lectures prior to the class, they had knowledge in advance of the course material, enabling them to participate
in meaningful activities connected to the material in class (VanderMolen et al., 2018).

Furthermore, the lightboard setup can assist students with their presentations for their classes (Birdwell & Peshkin, 2015; Educause, 2014). The lightboard videos, according to Rogers and Botnaru (2019), made a significant contribution to student learning since they can enhance both visual and auditory memory linked with video lectures.

**Inspires Student Engagement for Learning**

Research by Rogers and Botnaru (2019) found that there is a significant correlation between student engagement and satisfaction with lightboard videos. According to studies (McCorkle & Whitener, 2017; Rulino & Fabriana, 2022; Schweiker et al., 2020; Skibinski et al., 2015; VanderMolen et al., 2018), when students see that the lecturer is actively describing different steps of the content while looking at them, they become more attentive and engaged with the lightboard videos and that in turn, increases student performance. Ye (2016) stated that this aspect of lightboard videos allow more rich communication and supplements non-verbal communication, which is consistent with this point of view. According to her, lightboard videos' distinctive elements of continual eye contact between faculty and students and the high contrast glowing text make them more interactive, personal, and interesting. Other researchers' findings supported this idea that lightboard video's faculty's personal presence on the screen had a significant effect on students' engagement (Guo et al., 2014; Lubrick et al., 2019).

Consistent with the view, research by Rogers and Botnaru (2019) found that students remarked on the lightboard videos of being very user friendly, beneficial for learning, and accepted the videos as a rewarding addition to the course resources. Lightboard videos had a
good impact on student learning and according to VanderMolen et al. (2018), lightboard videos greatly boosted student-to-content and student-to-faculty engagement with the replication of face-to-face interaction and the body language exhibited every second. They also commented that the students found the lightboard videos were efficient for their learning purposes and they recommended in favor of it as those benefit learning.

Skibinski et al. (2015) claimed that lightboard videos present a dynamic method of disseminating condensed information. Additionally, Rosasco's (2018) workshop observed that students spend much more time on video materials than on reading and writing ones. Indeed, studies have shown that students prefer short, snappy videos with the dynamic element of drawing on an electronic board (Fung, 2017; Guo et al., 2014), and that talking-head faculty videos were more engaging because they foster a human presence with the faculty and student making eye contact (Guo et al., 2014; Fung, 2017; Ye, 2016). Additionally, the lightboard videos' feature of writing in the air drew students' attention and makes visually captivating videos that helped students connect (Malyutina et al. 2021; Rosasco, 2018). Moreover, the lecture video was made more engaging by the handwritten remarks added throughout the recording process (Educause, 2014).

**Effect Size of the Incorporation of Lightboard Videos**

Evidently, instructional videos made with the application of lightboard technology can be more effective to capture student attention and that eventually will lead them to be more engaged in studies. However, at the same time, it was not clear how effective lightboard instructional videos were and hence, before the integration of lightboard videos for a course content, the effect
needs to be measured quantitatively. Therefore, in order to determine the effect size of the incorporation of lightboard instructional videos, a meta-analysis to summarize and review the findings of previous research was performed by this researcher that consisted of the following methods which were applied by the studies that were available publicly, online or in libraries.

1. Evaluating lightboard technology
2. Observational and qualitative studies on the effectiveness of lightboard videos
3. Quantitative and mixed-methods studies on the effectiveness of lightboard videos
4. Feedback on the instructional qualities of the lightboard videos
5. Comparison studies involving lightboard videos with other instructional materials

The problems that this study encountered while doing the meta-analysis that there was inconsistency in terms of techniques applied to incorporate lightboard technology; it was applied for different purposes to determine the effect of lightboard videos on various aspects of student learning by different researchers and most importantly, not many research were done on lightboard technology.

A comprehensive search for relevant research was conducted for this study in the major bibliographic databases like ERIC and Google Scholar. In addition, the reference list of the reviewed articles was manually searched if that involves lightboard. A total of 26 studies were found related to lightboard technology but only six of them actually performed some investigation on the impact of incorporating lightboard technology while the rest either just evaluated lightboard technology or provided some feedback on the instructional qualities of the lightboard videos or compared lightboard videos with other instructional materials. Moreover, out of six that calculated the impact of integrating lightboard technology to some extent, one
each applied quantitative and mixed-methods whereas, the other four used qualitative methods. It was difficult to simply calculate the mean of the effect sizes based on the papers analyzed because they all used different meta-analysis techniques, with some being more accurate than others. Therefore, an attempt has been made by this study to adopt some kind of weight specifically for the qualitative study findings to summarize the effectiveness of lightboard technology implementation. Hence, in this research scope, findings were divided by ‘/’ on account of simplicity/clear understanding, clarity/better explanation/usefulness, convenience/in order/effectiveness, enjoyment/attractiveness and educational/facilitate learning/engagement have given the same weightage.

Research by Rulino and Fabriana (2022) found that 94% of students liked the lightboard instructional videos for its simplicity/clear understanding whereas it was 80% for the study by Fallas-Ramirez et al. (2022). Likewise, on account for clarity/better explanation/usefulness, the result was 98% for Rulino and Fabriana (2022), 74% for Fallas-Ramirez et al. (2022), 80% for Schweiker et al. (2020) and 75% for VanderMolen et al. (2018). The percentage of student opinion regarding convenience/in order was 92%, 79% and 80% respectively for Rulino and Fabriana (2022), Fallas-Ramirez et al. (2022), and Schweiker et al. (2020). Additionally, on account of educational/facilitate learning/study engagement, lightboard videos scored for 93%, 74%, 70% and 75% for study findings by Rulino and Fabriana (2022), Fallas-Ramirez et al. (2022), Schweiker et al. (2020) and VanderMolen et al. (2018) respectively. Moreover, students favored the attractiveness/enjoyment for the lightboard videos as 99%, 60% and 100% for studies performed by Rulino and Fabriana (2022), Schweiker et al. (2020) and VanderMolen et al. (2018) respectively. VanderMolen et al. 2018 observed that using lightboard video technology
offers a reliable pedagogical framework for explaining difficult concepts. Particularly when it comes to challenging math problems that ask for several steps, the usage of lightboard Video Technology was a helpful teaching tool. Their limited analysis of survey responses from students showed that our students responded well to and learned effectively from recordings made using lightboard Video Technology. Consistent with the view, Schweiker et al. (2020) found that exam results before and after the addition of lightboard videos as a supplemental learning tool allowed them to assess the effectiveness of using them as a teaching tool. The researchers reviewed the exam scores throughout a four-year period after the lightboard was used as a learning aid, with the average exam scores increased from 58.92% (N=48 students) to 75.10% (N = 50 students), 76.85% (N = 48 students), 74.21% (N = 54 students), and 81.00% (N = 61 students). In addition, Rulino and Fabriana (2022) found that learning videos employing lightboard offer a reliable pedagogical framework for explaining difficult ideas and can increase students' comprehension, engagement, and learning pleasure. Their research demonstrated that lightboards were useful for presenting information to an audience and the material shown on the lightboard received a very positive response from the respondents. Moreover, Fallas-Ramirez et al. (2022) observed that the vast majority of students who used videos in which mathematical concepts were developed using a lightboard were happy with this method because they thought that the study of these concepts was organized and gave them a clear comprehension by being conveyed in a more effective manner. Additionally, their coursework was easier to access, which promoted higher learning. The results of the study by Okere (2022) also indicated that most students regarded the use of the lightboard technology to be engaging and to more than 70% of the students in each course, using a lightboard simulated a face-to-face in-class experience. All these qualitative studies observed
that lightboard facilitates student learning in several aspects but none of them provided enough data to measure the effect size of lightboard integration. Contradictorily, Rogers (2018) did a quantitative study and found that although there was a general trend showing that students' performance on in-class assignments generally improved in lessons where students watched the lightboard videos as part of their pre-class preparations, the variability of the assignment-level data and modest overall increases (1.45% and 1.22% respectively) suggested that the correlation was weak between student learning and the use of lightboard videos. In addition, Rogers and Botnaru (2019) applied mixed-methods in their approach and observed that the average student scores on 69.2% of the in-class assignments improved for the study group, according to the data, which also suggested only a small improvement in academic performance overall as analyzed from the quantitative data. However, the Likert scale survey's overall averages demonstrated a solid support for lightboard videos in terms of comprehension, engagement, and satisfaction. It was clear that even from the research that measured the effectiveness of lightboard instructional video materials to some extent, those are not really helpful to determine the effect size.

Suggestions for Best Practices

Researchers suggested best practices from their own experiences while working with the lightboard. It was advised to wear clothing without logo or brand symbols as they would appear reversed in the final video clip (Fung, 2017; McCorkle & Whitener, 2017; Okere, 2022; Schweiker et al., 2020); be careful about the limited area available for writing (Fung, 2017; Okere, 2022); avoid wearing jewelry or any shining stuff (Fung, 2017); plan ahead and have a carefully written script in hand (Birdwell & Peshkin, 2015; Fung, 2017), McCorkle and Whitener
(2017) recommended to employ a ‘storyboard’ technique to have smaller chunks of video content ready at hand with the ability of student engagement, emphasis should be on delivering the key concepts (Rosasco, 2018); and writing should be as legible as if written on a white or black board (Fung, 2017). In addition, avoid bright, patterned clothes as it might blend into the dark background or the dry erase markers (McCorkle & Whitener, 2017; Malyutina et al., 2021), wear medium tone clothes instead of black or white (McCorkle & Whitener, 2017). Moreover, McCorkle and Whitener (2017) suggested using washable Expo dry erase markers as those were easier to clean from the lightboard and that microfiber cloths were best for cleaning (Rosasco, 2018). The best videos for student engagement included example problems (Educause, 2014; Rosasco, 2018) and homework explanation (Educause, 2014). Furthermore, according to VanderMolen et al. (2018), the real benefits of lightboard technology was experienced in explaining problems with multi-step solutions whereas Educause (2014) recommended to use the lightboard videos for STEM courses as those relies heavily on visuals, diagrams and charts to explain the course content in a better way. Some researchers suggested having a support center handy while creating the videos was always helpful (Educause, 2014; Peshkin et al., 2014; Rogers & Botnaru, 2019).

**Limitations Related to Lightboard Technology**

According to researchers, videos created through the lightboard technology required full proof preparation and planning ahead in order to avoid retakes and post-editing (Educause, 2014; McCorkle & Whitener, 2020); amending a writing error is problematic (Educause, 2014). Also, as only short duration videos can be created (Ye, 2016; McCorkle & Whitener, 2017), it was not
suitable for more text related subjects (McCorkle & Whitener, 2017). In addition, learners might feel extraneous cognitive load while watching the videos (McCorkle & Whitener, 2017). Moreover, researchers found that lightboard can only be used in a studio and cannot fit in a classroom as it requires a mirror image of the writing on the lightboard, otherwise the class would see the faculty is writing in reverse (Educause, 2014; Skibinski et al., 2015; Ye, 2016). Research findings of Rosasco (2018) on student feedback stated that the color contrast for the lightboard videos was not perfect as it was blending with the dry erase marker and the background color. Also, the presentation flow was interrupted owing to the limited area availability for writing and the time employed to wipe the lightboard clean (Educause, 2014; Rosasco, 2018; Ye, 2016). Additionally, Skibinski et al. (2015) cautioned that the lightboard glass board is fragile. Finally, as the videos are created through a mirror reflection, the hand used for writing becomes reversed (Ye, 2016).

Summary

This study sought to determine the perceptions of engineering students on using technologically sophisticated video course materials produced using lightboard technology on their engagement to become actively involved in their learning. In order to ascertain whether the incorporation of lightboard technology was successful, past research findings in this area were examined. The investigation demonstrated that lightboard technology may be used to create visually appealing educational videos that are user-friendly, allow the presenter to face the audience, and appear to be delivered in a typical classroom (Birdwell & Peshkin, 2015; Cadena et al., 2019; Fung, 2017; Rulino & Fabiana, 2022). Moreover, lightboard videos have the unique
ability to create a personal connection between the faculty and the students (Fallas-Ramirez et al., 2022; Okere, 2022; VanderMolen et al., 2018). Furthermore, researchers observed significant improvements in in-class and homework assignments, as well as improved understanding of the crucial ideas and significant themes with the incorporation of lightboard videos (Educause, 2014; Rogers & Botnaru, 2019; Rosasco, 2018). Studies (McCorkle & Whitener, 2017; Rulino & Fabriana, 2022; Schweiker et al., 2020; Skibinski et al., 2015; VanderMolen et al., 2018) shown that students became more engaged and attentive when they saw the faculty actively describing various steps of the content while looking at them. According to additional research, which supported this theory, learning was facilitated by lightboard videos because of their clarity, improved explanation of the topic, efficient ordering, and study involvement (Fallas-Ramirez et al., 2022; Rulino & Fabriana, 2022; Schweiker et al., 2020). Even though the effect size could not be calculated from the previous research findings, it was evident that, when lightboard video resources are included and specified best practices are followed, learning on a variety of aspects can be facilitated.

According to research, there are several significant outcomes that are correlated with student engagement, which makes it imperative for learning. A few of these results include improved academic performance, acceptance by peers, emotional stability, and a decrease in risky behaviors like drug and alcohol abuse, smoking, and sexual activity (as cited in Bear & Harris, 2018). Heller et al. (2010) observed that students respond well to engaging teaching, which incorporates research, active learning, peer-to-peer activities, and self-reflection. They found that students claimed that the presence of the professors adds something engaging to the lectures, whether it's their enthusiasm for the subject matter or their manner of instruction.
Consistent with this view, Ahshan (2021) commented that adaptive pedagogies for engineering courses, learner interactions, interactive teaching and learning methodologies, and active learning activities can all help to promote active student engagement.

Researchers suggested that it was important to understand the impact of course materials on student engagement and only then a systematic instructional design can be prepared to improve the features of the content towards encouraging better student engagements and facilitate learning (Cook et al., 2009; Hueng and Hew, 2016). Consistent with this view, other researchers recommended that faculty should consider specific strategies depending on the learning environment, online or traditional, to enhance students’ performances (Nehme, 2010; Hamada & Hassan, 2016). It was evident and Arora and Sharma (2019) noticed that instructional video materials were the most commonly used ARCS strategies. Hence, the important considerations regarding the instructional design that my research needed to make were the procedure to make the learning experience for engineering students more invigorating and engaging, beneficial for their career goals and relevant to the content, the measures to be taken to make students confident, and a desirable and satisfying learning process. The technique that I integrated and implemented for my research based on ARCS was inclusion of technologically advanced video learning materials created using lightboard technology. The theoretical foundation was based upon CTML, CLT, and SAT. The video materials included sample computations, example problems, illustration of course and related concepts with sketch and diagram, problems that require multi-step solutions, and small subject explanations. The lightboard videos were integrated into the online course content and were accessible through the learning management system (LMS). In addition, unlisted YouTube links were created for the
videos and emailed to the students for easier accessibility through their smart devices. Keller (2016) advocated that motivational techniques need to be implemented based on the particular characteristics of the technology available but even then fundamental principles of inspiring student learning should be followed. For my research, the strategies for ‘attention’ were associated with concreteness in the way of visually representing course related matters like computations, example problems, illustration of concepts with sketch and diagram (Keller, 1987). Attractive visuals and graphical illustrations related student attention with the content as those included associated examples and analogies (Feng & Tuan, 2005; Hamada, 2008). Hence, lightboard videos naturally created relevance. Faculty organized the course content with appropriate levels of difficulty to make students learn independently (Keller, 1987), supported and encouraged individual student needs (Liao & Wang, 2008), and clearly discussed the learning goals and the way to accomplish them; all these developed confidence in the learners. For satisfaction, faculty praised the students verbally (Feng & Tuan, 2005; Liao & Wang, 2008; Nehme, 2010).
CHAPTER 3. METHODOLOGY

Statement of the Problem

The lack of student engagement is significantly prominent in engineering education (Chen et al., 2008; Simmons et al., 2019). It is a serious problem since student disengagement can lead to disappointing academic performance, mediocre program outcomes, and alarmingly high academic attrition rates for engineering institutions (Adams et al., 2011; Chang et al., 2011; Chen et al., 2008; Craft & Capraro, 2017; Hadgraft & Kolmos, 2020; Simmons et al., 2019) and accordingly, jeopardize the supply of qualified future engineers (Chen et al., 2008; Simmons et al., 2019). Hence, it has become necessary to keep focus on student engagement and provide continuous support at all levels of engineering education to stimulate students’ learning engagement (Chang et al., 2011; Craft & Capraro, 2017). Accordingly, researchers explored different approaches to engineering education with emphasis placed upon the role of different learning environments to induce student engagement (Chen et al., 2008; Simmons et al., 2019). In various learning contexts, Felder et al. (2000) asserted that there hasn't been much of an impact on engineering students' study engagement despite the use of multiple improvement strategies. Adams et al. (2011) expressed a similar opinion, noting that although considerable money and a range of tactics have been poured into engineering education, the outcomes have not yet been good enough to increase student engagement. Li et al. (2019) added engaging students was not always effective with traditional teaching methods.
It is evident from exploring different learning environments that the trend for engineering education is towards student-centered active learning through the employment of digital learning tools to make teaching more productive, and where the learning environment influences better student engagement (Hadgraft & Kolmos, 2020; Koretsky & Magana, 2019). More resources need to be explored to encourage an enriching learning experience for the engineering students to boost up their engagement into learning (Simmons et al., 2019). Cadena et al. (2019) stated that course content is one area where faculty are constantly striving to improve to keep students engaged as everything depends upon students’ responsiveness towards the instructional material. Other researchers have recommended using comprehensive visual materials in engineering courses, as visuals instill more information in students than auditory information (Babich & Mavrommatis, 2004; Felder et al., 2000). In addition, researchers observed that video course content have the capacity of engaging students better than other types of content and provides the nuances of non-verbal communication (Cadena et al., 2019; Fung, 2017; Gudimetla & Iyre, 2006; VanderMolen et al., 2018). The need has been identified but still a void is noticed that high quality video content has limited or almost no application in engineering education and hence, Cadena et al. (2019) have recommended application of advanced multimedia-technology tools for the creation and incorporation of technologically advanced video content for engineering education to keep students motivated and thereby, engaged for learning.

Research Purpose

The purpose of this study was to investigate the perceptions of engineering students on incorporating technologically advanced video course materials (TAVCM) created with multimedia technology on their engagement in learning. Previous research indicated that an
important prerequisite for effective learning among engineering students is engagement, and that engagement can be positively influenced with interventions such as video course materials (Babich & Mavrommatis, 2004; Cadena et al., 2019; Felder et al., 2000; Fung, 2017; Gudimetla & Lyre, 2006; Liarokapis et al., 2004). The objective of this study was to include TAVCM created with the help of advanced multimedia technology tools and investigate the perceptions of engineering students on its impact on their learning engagement. For this purpose, this research applied the lightboard technology tool to create technologically advanced video course materials (lightboard videos) for selected engineering courses and integrated those into the course contents for students. The research findings will facilitate student learning for engineering education and inspire them for better performance and that in turn, will supply quality engineers to the society. Faculty will be motivated to create a better instructional design for the courses. It will also help the college for producing quality engineers.

The study was conducted in the college of engineering of a public university and the participants were 191 engineering students and 5 faculty members. The process of convenience sampling was used to select the participants. A mixed-methods case study design was implemented as this methodology was ideal for my research because it is typically employed when the goal of the study is to develop cases for families, clinics, or schools (Creswell & Plano-Clark, 2017) and I wanted to develop comprehensive, useful understandings and conclusions as well as for comprehending the complexity of a case. A survey instrument was employed to collect both quantitative and qualitative data related to engineering students’ perceptions on lightboard videos. It was important to not only collect data from the student participants to analyze and infer results but also to validate them, particularly in terms of qualitatively rich
perspectives from the faculty participants as they recorded the lightboard videos with the intent of inducing student engagement with the course content and they experienced students’ reactions towards the videos. Both types of data were collected and analyzed simultaneously. The results were then integrated and interpreted by way of comparing the findings from the student and faculty participants. The study intended to address the following research questions.

Research Questions

This mixed-methods case study sought to investigate the perceptions of engineering students on lightboard videos on their learning engagement. The following primary research questions were used for the purpose of data collection and analysis:

Quantitative

1. What are engineering students’ perceptions of learning engagement with video course materials created with lightboard technology?

Qualitative

2. How do engineering faculty perceive the use of video course materials created with lightboard technology would influence student learning engagement?
3. How do engineering students perceive the use of video course materials created with lightboard technology would influence student learning engagement?
Mixed

4. How does student data and faculty data help understand the effectiveness of video course materials created with lightboard technology?

Research Design

The conceptual framework of this study was built using the mixed-methods case study approach and assumptions of philosophy. According to Creswell and Plano Clark (2007), a worldview or paradigm is a fundamental collection of assumptions and beliefs that serve as a framework for study. It demonstrates how the researcher perceives the world and approaches their work. The philosophical worldview of this study is based upon an evolving constructivist approach; the objective was to establish and define the characteristics of the case. It places a strong emphasis on the flexibility of researchers to select the research methods, strategies, and procedures that best suit their requirements and objectives (Creswell, 2007) and consists of the following steps: (1) determining the information (evidence) need; (2) locating the necessary evidence and critically evaluating it; and (3) critically evaluating the offered evidence in light of the problem and context that the evidence should aid to address. It gives the study subject the utmost priority (Tashakkori & Teddlie, 2003). The pragmatic researcher is able to preserve both objectivities in the gathering and interpretation of data and subjectivity in their own thoughts on research.

There are a number of reasons why academics choose to employ mixed-methods in their study. One of the primary justifications is, it makes sense the use of both qualitative and quantitative data in a single research project as that might result in a much deeper level of
insight, whereas a single methodology may just produce data at the surface level (Tashakkori & Teddlie 2003). Moreover, combining quantitative and qualitative methodologies strengthens each approach's advantages and enables a more comprehensive analysis (Ivankova et al., 2006; Tashakkori & Teddlie, 1998). Such methods, according to Creswell and Plano Clark (2011), allow for the measurement of overlapping but different facts of a phenomenon, resulting in an improved, wider understanding of that phenomenon. A deliberate blending of both qualitative and quantitative approaches is utilized in a single research study in mixed-methods research, which can be seen as a sort of philosophically based inquiry (Shannon-Baker, 2016). The philosophical or theoretical framework(s), techniques of data collecting and analysis, overall research design, and/or discussion of research conclusions can all incorporate this combination or integration of the two methodologies. The goal of a mixed-methods study is to offer a deeper comprehension of a phenomenon than would otherwise be possible with only one method (Creswell & Plano Clark, 2011).

Three concurrent and three sequential designs are among the six most often utilized designs that Creswell et al. (2003) identified. In addition, a core mixed-methods design was intersected with a different type of technique using a mixed-methods case study or mixed-methods comparative case study approach. According to Creswell and Plano-Clark (2017), a mixed-methods study design is one in which the case(s) are developed for comparative analysis or to provide in-depth evidence for a case or cases and serve as the study's culminating or ending activity where the study's outcomes are derived from the collection, analysis, and integration of both quantitative and qualitative data. This methodology was ideal for my research because it is typically employed when the goal of the study is to develop cases for families, clinics, or
schools. According to Creswell and Plano-Clark (2017), mixed-methods case study designs are helpful for developing comprehensive, useful understandings and conclusions as well as for comprehending the complexity of a case.

Rationale for Employing Mixed-Methods Case Study

The use of mixed methods case study was appropriate for this research since it involved the collecting of both quantitative and qualitative data, findings from both types of data, and the integration of those findings for bringing forth comprehensive evidence for the case in the comparative analysis. The pinnacle of this research was a single case. A case, according to Yin (2014), could be an action that is bounded by certain criteria. As a result, this study included one distinctive case that was bound by the requirement to determine how lightboard videos affected engineering students' engagement in their studies. The case was identified and the boundaries for the case was defined for the study purpose; the case included every faculty participant and the entire engineering student population that participated in this research. The perspectives of both faculty and students were crucial in establishing the themes that emerged from the research findings as perspectives of both are equally important to establish the research findings. Multiple forms of data were collected for the case and the data were analyzed within and across for both faculty and student data. The aim of this complex mixed-methods case study research was to gather information on lightboard videos from multiple sources in order to get a comprehensive understanding of the case. This choice of study design also made sense because my research could use data to support the creation of varied situational profiles that would illustrate the range
of outcomes possible and aid in the understanding of how lightboard videos affect engineering students’ learning engagement.

**Philosophical Assumptions**

As the case evolved over the course of the study, the philosophical foundation tended to be an evolving constructivist approach; the objective was to establish and define the characteristics of the case. According to the philosophy, a variety of viewpoints were developed throughout the research process to characterize the case’s complexity. This design has a robust qualitative orientation, and in my research, the majority of the philosophical approaches were more in line with the qualitative viewpoint, where the theoretical framework offered direction for examining the case as intricate systems that integrated various data sources.

**The Mixed-methods Case Study Design Procedures**

The mixed-methods case study design intended to provide a more in-depth and nuanced understanding of the case by utilizing both quantitative and qualitative data. This research chose a convergent way of collecting data and used it as a procedural guide since it has the added benefit of advancing the identification and description of the case. First, both quantitative and qualitative data was collected and analyzed. The two sets of results collected from the faculty and student participants were then merged using joint displays and themes were generated.

This mixed-methods case study approach is challenging to implement despite its ubiquity and simplicity. Priority, implementation, and integration of the quantitative and qualitative methodologies are all challenges that the study must address (Creswell et al., 2003; Ivankova et
al., 2006; Morgan 1998). Thus, it is crucial to decide whether the quantitative or qualitative (or both) approaches receive more weight in the study design, if there is any order in which the quantitative and qualitative data will be collected or they will be collected simultaneously and analyzed, and to determine the phases of the study where the quantitative and qualitative approaches will be actually mixed or integrated. Additionally, an explicit way is required to visually portray all the subtleties of the study design so that it could be better understood by both possible readers and reviewers. This decision-making process was influenced by the study's purpose and its research questions when resolving such problems.

Priority is the tendency of the researcher to emphasize either quantitative or qualitative data (or both) over the other during the study's data collection and analysis phases (Creswell 2003; Morgan, 1998). This research implemented a convergent design and so both quantitative and qualitative data were collected simultaneously. Also, it was influenced by the research purpose of examining the perceptions of engineering students on lightboard videos on their learning engagement that required interpreting the findings from both types of data collected from faculty and students.

Implementation describes the order, one after the other, or concurrent nature of the quantitative and qualitative data collected and analyzed (Creswell et al. 2003; Morgan 1998). This research collected and analyzed both types of data concurrently. The purpose of this phase is to determine the potential influence of particular variables (lightboard videos) on engineering students' learning engagement.

In the analysis and conceptualization of phenomena using mixed-methods research, data integration is a crucial procedure and creative approach. Data integration can take place at any
stage of the research process, from developing the research's aims and objectives to its design, procedures, analysis, and outcomes. Data integration primarily serves the following goals: 1) illustration, 2) convergent validation, and 3) development and accomplishment of data richness. The term "integration point" describes the location where qualitative and quantitative research meet. Meaningful integration provides additional insight into the research questions and sets mixed-methods apart from other methodologies in which there is no database mixing. The integration for this mixed-methods case study design happened at the point when the results from the two databases merged together to interpret the case to develop themes regarding the perceptions of engineering students on lightboard videos on their learning engagement. Furthermore, as the case progressed, this study was able to contrast the data collected from faculty and students in order to illustrate the differences in the ways in which the case offered information on the research questions.

**Integration Intent**

Two unique sets of data collected from the faculty and student participants were included in this study, both of which were constrained by the need to ascertain how lightboard videos impacted engineering students' engagement in their studies. The perspectives of both were crucial in establishing the themes that emerged from the research findings as it helped in developing a holistic understanding of the findings that were validated and reliable. For the purposes of the study, a single case was identified and delimited that comprised all of the participating faculty members and all of the engineering students who took part in the research.
The results of the systematic review, which emphasized the scarcity of research using mixed methodologies for the subject of interest, served as the foundation for this study's design. Because no other studies have utilized this methodology and research approach for the topic, it was decided that integrating them will result in a richer, deeper knowledge of engineering students' engagement with their studies. It can be challenging to produce reliable meta-inferences that can be used to draw broad conclusions when using mixed approaches, which makes maintaining a high-quality analysis during data integration problematic (Othman et al., 2020). As a result, various potential validity concerns should be taken into account during data integration.

Validity and quality considerations in mixed-methods research have long been recognized as the most crucial elements of a project (Tashakkori & Teddlie, 2003). Quantitative validity for the student survey data was established as this research has used the quality instrument (student perception survey questionnaire) developed by Rogers (2019) for his research that examined “effect of lightboard videos on student learning and perceptions in a flipped classroom model” and so the construct being measured were meaningful. Also, the responses received from the student participants were reliable indicators as they were consistent for different courses where lightboard videos were integrated into the course content. Different validation strategies were employed by this researcher for the qualitative data collected. Member checking was done by examining the accuracy of data collected from one participant with the reflection of other key participants. Triangulation of data was established as data was collected from different sources. Moreover, responses from several participants built the evidence for the themes generated.
Moreover, the boundary for the case was defined and rationale was provided for using the mixed-methods case study design. In addition, parallel questions were created for both faculty and student participants that addressed the same concepts, sample size was the same for collecting quantitative and qualitative data for the students, integration strategy of joint display was used for the data analysis, and cross-analysis was performed. This therefore implies that a number of tactics were used to counter possible risks to accurately assessing and deriving conclusions from the combination of the two forms of data.

Researcher’s Positionality

This researcher completed his M.S. in Management Information Systems (MIS) and M.A. in Economics, presently pursuing Ph. D. in Instructional Technology, and has been working for the College of Engineering of a public university for the last almost eight years as an Information Technology (IT) support associate. That is to say, he is related in some way with the College of Engineering but at the same time neither he is an engineer, nor he belongs to any of the categories, namely, student, faculty, and administrators of the college. Therefore, the reflexivity condition did not affect the research in a negative way.

Visual Diagram

A graphical representation makes a mixed-methods study easier for interested readers to understand (Creswell et al. 2003; Tashakkori & Teddlie, 1998). My research utilized the recommendations and produced the following visual representation (see Figure 1) of the mixed-methods case study design techniques.
Figure 1: Visual Diagram for Mixed-Methods Case Study Design
Figure 1 illustrates the order in which the study's research activities took place, detailed every step of the data collection and analysis process, and provided a summary of the results or products from each type of data of the research. Additionally, it identified the moments in the research process where the integration or mixing of the results from both the quantitative and qualitative phases took place. It also illustrated the connections between the quantitative and qualitative phases and the linked outputs. Planning for the whole process was done first that involved, getting IRB approval, getting at least one lightboard video relevant to the course be recorded (one faculty recorded two lightboard videos), preparing the student perception survey (Appendix A), preparing the faculty interview questionnaire (Appendix B), and preparing the consent form for the participants. Either the faculty or this researcher reserved the lightboard studio and they were the only persons present during recording. The lightboard videos were then uploaded into the Blackboard by the corresponding faculty. Also most of the faculty participants emailed the students an unlisted YouTube link for them and suggested they go through it as it was relevant to the course concerned. The smallest length of the videos was of 6 min 48 s whereas the largest was of 8 min 28s. One of the faculty participants pulled up PowerPoint slides and annotated it for part of the recording along with spoken and written instructions, while other faculty just spoke and wrote while recording. The initial phase started with the collection of both quantitative and qualitative data from the student participants through the survey instrument and simultaneously collecting qualitative data from the faculty member participants through the interview questionnaire. This phase also involved analysis of quantitative data using descriptive and inferential statistics along with depicting the findings in the way of generated themes. Concurrently, qualitative data collected from both student and faculty participants were analyzed
for coding and thematic analysis. Qualitative findings were presented as themes also. The integration of this mixed-methods case study design occurred at the final phase when the findings from the student and faculty participants were combined to analyze the case and create themes about engineering students' perceptions on their engagement with the learning process through lightboard videos. In order to highlight the variations in the ways that the case provided information on the research topics, this study was able to compare the data gathered from faculty and students. Then final themes were generated, discussions were made comparing the findings with earlier research, and limitations and recommendations for future research were made.

Sampling Design

Participants

This research examined the perceptions of engineering students on lightboard videos on their engagement for learning. The lightboard videos were integrated into the course contents for 5 engineering courses into the Blackboard (BB) and an unlisted YouTube link of the lightboard videos were also emailed to the students for the courses by most of the corresponding faculty. The study was conducted in the college of engineering of a public university and the participants were 191 engineering students actively enrolled for the 5 courses for which the lightboard videos were included in the course content and 5 faculty members who were the instructors of those courses.
Participant Selection

The process of convenient sampling was used to select the participants as the characteristics of the specific group of participants matched the idiosyncrasy of the research questions being studied. The study sample included 191 students enrolled in 5 engineering courses for Fall 2023 semester where the lightboard videos were included and the 5 respective faculty members. The participants fulfilled specific criteria for students and faculty respectively. The study sample was restricted to only this group of participants since for no other engineering courses lightboard videos were incorporated. Criteria for selecting the student participants included (1) enrolled and active in Fall 2023 semester for an engineering course where the lightboard videos are included; (2) have familiarity with audio-video course materials; (3) have never used course materials created with lightboard technology; and (4) participate as a student for only one engineering course for which lightboard videos are incorporated. The criteria for selecting the faculty participants for the qualitative stage included (1) faculty teaching engineering courses for more than one semester; (2) teaching an engineering course in Fall 2023 semester for which lightboard videos are incorporated; (3) faculty members are familiar with audio-video course material; (4) have never included course materials created with lightboard technology; and (5) participate as faculty for only one engineering course for which lightboard videos are incorporated. Criteria fulfilment ensured that the student participants were invited to take part in the anonymous in-class student perception survey and that the faculty participants were contacted in-person by this researcher requesting to participate in the face-to-face interview voluntarily.
Time Frame

This researcher requested the faculty participants and accordingly, they created the lightboard videos and uploaded into the BB course content before the Fall 2023 semester began. As the student participants progressed through the specific engineering course for three weeks during Fall 2023 semester, both quantitative and qualitative data were collected from them through the anonymous in-class student perception survey. Simultaneously, more qualitative data collection was done from the faculty participants by way of semi-structured open-ended interview questionnaires. The study was conducted in a time frame of seven weeks from the beginning of Fall 2023 semester. Data preparation and data input into the specific software used for data analysis were completed during the fourth and fifth week of the Fall 2023 semester. Data analysis and interpretation were done during the weeks of sixth through ninth of the Fall 2023 semester.

Measures

This research with a mixed-methods case study design investigated the potential of lightboard videos to inspire student engagement by acquiring both quantitative and qualitative data from an anonymous in-class student perception survey (Appendix A) of 191 student participants who were enrolled for the specific engineering courses where lightboard videos were integrated for Fall 2023 semester, fulfilled the criteria and was willing to participate voluntarily. The original survey instrument was developed by Rogers (2019). A rigorous decision making process was taken to select an effective survey tool. Appropriate steps were taken to verify that each survey question is pertinent to the outcome being measured and that the important questions
have not been left out. The original survey had 24 items consisting of two questions on student demographics, “five open-ended short answer questions on student perceptions about the flipped classroom model (FCM)” (Rogers, 2019; part 1), and 17 five-point Likert scales focused to collect student participants’ perceptions on lightboard videos (Rogers, 2019; part 2). The anchor for part 2 of the survey was ‘how much agree’ the item was since it was focused to determine students’ perception. The anchor scale was (1) strongly disagree (2) disagree (3) neither agree nor disagree (4) agree (5) strongly agree. An important phase in the survey selection process was to thoroughly analyze the survey's content in order to enhance the general quality and representativeness of the scale questions. The part 2 of the original survey perfectly matches this researcher’s intention of collecting quantitative data on engineering students’ perception on lightboard videos and so it was kept almost intact with the only exception that it was made part 1 of Appendix A for this research. Validity and dependability of the instruments and tools used in quantitative research are crucial factors to take into account. Reliability and validity of the survey scale items was already established as it was developed and applied by Rogers (2019) for his research. Moreover, as this researcher intended to collect qualitative data also from the student participants to get insight regarding student perspectives on lightboard videos, the open-ended short answer questions of part 1 of the original survey (Rogers, 2019) were replaced accordingly, reduced to 4 short answer questions instead of the original 5 and was made part 2 of Appendix A. In addition, grade point average (GPA) and demographic data were not a part of this research so those questions of the original survey were eliminated. That decreased the number of items for this research to 21 instead of 24. The part 1 of the survey (Appendix A) collected descriptive statistics from student participants’ responses towards seventeen 5-point
Likert scale questions with the focus on the potential of lightboard videos in influencing engineering students’ engagement for learning. Whereas, part 2 of the survey (Appendix A) collected qualitative data from 4 short answer structured questions to get insight regarding student perspectives on lightboard videos. Concurrently, qualitative data were also collected from purposefully selected 5 faculty members in the form of semi-structured interviews developed by the researcher (Appendix B) with 9 open ended questions to get faculty’s perspectives on lightboard videos. This strategy's major objective was to see if lightboard videos might boost engineering students' engagement in academic pursuits. The goal of the mixed-methods case study design was to offer a more comprehensive and nuanced understanding of the case by combining quantitative and qualitative data. The short answer responses from the student participants and interviews of the faculty participants produced in-depth narrative accounts of the experiences of the participants with the lightboard videos in an effort to comprehend the dynamics of the lightboard videos integration and facilitate engineering students' learning. It was important to not only collect quantitative data from the student participants to analyze and infer results but also to further explain them, particularly in terms of qualitatively rich perspectives. The results from both quantitative and qualitative data were then integrated and interpreted by way of comparison and contrast.

Data Collection Procedures

This mixed-methods case study employed stringent procedures during the design, methodologies, implementation, interpretation, and reporting stages of the study to ensure research integrity. These measures assisted the researcher in conducting a well-designed study
and reducing the likelihood of biases in the data. In order to finish a mixed-methods data analysis and comprehend the combined data, it was crucial to integrate the data after the analyses of the quantitative and qualitative data in order to construct meta-inferences. This procedure followed the guidelines for a mixed-methods case study design. Meta-inferences were formed from integrated quantitative and qualitative methods and data, and conclusions addressing the validity and credibility of the study design were made from the combined methods and data.

Ethical considerations, written permission, verbal and written consent, anonymity and secrecy, voluntary involvement, and withdrawal were all covered during the research process. The research process also covered recruitment strategies, participants who were identified, the kind of data to be collected, the right sample size, locations, recording technique that was identified, and data collection and analysis techniques. The validity and reliability of the quantitative data and results as well as the veracity and dependability of the qualitative data and conclusions were evaluated using different methodologies.

Initiating the data collection process required that the researcher has approval from campus-based institutional review board (IRB), from individuals providing the data (and their representatives), as well as from individuals who are in charge of sites (Creswell & Plano Clark, 2007). In addition, the researcher needed to have obtained the CITI certification within 5 years from the commencement of the study. The researcher filled out the required application form with detailed description of research procedures, copies of informed consent and assent forms, and copies of the instruments and protocols to the university IRB. It also included a description of the risk level involved (if any). In addition, it was guaranteed that the rights of the participants will not be affected in any way during the research procedure. Those faculty members as well as
students who satisfy the inclusion requirements were contacted about taking part in the study. All participants were asked to sign the consent form before participating. The consent form provided all the information on the research procedure, research purpose and possible risks if any. This research received an IRB letter of exemption before the data collection procedure began.

For this complex study design, the quantitative and qualitative data collected were embedded in a case design structure. Also, the data collection decisions for this research involved determining the boundaries for the case and the criteria for inclusion into the case. In addition, rigorous data collection methods were employed and the two sets of data collected from the faculty and student participants were aligned to encourage smoother within and across data comparisons. This convergent research design collected survey responses from engineering students for both quantitative and qualitative data, and conducted semi-structured interviews for the faculty members to collect qualitative data.

Quantitative

The goal of the quantitative data was to examine the potential of the engrossing lightboard videos in inspiring engineering students’ learning engagement. The quantitative data was collected via an anonymous in-class student perception survey instrument developed by Rogers (2019) for his research that investigated “effect of lightboard videos on student learning and perceptions in a flipped classroom model” structured to get the responses related to engagement of engineering students in part 1 of the student perception survey consisted of 17 Likert scale questions (Appendix A). All the questions were pertinent to the outcome being measured and that any important questions have not been left out. The student perception survey
data was conducted in-class and data was collected from the student participants who consented to take part voluntarily in the research.

**Qualitative**

The student qualitative data was collected from student responses for 4 short-answer questions of part 2 of the anonymous in-class student perception survey (Appendix A) and by way of individual face-to-face interviews that consisted of 9 semi-structured open-ended questions (Appendix B) from a purposive sample consisting of five faculty members in order to get rich in-depth perceptions on the potential of lightboard videos in encouraging engineering students’ learning engagement. Duration of each interview was approximately 30 minutes and was recorded. The interviews were also transcribed. This helped in obtaining a more holistic picture of the research findings as well as provided the opportunity to rewind to have a better grasp of the materials while doing the data analysis. All faculty participants received the semi-structured open-ended questionnaire (Appendix B) before the scheduled date and time for the interview so that they may think about the questions and prepare more thorough answers. Additional follow-up questions were asked at various points during the interview to help clarify or elaborate on responses. The process and content of data collection activities is summarized in Chapter 4, which was followed by an examination of the research questions in connection to study interview results. Participants’ comments were provided where relevant to support findings based on the data. Participants' real names were replaced with pseudonyms to safeguard their privacy. Five principles and methodologies have been proposed in previous studies to establish and sustain rigor in qualitative research (Othman et al., 2020). These principles include
credibility, dependability, confirmability, transferability, and reflexivity. In this investigation, various validation methods were employed. The accuracy and consistency of the interview transcripts were confirmed, and member checking was used to validate the qualitative instrument (Ketsman, 2019). Rich and thick explanation of findings was another qualitative validation approach that was employed in this study to allow readers to make their own conclusions regarding transferability of findings to various learning environments (Ketsman, 2019). Finally, in order to improve validity, the researcher explained his positionality to the readers in order to assist them understand the situation and potential personal biases that could affect the interpretation and application of qualitative data (Ketsman, 2019).

Data Analysis Procedures

As such approaches to empirical inquiry affording multiple methods frequently result in superior research as compared to single method research, the core of many mixed-methods research approaches is the quest for collecting and analyzing a mix of quantitative and qualitative data within a single study to clasp the veracious form of participants' first-hand experience of phenomena (Creswell 2005; Tashakkori & Teddlie 2003). The main goal of a study like this is to ultimately aggregate the opinions of participants who have personally experienced the occurrence into collective categories from which conclusions can be formed. In order to achieve this, emergent themes from the data had to be identified that will then be served as the basis for further data organization and analysis.

Quantitative data analysis procedure started with data preparation. Quantitative data collected from engineering students through their responses towards the 17 Likert scale questions
of part 1 of the student perception survey were used to establish the variables, assigning numeric values to the variables, and using it as input in IBM's Statistical Package for Social Sciences (SPSS) version 28 software. The data were then checked for any data entry errors. Visual exploration of the data was performed next to scan for the trend to scrutinize if the data were normally distributed. Thereafter, descriptive analysis was conducted for all the variables. Both univariate and multivariate statistical techniques were used. To ascertain students' perceptions on lightboard videos, central tendency measures including mean, median, mode, and standard deviation were computed for the student responses on part 1 of the student perception survey of Appendix A. If there was any missing data, it was conveyed properly. The statistical results were then summarized in terms of text and tables. The findings were then compared and interpreted in terms of the concerned research question and presented by way of themes.

On the other hand, the student qualitative data were prepared to enter into Nvivo 12 software for coding and thematic analysis. However, the qualitative data collected from the faculty interviews were started with the checking for transcription accuracy by comparing the transcription with the audio recording. The data were then organized by data type and particular participant (student or faculty) to facilitate the analysis through Nvivo and manually. A memo was created by this researcher by exploring through both student and faculty qualitative data and some initial codes were generated. Multiple approaches were applied for the coding of qualitative data. Three data analysis techniques were applied for the data analysis, namely, constant comparison, keywords-in-context, and word repetition. During constant comparison, small segments were taken off from the participant’s interviews and initial codes were created by comparing the incidents concerning the research question (Leech & Onwuegbuzie, 2007).
Thereafter, information found from those initial codes were grouped into different categories with relevant description for the intermediate coding. A final grouping was done after re-examining the categories. Word repetitions and keywords-in-context were done simultaneously to understand the inherent meaning of a word used by a participant in a specific context. For this purpose, word frequency was done for the whole interview of a participant and then the frequently used meaningful words were analyzed in the context. Initial themes were generated through these analyses and compared with the initial codes created by the researcher manually. Checking and verification were done to determine if one or more of the categories can be linked together to generate a major or minor theme. Major and minor themes were then examined by way of compare and contrast. Next, all the themes were put together for in-depth inspection to check the relevance and their fit into the research. Examination of the themes were done again to determine if any merging of the themes was possible depending on any common criteria or if there was a need to divide a major theme into sub-themes. Next the original transcripts were compared with the themes generated to verify that every relevant information was categorized. Evidence for the themes generated were provided by way of direct quotes from the participants’ data. Finally, the findings were summarized by way of themes to answer the concerned research questions.

The 'following a thread' technique was used during data analysis. A thread is followed when a theme or topic from one data set appears across multiple components. This process began with data analysis of each component for the two sets of data to uncover noteworthy discoveries and questions that needed further investigation. At the interpretation and reporting level, data integration entailed employing a "weaving technique" to display the key findings from
quantitative and qualitative data theme by theme, and then summarizing these findings in a narrative format. In order to provide a larger and more thorough assessment of participants' responses and the study topic, a joint display for the quantitative and qualitative data findings was used to find new insights from the combined data. A comparison of the results provided a comprehensive picture of the research topic and suggested directions for future study, application, and pedagogical policy.

The discussion of the overall study's findings included both qualitative and quantitative phase data. This research conducted a mixed-methods case study to better understand how lightboard videos affected engineering students' learning engagement. Results from both types of data analysis were merged in the discussion section to provide a more comprehensive response to the research questions and create a more robust and insightful picture of the research problem. A joint display of the findings was then provided to help glancing through the overall findings. Through this approach, the statistical findings from the quantitative phase were further clarified and explained by the findings from the qualitative phase. It helped in examining if the student survey data and faculty interview data facilitated the understanding of the potential of lightboard videos. The outcomes of the study were then grouped to the respective quantitative, qualitative and mixed research sub-questions for detailed discussion. Citations from relevant literature that reflect both quantitative and qualitative published studies on the subject were used to support the discussion.
Anticipated Findings

To determine the potential of the lightboard videos in influencing engineering students’ learning engagement positively, any mean response of greater than 3.5 will imply that the trend is towards a superlative degree of ‘agree’ and will suggest that the participants are truly in favor of applying the lightboard videos into the course content. The Likert scale mean score was given the following interpretation ranges: 1.0-2.4 (Negative attitude), 2.5-3.4 (Neutral attitude), and 3.5-5.0 (Positive attitude) (Kenpro, 2021). The quantitative analysis results should suggest that participants realized the potential of the lightboard videos as the range of the mean responses will be more than 3.5. In addition, the quantitative results will confirm and strengthen the quantitative findings that participants are truly in favor of applying lightboard videos to boost up engineering students’ engagement in studies. Moreover, it is expected that the normal curves of the histograms will show a negative skewness to confirm this view. Likewise, the results will imply that faculty members think that the engineering students will react positively towards the lightboard videos.

The results will have important implications regarding delivering engineering instruction. Previous studies found that interventions such as “video course materials” is important for effective student engagement (Babich & Mavrommatis, 2004; Cadena et al., 2019; Felder et al., 2000; Fung, 2017; Gudimetla & Iyre, 2006; Liarokapis et al., 2004; VanderMolen et al., 2018). Confirming the view, this research will clearly indicate that the incorporation of lightboard videos for engineering education will facilitate engineering students’ learning engagement.
CHAPTER 4. DATA COLLECTION AND ANALYSIS

Statement of the Problem

Lack of student engagement was always a major concern and engineering education is no exception (Chen et al., 2008; Simmons et al., 2019). It is a significant issue as it hampers academic performances of engineering students, impedes student retention for engineering colleges and in turn, results in less production of quality engineers for the society (Adams et al., 2011; Craft & Capraro, 2017; Hadgraft & Kolmos, 2020). Furthermore, student disengagement compromises the supply of qualified future engineers (Chen et al., 2008; Simmons et al., 2019) by leading to mediocre program outcomes, poor academic performance, and alarmingly high academic attrition rates for engineering institutions (Chang et al., 2011; Chen et al., 2008; Craft & Capraro, 2017). In order to encourage students' learning engagement, it is now crucial to maintain a focus on student engagement and offer ongoing support at all stages of engineering education (Chang et al., 2011; Craft & Capraro, 2017).

Exploring various learning environments has shown that the trend in engineering education is toward student-centered active learning using digital tools to increase productivity in the classroom and where the learning environment influences better student engagement (Hadgraft & Kolmos, 2020; Koretsky & Magana, 2019). To support an enjoyable learning experience for engineering students and increase their engagement in their studies, more resources need to be investigated (Simmons et al., 2019). According to Cadena et al. (2019),
course content is one area where staff continually work to enhance to keep students engaged because everything depends on how well they respond to the course materials. According to several researchers, employing complete visual materials in engineering classes is advised because visuals help students retain information better than auditory ones (Babich & Mavrommatis, 2004; Felder et al., 2000). Researchers have also found that video course materials can better engage students than other types of information and convey the nuances of non-verbal communication (Cadena et al., 2019; Fung, 2017; Gudimetla & Iyre, 2006; VanderMolen et al., 2018). As a result, Cadena et al. (2019) suggested using cutting-edge multimedia-technology tools to create and incorporate technologically advanced video content for engineering education in order to keep students engaged in learning. The need has been identified, but a void is still noticed that application of high quality video material to improve the learning engagement of engineering students has limited application in engineering education.

Purpose of the Study

This study examined how using multimedia-based, technologically advanced video course materials affects engineering students' engagement in their studies. Learning engagement of engineering students is a necessary condition for effective learning, according to previous research (Babich & Mavrommatis, 2004; Cadena et al., 2019; Felder et al., 2000; Fung, 2017; Gudimetla & Iyre, 2006; Liarokapis et al., 2004) and that engagement can be positively influenced by interventions like video course materials. To achieve these goals, this research applied the lightboard technology tool to produce video course materials for a few engineering courses before incorporating them into the curriculum for students. The purpose of this research
was to examine the perceptions of engineering students on video course material created with lightboard technology (hereafter it will be mentioned as lightboard videos) on their engagement for learning.

Research Questions

This mixed-methods case study sought to investigate the perceptions of engineering students on lightboard videos on their learning engagement. The following primary research questions were used for the purpose of data collection and analysis:

Quantitative

1. What are engineering students’ perceptions of learning engagement with video course materials created with lightboard technology?

Qualitative

2. How do engineering faculty perceive the use of video course materials created with lightboard technology would influence student learning engagement?
3. How do engineering students perceive the use of video course materials created with lightboard technology would influence student learning engagement?

Mixed

4. How does student data and faculty data help understand the effectiveness of video course materials created with lightboard technology?
Data Collection and Analysis

The population of this study included engineering students currently enrolled in five engineering courses and faculty members who teach those courses at the research university. Five engineering faculty members created lightboard videos for five engineering courses and incorporated them into the course contents for the engineering students of the corresponding courses and hence, only those engineering students and faculty were selected to participate in this study. A total of 191 engineering student participants took the anonymous in-class survey (Appendix A) where part 1 of the survey collected quantitative data from student participants’ responses towards seventeen 5-point Likert scale questions with the focus on the potential of lightboard videos in influencing engineering students' engagement for learning. The part 2 of the survey (Appendix A) collected qualitative data from 4 short answer structured questions to get insight regarding student perspectives on lightboard videos and 180 engineering student participants responded. Simultaneously, qualitative data was collected from the five faculty participants in the form of interviews (Appendix B) that consisted of semi-structured open ended questions to get faculty’s perspectives on lightboard videos. Table 1 highlights the research instruments that were applied into my dissertation.

Analysis of Research Questions

Chapter four is organized into many overarching sections that are based on the thematic categories that emerged during the coding process and the theoretical framework that is covered in the second chapter. Four research questions guided this study of determining the perceptions of engineering students on lightboard videos on their engagement in learning. The results and
Table 1

Data Sources and Details

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Part 1 of student perception survey (Appendix A)</td>
<td>17 items; 191 participants (100% response rate)</td>
</tr>
<tr>
<td>2. Part 2 of student perception survey (Appendix A)</td>
<td>4 items; 180 participants (94.2% response rate)</td>
</tr>
<tr>
<td>3. Faculty interviews</td>
<td>5 faculty interviews (100% response rate)</td>
</tr>
</tbody>
</table>

analysis for research questions are depicted in a chronological order; results and analysis for research question 1 followed by results and analysis for research question 2 followed by results and analysis for research question 3 and finally, results and analysis for research question 4. The research questions are restated first and then the corresponding results and analysis are provided. The quantitative data's themes for the first research question are determined, along with the data sources that were most helpful in producing these themes. The Likert scale data from Appendix A's first part was examined for the purpose. The presentation of the faculty interview data and the qualitative data gathered from the short answer questions in part 2 of Appendix A comes right after the numerical data. The same structure applies to the sections that follow for research questions two, three, and four. Moreover, I demonstrated how the results address each of the four research questions. To keep the participants' identities secured, pseudonyms are employed. My study's main conclusions are briefly summarized at the end of chapter four.
Analysis of Research Question 1

Research Question 1: What are engineering students’ perceptions of learning engagement with video course materials created with lightboard technology?

In order to answer this question, responses were collected and analyzed from 191 engineering student participants that combined all the student participants enrolled in five engineering courses for which the lightboard videos were integrated on seventeen questions with 5-point Likert scale responses (Part 1 of Appendix A). In addition, analysis for the data for each of the five classes were done separately after analyzing the combined data to determine if individual course data findings confirm or differ from the findings for the combined data. IBM's Statistical Package for Social Sciences (SPSS) version 28 was used for data analysis. To analyze the survey data, descriptive statistical techniques were used. In order to ascertain students' perceptions on lightboard videos, central tendency measures including mean, median, mode, range and standard deviation were computed. Also, to determine the skewness, histograms with normal curves were drawn. The output of analyzing the data is given in Appendix C. The themes generated from the analysis are discussed after the tabular presentations of the findings. Table 2 presents a total of 17 items, making it possible for readers to compare and take in a lot of information without feeling overwhelmed. As illustrated in Table 2, for the combined data, all the items have the majority of the student participants responding in the favor of lightboard videos. A close scrutiny revealed that at least 72.3% of the student participants either agreed or strongly agreed that lightboard videos have the potential to influence engineering students’ learning engagement positively.
Table 2
Overall Response Percentages for the Likert Scale Questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neither agree or disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q 1</td>
<td>0.5%</td>
<td>1.6%</td>
<td>7.3%</td>
<td>27.2%</td>
<td>63.4%</td>
</tr>
<tr>
<td>Q 2</td>
<td>0.5%</td>
<td>1.0%</td>
<td>10.5%</td>
<td>34.0%</td>
<td>53.9%</td>
</tr>
<tr>
<td>Q 3</td>
<td>1.0%</td>
<td>1.0%</td>
<td>10.5%</td>
<td>29.8%</td>
<td>57.6%</td>
</tr>
<tr>
<td>Q 4</td>
<td>0.5%</td>
<td>1.0%</td>
<td>12.0%</td>
<td>37.2%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Q 5</td>
<td>0.5%</td>
<td>1.0%</td>
<td>18.3%</td>
<td>36.1%</td>
<td>43.5%</td>
</tr>
<tr>
<td>Q 6</td>
<td>0.0%</td>
<td>3.1%</td>
<td>20.4%</td>
<td>29.3%</td>
<td>46.6%</td>
</tr>
<tr>
<td>Q 7</td>
<td>0.0%</td>
<td>1.0%</td>
<td>14.1%</td>
<td>30.9%</td>
<td>53.9%</td>
</tr>
<tr>
<td>Q 8</td>
<td>0.0%</td>
<td>2.6%</td>
<td>17.8%</td>
<td>37.2%</td>
<td>41.9%</td>
</tr>
<tr>
<td>Q 9</td>
<td>0.0%</td>
<td>3.7%</td>
<td>9.9%</td>
<td>37.7%</td>
<td>48.7%</td>
</tr>
<tr>
<td>Q 10</td>
<td>0.5%</td>
<td>1.6%</td>
<td>13.6%</td>
<td>41.9%</td>
<td>42.4%</td>
</tr>
<tr>
<td>Q 11</td>
<td>0.5%</td>
<td>4.7%</td>
<td>22.5%</td>
<td>39.8%</td>
<td>32.5%</td>
</tr>
<tr>
<td>Q 12</td>
<td>0.5%</td>
<td>2.6%</td>
<td>12.6%</td>
<td>29.3%</td>
<td>55.0%</td>
</tr>
<tr>
<td>Q 13</td>
<td>0.5%</td>
<td>1.0%</td>
<td>16.2%</td>
<td>33.0%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Q 14</td>
<td>0.5%</td>
<td>0.5%</td>
<td>17.3%</td>
<td>33.5%</td>
<td>48.2%</td>
</tr>
<tr>
<td>Q 15</td>
<td>0.5%</td>
<td>3.1%</td>
<td>15.7%</td>
<td>30.9%</td>
<td>49.2%</td>
</tr>
<tr>
<td>Q 16</td>
<td>1.0%</td>
<td>2.1%</td>
<td>16.2%</td>
<td>30.4%</td>
<td>49.7%</td>
</tr>
<tr>
<td>Q 17</td>
<td>0.0%</td>
<td>0.5%</td>
<td>12.6%</td>
<td>35.6%</td>
<td>50.8%</td>
</tr>
</tbody>
</table>

It was depicted earlier in the methodology chapter that any mean response of greater than 3.5 will imply that the trend is towards a superlative degree of ‘true’ and will suggest that the participants are truly in favor of applying the lightboard videos. The Likert scale mean score was given the following interpretation ranges: 1.0-2.4 (Negative attitude), 2.5-3.4 (Neutral attitude), and 3.5-5.0 (Positive attitude) (Kenpro, 2021). The analysis results showed that participants realized the potential of the lightboard videos in inspiring engineering students’ engagement for learning as the range of the mean responses for all the variables are more than 3.5. Table 3 summarizes all the engineering student participants’ responses (combined data for the five engineering courses) to the seventeen Likert-scale questions determining student perceptions on
lightboard videos (the scale ranges from 1-strongly disagree to 5-strongly agree) from part 1 of Appendix A. Moreover, the higher average standard deviation (SD) of 0.806 implied that more data points are respectively above the mean. That is, more student data fell further away from the mean, indicating the existence of frequent extreme values. Answers to one of the questions were missed for Q 5, Q 6, Q 8, Q 15, Q 16, and Q 17.

Table 3
Responses for Student Perceptions on Lightboard Videos

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.51</td>
<td>.746</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.40</td>
<td>.760</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.42</td>
<td>.803</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.34</td>
<td>.770</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.22</td>
<td>.817</td>
</tr>
<tr>
<td></td>
<td><strong>4.38</strong></td>
<td><strong>.779</strong></td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.20</td>
<td>.874</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.38</td>
<td>.764</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.19</td>
<td>.820</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.31</td>
<td>.799</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.24</td>
<td>.784</td>
</tr>
<tr>
<td></td>
<td><strong>4.26</strong></td>
<td><strong>.808</strong></td>
</tr>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>3.99</td>
<td>.888</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.36</td>
<td>.839</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.29</td>
<td>.813</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.28</td>
<td>.804</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>4.26</td>
<td>.874</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>4.26</td>
<td>.881</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.37</td>
<td>.722</td>
</tr>
<tr>
<td></td>
<td><strong>4.26</strong></td>
<td><strong>.832</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Overall Mean</strong></td>
<td><strong>4.30</strong></td>
</tr>
</tbody>
</table>
The average response was 4.30 (approximately) with a high of 4.51 and a low of 3.99 respectively. This indicates that students are strongly in favor of lightboard videos. The range was only .51 between the highest and the lowest mean. The highest mean of 4.51 was achieved for Q 1 (the video was easy to watch and understand) whereas, the lowest mean was achieved for Q 11 (I found the video interesting and stimulating). It is worth mentioning that for Q11 the mean was the lowest (though it was more than 3.5) among all the Likert scale questions across all the courses. It was not possible to determine the reason as the Likert scale response data was collected through an anonymous in-class student perception survey. Also, the average SD of student responses was 0.806 with a high of 0.888 and a low of 0.722 respectively. The highest SD of 0.888 was achieved for Q 11 (I found the video interesting and stimulating) whereas, the lowest SD was achieved for Q 17 (Overall, I enjoyed and recommended the lightboard videos). This result confirmed the fact that students strongly favored lightboard videos. Moreover, consistent with these findings, the normal curves for the histograms against all the questions are skewed negatively proving students’ preference for lightboard videos. Following three distinct themes emerged from the analysis.

1. Lightboard videos helped in understanding the course content
2. Lightboard videos were engaging
3. Lightboard videos facilitated learning satisfaction

**Lightboard Videos Helped in Understanding the Course content**

According to the engineering students who took part in the research, it was simple to view and comprehend the lightboard videos. They felt that the lightboard videos made the course material easier for them to visualize. The lightboard videos also assisted the students in
recognizing the main ideas of the material. Additionally, students said that having handwritten notes for the lightboard videos improved their comprehension. In general, their understanding was enhanced by the lightboard videos.

**Lightboard Videos Were Engaging**

The engineering students that took part in the research said that it was simpler to pay attention and follow the course material because the lightboard videos were interactive. They felt that the video was a suitable length and that watching the lightboard videos was a worthwhile use of their time. Students believed that using lightboard technology to engage them in learning was a suitable approach. The engineering students had an engaging overall experience watching lightboard videos.

**Lightboard Videos Facilitated Learning Satisfaction**

The lightboard videos sparked the curiosity and stimulation of engineering students. They thought the technology in the video looked intriguing and that lightboard technology is a useful teaching tool. They went on to say that they would suggest lightboard videos to their friends and that more should be made and used for engineering classes in general as well as their own. As a whole, the lightboard videos were well-received and suggested by the engineering students.

Data from individual courses where the lightboard videos were integrated into the course content were also analyzed separately and found that the findings were perfectly aligned with the themes derived from the combined data. The outputs are given in Appendix D. For course 1, The
mean response was 4.17 (roughly), with a high of 4.57 and a low of 3.89. Please refer to Table 4 for more information. This shows how popular lightboard videos are among students. Also, the average SD of student responses was 0.824. The highest SD of 0.968 was achieved for Q 3 (The video helped identify major points) whereas, the lowest SD of 0.608 was achieved for Q 1 (The video was easy to watch and understand). This outcome supported the notion that students favor lightboard videos greatly. Also, in line with these findings, the histograms for all the questions'

Table 4

Responses for Student Perceptions on Lightboard Videos for Course 1

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.57</td>
<td>.608</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.17</td>
<td>.822</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.34</td>
<td>.968</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.14</td>
<td>.810</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.06</td>
<td>.776</td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.00</td>
<td>.939</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.37</td>
<td>.731</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.06</td>
<td>.838</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.06</td>
<td>.906</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.09</td>
<td>.781</td>
</tr>
</tbody>
</table>

Understanding 4.26 .797

Engagement 4.12 .839

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>3.89</td>
<td>.900</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.43</td>
<td>.698</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.31</td>
<td>.718</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.23</td>
<td>.942</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>3.94</td>
<td>.952</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>3.97</td>
<td>.937</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.24</td>
<td>.699</td>
</tr>
</tbody>
</table>

Satisfaction 4.14 .835

Overall Mean 4.17 .824
normal curves were skewed negatively, demonstrating students’ preference for lightboard videos.

For course 2, the mean response was 4.29 (roughly), with a high of 4.70 and a low of 4.04. Please refer to Table 5 for more information. This shows how popular lightboard videos were among students. Also, the average SD of student responses was 0.829. The highest SD of 0.996 was achieved for Q 12 (The video’s technology is attractive) whereas, the lowest SD of .665 was achieved for Q 10 (Overall, the lightboard video was engaging) and Q 16 (I would

Table 5
Responses for Student Perceptions on Lightboard Videos for Course 2

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.39</td>
<td>.891</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.04</td>
<td>.825</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.17</td>
<td>.887</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.30</td>
<td>.822</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.13</td>
<td>.920</td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.04</td>
<td>.878</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.70</td>
<td>.703</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.48</td>
<td>.846</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.17</td>
<td>.834</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.48</td>
<td>.665</td>
</tr>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>4.04</td>
<td>.976</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.09</td>
<td>.996</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.09</td>
<td>.900</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.30</td>
<td>.765</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>4.48</td>
<td>.730</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>4.48</td>
<td>.665</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.48</td>
<td>.790</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>4.28</td>
<td>.832</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>4.29</td>
<td>.829</td>
</tr>
</tbody>
</table>
recommend developing and using more lightboard videos for other engineering courses). This outcome supported the notion that students favor lightboard videos greatly. Also, in line with these findings, the histograms for all the questions' normal curves were skewed negatively, demonstrating students' preference for lightboard videos.

Course 2 was the only graduate level course whereas, three of the remaining four courses were undergraduate level courses and one was a combined course. In order to compare the trend between the undergraduate and graduate courses, a combined data was prepared for the undergraduate courses and analyzed. The outputs are given in Appendix E. Table 6 summarizes all the undergraduate engineering student participants’ responses (combined data for the three undergraduate engineering courses) to the seventeen Likert-scale questions determining student perceptions on lightboard videos (the scale ranges from 1-strongly disagree to 5-strongly agree) from part 1 of Appendix A. The average response was 4.33 (approximately) with a high of 4.52 and a low of 4.01 respectively. This indicates that even undergraduate engineering students also are strongly in favor of lightboard videos and the trend is quite similar compared with the graduate course. The range was only .51 between the highest and the lowest mean. Similar to the graduate course, the highest mean was achieved for Q 1 (the video was easy to watch and understand) whereas, the lowest mean was achieved for Q 11 (I found the video interesting and stimulating). However, these inferences might not offer a proper comparison owing to the fact that there was less number of graduate level courses and less number of graduate student participants than undergraduate courses and undergraduate student participants.

For course 3, The average response was 4.31 (roughly), with a high of 4.46 and a low of 3.85. Please refer to Table 7 for more information. This shows how popular lightboard videos are
Table 6

Responses for Lightboard Videos for Undergraduate Courses

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.52</td>
<td>.755</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.52</td>
<td>.703</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.48</td>
<td>.734</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.39</td>
<td>.747</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.27</td>
<td>.808</td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.28</td>
<td>.850</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.32</td>
<td>.774</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.17</td>
<td>.805</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.41</td>
<td>.749</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.24</td>
<td>.799</td>
</tr>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>4.01</td>
<td>.875</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.38</td>
<td>.841</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.32</td>
<td>.822</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.29</td>
<td>.776</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>4.30</td>
<td>.862</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>4.30</td>
<td>.887</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.39</td>
<td>.716</td>
</tr>
</tbody>
</table>

| Overall Mean | 4.33 | .790               |

among students. Also, the average SD of student responses was 0.754. The highest SD of 0.870 was achieved for Q 15 (I would recommend developing and using more lightboard videos for this class) whereas, the lowest SD of .605 was achieved for Q 2 (The video helped me visualize the content). This outcome supported the notion that students favor lightboard videos greatly.
Also, in line with these findings, the histograms for all the questions' normal curves were skewed negatively, demonstrating students' preference for lightboard videos.

Table 7

Responses for Student Perceptions on Lightboard Videos for Course 3

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.46</td>
<td>.636</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.46</td>
<td>.605</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.41</td>
<td>.714</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.35</td>
<td>.677</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.22</td>
<td>.718</td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.22</td>
<td>.861</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.13</td>
<td>.802</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.04</td>
<td>.801</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.37</td>
<td>.734</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.13</td>
<td>.728</td>
</tr>
<tr>
<td>Understanding</td>
<td>4.38</td>
<td>.670</td>
</tr>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>3.85</td>
<td>.856</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.22</td>
<td>.839</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.30</td>
<td>.768</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.19</td>
<td>.729</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>4.19</td>
<td>.870</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>4.22</td>
<td>.861</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.26</td>
<td>.732</td>
</tr>
<tr>
<td>Engagement</td>
<td>4.22</td>
<td>.785</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>4.32</td>
<td>.808</td>
</tr>
<tr>
<td>Overall Mean</td>
<td>4.31</td>
<td>.754</td>
</tr>
</tbody>
</table>

For course 4, the average response was 4.26 (roughly), with a high of 4.47 and a low of 3.97.

Please refer to Table 8 for more information. This shows how popular lightboard videos are among students. Also, the average SD of student responses was 0.926. The highest SD of 1.047
was achieved for Q 12 (The video’s technology is attractive) whereas, the lowest SD of .851 was achieved for Q 7 (The length of the video was appropriate). This outcome supported the notion that students favor lightboard videos greatly. Also, in line with these findings, the histograms for all the questions' normal curves were skewed negatively, demonstrating students' preference for lightboard videos.

Table 8
Responses for Student Perceptions on Lightboard Videos for Course 4

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.41</td>
<td>.979</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.47</td>
<td>.915</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.44</td>
<td>.914</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.28</td>
<td>.924</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.19</td>
<td>1.030</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td>4.36</td>
<td>.952</td>
</tr>
<tr>
<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
<td>4.23</td>
<td>.884</td>
</tr>
<tr>
<td>7. The length of the video was appropriate.</td>
<td>4.28</td>
<td>.851</td>
</tr>
<tr>
<td>8. Watching the video was an effective use of my time.</td>
<td>4.09</td>
<td>.893</td>
</tr>
<tr>
<td>9. The lightboard technology is an appropriate way to engage students.</td>
<td>4.25</td>
<td>.880</td>
</tr>
<tr>
<td>10. Overall, the lightboard video was engaging.</td>
<td>4.06</td>
<td>.948</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engagement</td>
<td>4.18</td>
<td>.891</td>
</tr>
<tr>
<td>11. I found the video interesting and stimulating.</td>
<td>3.97</td>
<td>.967</td>
</tr>
<tr>
<td>12. The video’s technology is attractive (style wise).</td>
<td>4.25</td>
<td>1.047</td>
</tr>
<tr>
<td>13. The video is an effective tool for learning.</td>
<td>4.28</td>
<td>.958</td>
</tr>
<tr>
<td>14. I would recommend lightboard videos to my peers.</td>
<td>4.22</td>
<td>.941</td>
</tr>
<tr>
<td>15. I would recommend developing and using more lightboard videos for this class.</td>
<td>4.28</td>
<td>.888</td>
</tr>
<tr>
<td>16. I would recommend developing and using more lightboard videos for other engineering courses.</td>
<td>4.19</td>
<td>.998</td>
</tr>
<tr>
<td>17. Overall, I enjoyed and recommended the lightboard videos.</td>
<td>4.41</td>
<td>.756</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>4.23</td>
<td>.936</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Mean</td>
<td>4.26</td>
<td>.926</td>
</tr>
</tbody>
</table>
For course 5, the average response was 4.49 (roughly), with a high of 4.66 and a low of 4.21. Please refer to Table 9 for more information. This shows how popular lightboard videos are among students. Also, the average SD of student responses was 0.707. The highest SD of 0.830 was achieved for Q 16 (I would recommend developing and using more lightboard videos for other engineering courses) whereas, the lowest SD of .600 was achieved for Q 12 (The video’s technology is attractive). This outcome supported the notion that students favor lightboard videos

Table 9

Responses for Student Perceptions on Lightboard Videos for Course 5

<table>
<thead>
<tr>
<th>Comparison of Means for student perceptions on lightboard videos</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The video was easy to watch and understand.</td>
<td>4.66</td>
<td>.700</td>
</tr>
<tr>
<td>2. The video helped me visualize the content.</td>
<td>4.62</td>
<td>.644</td>
</tr>
<tr>
<td>3. The video helped identify major points.</td>
<td>4.60</td>
<td>.614</td>
</tr>
<tr>
<td>4. Having handwritten notations helped with my understanding.</td>
<td>4.51</td>
<td>.688</td>
</tr>
<tr>
<td>5. Overall, the lightboard video improved my understanding.</td>
<td>4.38</td>
<td>.739</td>
</tr>
<tr>
<td>Understanding</td>
<td>4.55</td>
<td>.677</td>
</tr>
</tbody>
</table>

| 6. The interactive nature of the video made it easier to pay attention and follow. | 4.38 | .822               |
| 7. The length of the video was appropriate.                    | 4.57 | .617               |
| 8. Watching the video was an effective use of my time.         | 4.43 | .688               |
| 9. The lightboard technology is an appropriate way to engage students. | 4.55 | .653               |
| 10. Overall, the lightboard video was engaging.                | 4.49 | .718               |
| Engagement                                                    | 4.48 | .700               |

| 11. I found the video interesting and stimulating.             | 4.21 | .806               |
| 12. The video’s technology is attractive (style wise).         | 4.66 | .600               |
| 13. The video is an effective tool for learning.              | 4.38 | .795               |
| 14. I would recommend lightboard videos to my peers.          | 4.47 | .687               |
| 15. I would recommend developing and using more lightboard videos for this class. | 4.45 | .829               |
| 16. I would recommend developing and using more lightboard videos for other engineering courses. | 4.47 | .830               |
| 17. Overall, I enjoyed and recommended the lightboard videos. | 4.53 | .654               |
| Satisfaction                                                  | 4.45 | .743               |
| Overall Mean                                                  | 4.49 | .707               |
greatly. Also, in line with these findings, the histograms for all the questions' normal curves were skewed negatively, demonstrating students' preference for lightboard videos.

**Summary of Findings for Research Question 1**

In summary, regarding research question 1, the statistical analysis can be interpreted as that the lightboard videos were easy to view for the engineering students and helped them in visualizing the content thereby facilitating their understanding on the subject. Also, faculty’s handwritten notations while creating the lightboard videos guided them in recognizing the key points of the content. Additionally, students realized that the videos created with lightboard technology are an efficient way of engaging students into learning by making the content easier for paying attention, students think that watching those short lightboard videos meant perfectly utilizing their time. Moreover, they perceived that the lightboard technology is really systematic in making attractive video contents that are beneficial for learning. Furthermore, it is important to note that the length of the videos for various courses, and the method by which the faculty recorded the lightboard videos—by bringing up PowerPoint slides with written and spoken phrases, or simply by writing and speaking—did not alter the general trend in students' impressions. Students really enjoyed and expressed their desire for including more lightboard videos for the concerned course and other engineering courses as well.

**Analysis of Research Question 2**

Research Question 2: How do engineering faculty perceive the use of video course materials created with lightboard technology would influence student learning engagement?
In order to answer this question, responses were collected and analyzed from five faculty participants on 5 questions (Q 1, Q 2, Q 3, Q 7, and Q 8) from Appendix B (open ended interview questionnaire for faculty). To keep their identity confidential, this analysis applied pseudonyms. The data from the interviews revealed a wide range of opinions. The following thematic groups were identified for the second research question based on an analysis of the participant replies.

1. No preparation required, only organize key points for the recording
2. A wider writing space with a marked boundary for writing will be helpful
3. Real time modification facilities
4. Additional software integration
5. Lightboard videos will help students to be engaged in studies
6. Faculty’s body gesture and facial expression will help students to follow
7. Lightboard videos offer a traditional classroom experience

No Preparation Required, Only Organize Key Points for The Recording

The faculty members claimed that they didn't need to do any extra planning before beginning the lightboard video recording. The majority of them said that they had viewed YouTube videos on lightboard and had mostly prepared their material in advance of the recording to ensure that key elements weren't overlooked. They had put their points down in documents in Word, PowerPoint, and PDF formats. According to one faculty,

I look at the syllabus. I take some notes, because I know I don't have a lot. I don't have an entire lecture time. I don't have 75 minutes to talk about the syllabus in the video. So I just you know kind of pick the important note, important points. And then I put those points into a slide, into a PowerPoint slide. Then I use that slide as a guide to help me present while recording the video. Yeah. So I used that, I project the PowerPoint on the
monitor, so I can do the live where I can see through it and I can see which page I'm on and then which one I want to, I want to talk about, clarify about those kinds of things. So that was the only preparation.

Another faculty stated that,

I wanted to make sure that there was a connection of what was going to take place. I figured out where I could highlight on that side of the lightboard rather than just have the first passive approach, which would be to just display a PowerPoint presentation with the animations of the PowerPoint presentation, but enable them to see my enthusiasm and my interest in highlighting the features on those slides. I think the one thing to make sure of was just to not to not just talk at the students, so I don't want it to be a video like you watch a YouTube video. I wanted them to see the action of writing and what those pieces I wanted to emphasize in the video. Okay, So, but I also did want to just transcribe and stuff that they would be able to read in a different document either, right? I didn't even want to write down what the distribution of homework scores were and all of that if there's another document that they have no reason to write up on the lightboard. I guess that's what I'm trying to say.

A Wider Writing Space with A Marked Boundary for Writing Will Be Helpful

One of the difficulties that the majority of the faculty members addressed was that, on occasion, they felt as though there wasn't enough room to write, particularly when they were coming up with logical solutions. Additionally, as they saw that writing on the margins was not recorded, an explicit boundary stating that writing beyond that will not be recorded will be very helpful. In this regard, I quote one of the faculty’s remark,

I thought the board space was not sufficient. Okay, for my course, because it requires a lot of writing equations. Okay. And drawing pictures. Right. Okay. So when I go to the classroom here, you know, how wide these whiteboards are, I start from one corner, and then I go all the way to the other corner or something? Yeah, it is more organized that way. I don't have to keep erasing anything. Yeah, right here we have to finish one formulation and then I cannot show what is in common between the two formulations. I understand what is right. So I erase it before I start writing the next. So you cannot put it side by side. It seems the space is limited. Space is definitely limited.
Real Time Modification Facilities

One other theme that emerged from the interviews was the suggestion that the existence of real-time modification facilities would have been beneficial. Faculty complained about how annoying it was to have to rerecord if they needed to add or edit anything, or if they missed parts of what they intended to record. They were constantly aware of the fact they could not make changes while recording and the only option was to re-record. One of the faculty members commented:

I think having kind of a pseudo real time editing mechanism so that if I talk for 15 minutes, and somewhere in there, there's three minutes in the middle that were lousy and not beneficial. Is there a way to take the kind of note that I want to go into the video editing challenges? I mean, I know that that's that itself. Yeah, but if there was a way to kind of put slices in it and say hey, this was bad and drop in and lightboard are for whatever that kind of video editing technology. If there's something that automatically says it's a transition that's taking place or here's a correction that's taking place.

Additional Software Integration

Faculty participants also suggested some software integration that would facilitate recording lightboard videos. It was advised to use digital writing and wiping off capabilities since this would solve problems with legible handwriting, color selection for writing, and—most importantly—faster erasing. While one teacher argued for software integration to make it easy to display related documents, another suggested having the option to toggle between showing and hiding the faculty's appearance. One faculty remarked,

I cannot easily erase them and how they erase them if there is no like you erase the entire page or some more smartboard way to just press a key and it erases everything. If it can be like a transparent screen with touch and stylus pen, then I can write it down digitally. And then I can easily digitally wipe them out or store it for later use right if I want to come back.
Another faculty supplemented it by saying,

I don't want my face to be in the video all the time. I understand. So if there is a way we can stop the video of myself, but more on the writing part. And I can come and go whenever it is needed. Yeah. So let's assume I'm talking about a machining operation. Okay, I'm showing a machine which is cutting some parts. So I can show the picture. And then I can point out, hey, here is the tool that is cutting here is the raw material that is being cut. Here is a router that is spinning, so that you can point and then at the time when you see my face, you can see my hand gestures, you can see how I'm drawing and pointing things. Okay, so the equation, right, you don't need to see the faculty’s face because they're just as you can see, for some time, but not for the entire time. Students need to be more focused on the equation, not on the faculty’s face.

Another faculty expressed his concerns:

I think right now is probably the most urgent need for me is there is no good software that actually pairs with the lightboard. So it's like you open it, open a document and you can view it. You can just present it as a screen but there is no software that is specifically designed for the lightboard video that allows you to easily display the document you have and combine that with your writing.

Lightboard Videos Will Help Students to be Engaged in Studies

Faculty participants were of the opinion that lightboard videos have the potential to help students to be engaged in studies. The dark background of lightboard videos along with fluorescent colors for writing made the videos captivating and consequently helped students focus on the study content. One of the faculty members remarked:

So the first thing I noticed is that the lightboard has a dark background and only the faculty is being highlighted. I think this is, this setup will help the learners to focus. And when I first had, when I first saw the lightboard videos, the other thing that attracted me were those glowing colors.

Another faculty was overwhelmed with the technology and expressed himself as follows,

“If this is the tool that we can use to retain our students, if this isn't the tool that we can use to
engage our students, then we should use positive resources.” A similar sentiment was shared by another faculty:

It takes time to change into that new stuff, but it's going to engage the students in a much more effective manner. So I'm thoroughly supportive, it's just, you need people that are willing to do it in the right kind of nuggets that students can eat. consumed, I should say, right, the truth. You can give a student a full chicken. They're not going to know how to eat it. You give it to him and nuggets and they'll eat it, right? And I would say that a lightboard would be one of those mechanisms that students, sorry the faculty, could see what level of engagement that students are getting out of it.

Faculty’s Body Gesture and Facial Expression Will Help Students to Follow

The faculty participants stated that their body language and facial expressions made it easier for the students to follow the material and, as a result, increased their level of study engagement. One really special aspect was being able to view the faculty's face while they were writing. As a result, the students felt a stronger connection when watching the lightboard videos, which allowed them to concentrate more during their studies. One faculty commented,

I think being able to see the faculty’s face while he or she is writing is very cool. I think that itself will help them focus because we do a lot of derivation, but we don't. We can look at the student and Turn around, turn around a lot. And then that kind of disrupts the teaching flow.

Corroborating the fact, another faculty stated,

The thing I like the best about the lightboard is the interaction. It can record my upper body gesture and my facial emotion. So that way when the learners are viewing this video or participating it online, then they can know they can have a better connection, which means I think that is so they can focus more. They can focus more on learning instead of listening to boring audios and looking at a bunch of static text. They can actually follow you, they can follow me better.

Same sentiment was shared by another faculty:

I am seriously considering, wouldn't it be more efficient and more effective for them to see me solve it in real time? Yeah, with the lightboard rather than because what happens
is, you look, you look at a page and you look oh, there's just everything there. It is what it is, but if they could see it happening in sequence, yeah. In their solution, yeah. Then I think that that's where it would be a benefit. And then the students would know that when they're doing their own solutions. It doesn't just all land on the page as a solution. There has to be this kind of sequencing in it in some manner.

Lightboard Videos Offer a Traditional Classroom Experience

For students, the lightboard videos provided a classic classroom experience. Faculty noticed that the lightboard videos resembled in-person instruction; students could follow along more easily because they could see and hear the faculty, as well as feel as though they were having a face-to-face conversation while the faculty demonstrated concepts or procedures in front of them. According to one faculty,

They can actually follow you, they can follow me better. And also they can follow me better because it looks like we're talking face to face. Yeah, those are the bodies faster than everything. And they can have easy access to the note that was my handwritten note.

Another faculty confirmed the opinion,

I think certainly its students can see and listen to your lecture through your face, like, you know, at least they can see your facial expression and they can see you show them those concepts or procedures in front of them. So that's good because if you think about it, right if you talk to someone Turn around, turn their back to you. You feel okay, maybe he's not talking to me or He's like, he's so face to face, right. So smooth and more energy for the students are focusing right, right, right.

He added,

Just a traditional classroom. You can use objects right? I mean, live objects, okay. Or some part objects. Okay. That you can Yeah, yes, it's more engaging because for example, you have a lightning ball, you know, they can move to simulate the trajectory of a projectile or like some bouncing the motion of the object.
Summary of Findings for Research Question 2

All of the faculty participants were teaching various courses for college of engineering and for several years. The majority of them viewed lightboard videos on YouTube and mostly prepared their materials for the recording so that the vital aspects are not lost when filming. This is how they prepared or approached making lightboard videos. They had PowerPoint, PDF, and Word documents with their important points printed on hand. When the faculty were asked for any improvement suggestions to the lightboard video experience to make it easier for the faculty to use the technology, the most common response was that there should be a marked boundary on the glass board suggesting not to write on the other side of it indicating that beyond this point it will not be shown in the recording. In addition, they recommended a wider space for writing. It was also mentioned that it would have been better if there were some kind of real time modification facilities provided. In addition, one of the faculty suggested that if digital writing and wiping off facilities can be included it will benefit the recording by providing desired writing color, fonts, font size and not wasting time while wiping off. Other recommendations were, software integration for easier display of other integrated documents, and switching on and off between showing and not showing the presenter’s image while recording the lightboard videos. Faculty members felt that these lightboard videos will help in maintaining learners' engagement. According to them, attractive visuals accompanied with the presenters’ body gesture and facial expression will help engineering students stay engaged in their studies, the videos will help the student pay more attention towards the contents. Moreover, it will make contents easier to understand for the engineering students and mimicking the traditional classroom experience of instructing facing towards the audience will help students follow the content easily.
Analysis of Research Question 3

Research Question 3: How do engineering students perceive the use of video course materials created with lightboard technology would aid in student learning engagement?

In order to answer this question, responses were collected and analyzed from the student participants from four short answer questions of part 2 of Appendix A. More context for the Likert scale numerical data was provided by the student short answer data. The short answers revealed a broad spectrum of viewpoints. The following thematic categories were produced by looking at the participant responses.

1. Learning with attractive engaging visuals
2. Faculty’s body gestures and facial expression helped following the content
3. Imitated traditional classroom
4. Made content easier to visualize
5. The lightboard videos were interactive
6. The writing was sometimes illegible
7. Sometimes the presenter’s image created distraction for the writing part
8. Pragmatic use of color contrast
9. Short duration videos are more useful
10. Lightboard videos helped in better understanding of the course content

Learning with Attractive Engaging Visuals

The way the text covered the faculty and the dark background with vibrantly colored writing delighted the students. They thought the notes were insanely clear and easy on the eyes.
They said the videos were aesthetically pleasing, easy to follow, basic and not overly complicated, and visually engaging. One student commented, “Simple and not distracting. It was aesthetically pleasing and easy to follow”. Sharing the same sentiment, another student remarked, “I enjoy the dark background with light writing, it’s easy on the eyes”. Another student was more specific and noted, “Visually it was good and the videos were engaging”. Corroborating the fact another student stated, “Engaging learning experience helps knowledge retention”.

Faculty’s Body Gestures and Facial Expression Helped Following the Content

Students reported that following the material was made easier by the lightboard videos' aesthetics and the ability to simultaneously see the faculty's writing and body language. The students found it interesting to observe both their faculty and his work at the same time. It was useful to see the faculty's reactions when they could see what he was actually pointing at and writing. One of the students remarked, “The aesthetics and ability to see the speaker’s body language and writing at the same time”. Consistent with the opinion, another student commented, “Seeing the writing and the professor, better than staring at their back”. Another student added, “You can see the teacher as well as his hand writing at the same time”. The expression of another student was, “You can see how the faculty reacts”,

Imitated Traditional Classroom

Despite the fact that the content was pre-recorded, the students claimed to have felt as though they were participating in a synchronous course. Compared to watching slides with
voiceover recordings, the lightboard videos were more like attending classes in person and helped the students focus on the subject. The feature that allowed students to see the material and hear the faculty just like in a traditional classroom setting was well-received by them. One student exclaimed, “Feels like you are engaged in a synchronous course even though the material was prerecorded”. Another student highlighted, “The lightboard videos helped me to concentrate on the topic because they were very similar to taking classes in-person as compared to watching slides with voiceover recordings”. Sharing a similar belief another student noted, “I liked being able to see the information while still being able to see and hear the professor. The video felt like being in class when I wasn’t”. This opinion was confirmed by another student also by stating, “I enjoyed the replication of a classroom setting. Seeing the professor and what he is physically pointing at and writing is helpful”.

Made Content Easier to Visualize

Students found that watching lightboard videos made things easier to visualize. It was simpler to comprehend the subject after the professor's screen was effectively projected onto the board before annotations. It was easier to see and understand and more captivating to watch. One of the students remarked, “It was easy to visualize the content and understand the concepts”. Consistent with the view, another student expressed, “It was more engaging to watch, easy to see/understand”. Sharing a similar sentiment, another student commented, “lightboard videos appeared very lively. Also, these videos helped me to understand concepts better as compared to other types of live video lectures I attended earlier”.
The Lightboard Videos Were Interactive

Students expressed appreciation for the interactive nature of the video and the inventiveness of the lightboard technology. They found lightboard videos to be highly intriguing, and the interactive format made learning more engaging. A student remarked, “I liked the creativity behind the video and how interactive it was. It was engaging to see my professor and his work at the same time”. Corroborating the fact another student stated, “Interactive format to my learning experience”.

Writing Was Sometimes Illegible

Students discovered that, for a variety of reasons, the writing in the lightboard videos was occasionally unreadable. There were instances where the handwriting wasn't clear enough, the font shade was too light, some equations written at the end were not visible, and the font color wasn't appropriate for the background. Additionally, at times, the professor's light-colored shirt obscured some of the words, making it challenging to read. One student highlighted the fact, “The markers need to be more legible on the board, sometimes it is hard to see the content. The font shade was light.” Sharing the same opinion, another student stated, “The writing on the board was hard to read at points, the font color should be appropriate to the background”. A different point was mentioned by some students, “Some equations written at the end were not visible”. Another student mentioned, “The board handwriting wasn’t clear enough” and “It was difficult to read some of the words due to the professor’s light colored shirt behind the light colored markers”.

Sometimes The Presenter’s Image Created Distraction for The Writing Part

Students' opinions also revealed another theme: occasionally, the presenter's image distracted them from the writing portion. Certain texts don't appear because of an uneven background because the person writing on the lightboard is behind the text. When the professor is standing behind the words, it can occasionally be difficult to read what was written. I quote one of the students, “When staff teaches the letters are being hided”. Supporting the view, another student stated, “Because of the person writing on the lightboard is behind the text, some texts don’t appear due to inconsistent background”. Same sentiment was shared by another student, “At times it can be hard to see what was written when the professor is standing behind the words”.

Pragmatic Use of Color Contrast

As the students watched the lightboard videos, they came to understand that a practical decision about color contrast was required. The marker color should be carefully chosen so that it contrasts with the background, doesn't blend in with the presenter's outfit, and is not too light. One of the students cautioned, “Do not neglect contrast between background, which includes the speaker, and the writing”. Another student mirrored the opinion by stating, “Ask the professor to not use a colored marker that is similar to their shirt, or else it blends in”. In a similar sentiment, another student remarked, “Make the professors wear darker colors to contrast the text on the board, just like the background”. Another student mentioned, “Improve contrast and consistency of marker markings”.
Short Duration Videos Are More Useful

Students requested for short duration videos. According to the students' opinion, make videos short and interesting, break up videos into smaller segments if necessary as short videos help in retaining knowledge. One of the students commented, “Make videos short and interesting”. Consistent with the view, another student noted, “Keep it short and split them into parts based on concept”. Another student stated, “Keep videos short & simple but descriptive as short videos help to retain information”.

Lightboard Videos Helped Students in Better Understanding of the Course Content

The students claimed that because the lightboard videos built up the concepts and improved their comprehension of the subject, they were able to learn the material very quickly and with ease. Through interactive exercises, Lightboard could aid in improving their understanding of the material. According to one student, “It can help me understand the topics which I may have missed in the class. It is certainly better than just viewing presentation slides with sound.” Another student commented, “It can help to make me learn the content really quickly and the concepts get registered in mind easily.” Another student stated, “It will be going to help me build up concepts and better understanding of the subject.” A similar sentiment was shared by another student, “If technical drawings are involved, it would likely be easier to see, understand, and replicate”.

These views were further supported by the themes generated while analyzing research question 1.

1. Lightboard Videos Helped in Understanding the Course content
2. Lightboard videos were engaging

3. Lightboard videos facilitated learning satisfaction

**Lightboard Videos Helped in Understanding the Course content**

The engineering students who participated in the study reported that watching and understanding the lightboard videos was easy. They believed that the course material was easier for them to visualize thanks to the lightboard videos. The students were also helped by the lightboard videos to identify the key concepts in the content. Students also reported that their comprehension was enhanced by having handwritten notes for the lightboard videos. Overall, the lightboard videos improved their comprehension.

**Lightboard Videos Were Engaging**

Because the lightboard videos were interactive, the engineering students who participated in the study reported that it was easier to pay attention and understand the course material. They thought that watching the lightboard videos was a worthwhile use of their time and that the video was of a suitable length. Students thought it was a good idea to use lightboard technology to get them involved in the learning process. Overall, watching lightboard videos was an engaging experience for the engineering students.

**Lightboard Videos Facilitated Learning Satisfaction**

Engineering students were intrigued and stimulated by the lightboard videos. They believed that lightboard technology is an effective teaching tool and that the technology in the
video looked fascinating. The engineering students gave the lightboard videos a positive overall review and recommended them.

**Summary of Findings for Research Question 3**

The lightboard videos received overwhelmingly positive feedback from the students. The faculty’s body language and facial expressions helped students follow the lecture material, imitated typical classroom settings, made the material simpler to understand, and the videos were interactive, in their opinion. They also claimed that the videos were engaging and learning with attractive images. Summarizing the replies on what they disliked about lightboard videos, this study discovered that the writing was occasionally unreadable due to issues with the markers' ink quality, color blending that affected contrast, font size, and the writing itself. The students also objected to the presenter's appearance occasionally detracting from the writing portion. Their responses regarding how to make the lightboard videos better may be summed up as: use a contrasting color so that the presenter's clothes and the background do not clash; and propose making the videos shorter. When the student responses to the subject of how these lightboard videos can aid in their academic learning were studied, primarily two points of view emerged. They were able to comprehend the course material more clearly because of the lightboard videos, which also made learning new things simple. According to the Likert-scale responses, the lightboard movies were simple for engineering students to watch and helped them visualize the content, which facilitated their knowledge of the topic. Additionally, while making the lightboard videos, the teachers made handwritten notes that helped them identify the key concepts of the lesson. Students also recognized that using videos made using lightboard
technology is an effective technique for engaging them in the learning process by making it simpler for them to pay attention to the material. They also thought that the lightboard technology was very methodical in producing attractive video materials that were helpful for learning.

**Analysis of Research Question 4**

Research Question 4: How does student survey data and faculty interview data help understand the use or effectiveness of video course materials created with lightboard technology?

In order to answer this question, responses were collected and analyzed from the student participants from four short answer questions of part 2 of Appendix A and from eight Likert-scale questions, Q 2, Q 3, Q 5, Q 6, Q 9, Q 10, Q 11, and Q 13 of part 1 of Appendix A. Also, responses were collected and analyzed from five faculty participants on 4 questions (Q 5, Q 6, Q 7, and Q 8) from Appendix B (open ended interview questionnaire for faculty). To keep their identity confidential, this analysis used pseudonyms.

A wide range of opinions were reflected while analyzing both quantitative and qualitative data on engineering students’ perceptions of learning engagement with lightboard videos and how the engineering students perceive the application of lightboard videos would facilitate their learning engagement while analyzing research questions 1 and 3. The following themes were generated from the student participants’ responses.

1. Learning with attractive engaging visuals

2. Lightboard videos were engaging

3. Faculty’s body gestures and facial expression helped following the content
4. Imitated traditional classroom
5. Made content easier to visualize
6. The lightboard videos were interactive
7. The writing was sometimes illegible
8. Sometimes the presenter’s image created distraction for the writing part
9. Pragmatic use of color contrast
10. Short duration videos are more useful
11. Lightboard videos helped in better understanding of the course content

**Learning with Attractive Engaging Visuals**

The students were enthralled with the way the text covered the teacher and the dark background while the writing was brightly colored. They found the notes to be incredibly lucid and easy to read. They described the videos as attractive, basic and not unduly complex, aesthetically pleasing, and easy to follow.

**Lightboard Videos Were Engaging**

The engineering students who took part in the study said that it was simpler to stay engaged and comprehend the subject matter because the lightboard videos were interactive. They believed that watching the lightboard videos was a good use of their time and that the duration of the video was appropriate. Students felt that using lightboard technology to involve them in the learning process was a good idea. For the engineering students, watching lightboard videos was an engaging experience overall.
Faculty’s Body Gestures and Facial Expression Helped Following the Content

Students said that being able to simultaneously see the faculty's writing and body language in the lightboard videos, along with their attractiveness visually, made the material easier to follow. It was fascinating for the students to watch their faculty at work when they could actually see what he was writing and pointing at was helpful.

Imitated Traditional Classroom

The students stated that they felt as though they were taking a synchronous course, even though the material was pre-recorded. The lightboard videos helped the students focus on the material and were more like attending classes in person than watching slides with voiceover recordings.

Made Content Easier to Visualize

Students discovered that visualizing concepts became simpler after watching lightboard videos. After the professor's screen was successfully projected onto the board prior to annotations, the subject was easier to understand. It was more engaging to watch and simpler to see and comprehend.

The Lightboard Videos Were Interactive

Students conveyed gratitude for the video's interactive features and the lightboard technology's creative application. The interactive format of lightboard videos enhanced the learning experience and piqued their curiosity.
Writing Was Sometimes Illegible

Students found that the writing in the lightboard videos was sometimes unreadable for a variety of reasons. There were times when the background color of the font didn't go well with it, the handwriting wasn't clear enough, the font shade was too light, and some equations written at the end couldn't be seen. In addition, it was occasionally difficult to read some of the words because of the professor's light-colored shirt.

Sometimes The Presenter’s Image Created Distraction for The Writing Part

Another theme that emerged from the students' opinions was that sometimes they were distracted from the writing part by the presenter's image. Some texts are obscured by a sloppy background because the writer is behind the text on the lightboard.

Pragmatic Use of Color Contrast

The students realized that a practical choice regarding color contrast was necessary as they watched the lightboard videos. It's important to choose the marker color carefully so that it stands out against the background, doesn't match the presenter's attire, and isn't too light.

Short Duration Videos Are More Useful

Students sought to watch short videos. Students believe that short, engaging videos are the best way to retain information. If needed, longer videos can be divided into smaller segments.
Lightboard Videos Helped Them in Better Understanding of the Course Content

The students stated that they were able to pick up the material quickly and easily because the lightboard videos helped them understand the material better and built up the concepts. Lightboard could help through interactive exercises that improve their comprehension of the subject matter.

Similar to this, a variety of viewpoints were gathered during the analysis of the faculty interview data in order to address the faculty’s opinions regarding the use of lightboard videos to support students' learning engagement for research question 2. These are the themes that were developed.

1. No preparation required, only organize key points for the recording
2. A wider writing space with a marked boundary for writing will be helpful
3. Real time modification facilities
4. Additional software integration
5. Lightboard videos will help students to be engaged in studies
6. Faculty’s body gesture and facial expression will help students to follow
7. Lightboard videos offer a traditional classroom experience

No Preparation Required, Only Organize Key Points for The Recording

According to the faculty members, there was no additional planning required before starting the lightboard video recording. Most of them admitted to watching YouTube videos on lightboard and to having mostly prepared their material ahead of time to make sure important details weren't missed.
A Wider Writing Space with A Marked Boundary for Writing Will Be Helpful

One issue that most of the faculty members discussed was that sometimes they felt like there wasn't enough space to write, especially when they were formulating logical answers. An explicit boundary indicating that writing beyond that will not be recorded will also be very helpful, as they noticed that writing on the margins was not being recorded.

Real Time Modification Facilities

The idea that it would have been advantageous to have real-time modification facilities was another theme that surfaced from the interviews. Faculty expressed their annoyance at having to start over whenever they missed recording something important or needed to make edits. They knew all the time that they could not edit while they were recording and that they had to start over.

Additional Software Integration

Faculty also proposed integrating some software to make lightboard video recording easier. The recommendation was to utilize the digital writing and wiping off features, as this would address issues with readable handwriting, writing color selection, and—most importantly—quicker erasure. A teacher advocated for software integration to facilitate the display of related documents, while another proposed having a toggle feature to reveal or conceal the faculty's appearance.
Lightboard Videos Will Help Students to be Engaged in Studies

Faculty members who took part in the interview thought that using lightboard videos could encourage students to be engaged in education. Lightboard videos' fluorescent writing colors and dark backgrounds made them attractive to the eye, which in turn helped students concentrate on the material being studied.

Faculty’s Body Gesture and Facial Expression Will Help Students to Follow

The faculty participants reported that their facial expressions and body language enhanced the students' level of study engagement by making it simpler for the students to understand the material. Being able to see the faculty's face while they were writing was one extremely unique feature. As a result, when watching the lightboard videos, the students felt more connected, which improved their ability to engage while studying.

Lightboard Videos Offer a Traditional Classroom Experience

The lightboard videos gave the students a traditional classroom experience. Faculty observed that students could follow along more easily because they could see and hear the faculty, and they felt as though they were having a face-to-face conversation as the faculty demonstrated concepts or procedures in front of them.

An additional theme was generated when the faculty members were asked for their opinion on lightboard technology and lightboard videos.
Presenter’s Image Sometimes Creates Distraction for The Students

One of the faculty members cautioned that he felt that occasionally, the presenter’s image can create a distraction for the students from going through the writing. I quote him in this regard, “So it appears right, you're writing like this, although they're seeing it properly. But it is kind of distracting sometimes to the students. Not to me when I was writing on the board. Yeah, see what you're seeing first.”

For easy glancing through the results a joint display of results is provided in Table 9 below for both quantitative and qualitative data collected and analyzed from the students, and qualitative data collected from the faculty.

Summary of Findings for Research Question 4

In analyzing the findings corresponding to research question 4 it was observed that students found the lightboard videos easy to watch and understand. It helped learning different things easily by identifying major points and helped in visualizing the content. The technology is attractive and an effective tool for learning, an appropriate way to engage students. Faculty’s body gestures, handwritten notations, and facial expression helped thereby make it easier to pay attention. It imitates traditional classrooms. Students also showed concern over the fact that the faculty’s image sometimes creates distraction. They suggested shorter length videos and use of appropriate contrasting colors. Likewise, faculty members found that the lightboard videos made content easier to understand, the attractive display helped in student engagement. It helped students focus more on study. Faculty’s body gesture and facial expression helped students follow the steps. It replicated traditional classroom experience. They also cautioned that the presenter’s image sometimes creates a distraction for students. They also mentioned that it requires carefully selected contrast colors. They disliked the fact that the writing space is limited
Table 10

Joint Display of Results

<table>
<thead>
<tr>
<th>Student Quantitative Findings</th>
<th>Student Qualitative Findings</th>
<th>Faculty Qualitative Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to watch and understand.</td>
<td>Help in better understanding of course content.</td>
<td>Makes content easier to understand.</td>
</tr>
<tr>
<td>Helped identify major points.</td>
<td>Learning different things is easy.</td>
<td>Attractive display helps in student engagement.</td>
</tr>
<tr>
<td>Effective tool for learning.</td>
<td>Learning with attractive visuals.</td>
<td>It helps students focus more on study.</td>
</tr>
<tr>
<td>Helped visualize the content.</td>
<td>Engaging.</td>
<td>Faculty’s body gesture and facial expression help students follow the steps.</td>
</tr>
<tr>
<td>An appropriate way to engage students.</td>
<td>Faculty’s body gestures and facial expression helps.</td>
<td></td>
</tr>
<tr>
<td>Video is interesting and stimulating.</td>
<td>Imitates traditional classrooms.</td>
<td>Replicates traditional classroom experience.</td>
</tr>
<tr>
<td>Attractive technology.</td>
<td>Interactive.</td>
<td></td>
</tr>
<tr>
<td>Handwritten notations helped.</td>
<td>Interactive.</td>
<td></td>
</tr>
<tr>
<td>Interactive, made it easier to pay attention.</td>
<td>Faculty’s image sometimes creates distraction.</td>
<td>Presenter’s image sometimes creates a distraction for students.</td>
</tr>
<tr>
<td>Make shorter length videos.</td>
<td>Use contrasting colors.</td>
<td>Smaller videos.</td>
</tr>
<tr>
<td>Use contrasting colors.</td>
<td>Illegible writing due to certain reasons.</td>
<td>Requires carefully selected contrast colors.</td>
</tr>
<tr>
<td>Illegible writing due to certain reasons.</td>
<td>Needs wider writing space.</td>
<td>Limited writing space.</td>
</tr>
<tr>
<td>Needs wider writing space.</td>
<td></td>
<td>No marked boundary.</td>
</tr>
</tbody>
</table>

Digital write and wipe. |

Difficult to erase. |

Easy to use. |

Organize required staff before recording.
and there was no marked boundary. They also suggested real time modification, digital write and wipe facilities.

This study set out to investigate how engineering students' engagement with their studies is impacted by the use of multimedia-based, cutting-edge video course materials. According to prior research, engineering students' learning engagement is a prerequisite for effective learning and that engagement can be positively improved by interventions like video course materials. This project used the lightboard technology tool to create state-of-the-art video course materials for a few engineering courses before integrating them into the curriculum for students to accomplish these aims. This study aims to investigate how lightboard videos affect engineering students' engagement for learning. In chapter 5, the research's findings will be further discussed.
CHAPTER 5. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

The goal of this mixed-methods case study was to examine the potential of lightboard videos for enhancing engineering students' learning engagement. According to earlier studies, interventions like video course materials can have a positive impact on engagement (Babich & Mavrommatis, 2004; Cadena et al., 2019; Felder et al., 2000; Fung, 2017; Gudimetla & Lyre, 2006; Liarokapis et al., 2004). A growing number of academics argue that delivering video lectures using a variety of media is an effective educational strategy that may enhance student learning, satisfaction, engagement, and interest (VanderMolen et al., 2018). Accordingly, this research employed lightboard technology to create advanced multimedia course material and investigated the perceptions of engineering students on the lightboard videos on their learning engagement. The lightboard has become more prevalent on campuses all around the world in recent years due to how convenient it is for the faculty to be in the video. Naturally, concerns are raised about how this technology and the most effective pedagogical techniques might affect the learning engagement of engineering students. The need has been identified, but a void is still noticed that application of high quality video material to improve the learning engagement of engineering students has limited application in engineering education.

This research study was guided by four main research questions, each of which are addressed in more detail below. This study's main objective was to assess how "video course
material created with lightboard technology” (lightboard videos) affected engineering students' engagement into study. The anonymous in-class student perception survey on the lightboard (Appendix A), which collected both quantitative and qualitative data, included 191 engineering students from five engineering classes where the lightboard videos were incorporated as part of the curriculum. Additionally, the corresponding five engineering faculty members took part in in-person interviews (Appendix B), which involved semi-structured open-ended questions about lightboard videos. To identify emerging themes, all the data gathered from engineering students and faculty was examined, evaluated, and coded. Findings were strengthened and validated with the help of the triangulation of data from various sources, such as transcripts, comparisons of qualitative and quantitative data gleaned from surveys, interview questions, and reviewer notes in conjunction with member checks of transcribed interviews.

Discussion of Research Questions and Findings

Discussion of Research Question 1

Research Question 1: What are engineering students’ perceptions of learning engagement with video course materials created with lightboard technology?

Student data analysis for this research related to the first research question to investigate the perceptions of engineering students on lightboard videos on their learning engagement was especially encouraging because it suggested that students strongly agreed that the lightboard videos improved their understanding, engagement and satisfaction. The lightboard videos appeared to be well-liked by students, who also expressed a desire to see more of them in
engineering courses and to recommend them to their friends. Three major themes emerged from the findings of my research.

**Lightboard Videos Helped in Understanding the Course content**

My research observed that the engineering students found it simple to watch the lightboard videos, which also assisted them in visualizing the material and improving their understanding of the subject. Additionally, according to my student participants, while making the lightboard videos, the faculty made handwritten notes that helped them identify the key ideas of the lesson. In general, their understanding was enhanced by the lightboard videos. This is consistent with several earlier research findings that found that the main advantage with lightboard videos was that the faculty is facing the class while writing on the board, allowing the students to see facial expressions or even read lips or watching faculty actively working through a procedure, equation, or sketch and thereby created a sense of enhanced key concept and emphasis identification and understanding (Malyutina et al., 2021; McCorkle & Whitener, 2020; Rosasco, 2018).

**Lightboard Videos Were Engaging**

Student participants for my research realized that lightboard videos effectively engaged them in the learning process by making the material easier to pay attention to. Students believed that watching those brief lightboard videos meant efficiently using their time. They also thought that the lightboard technology was very methodical in producing engaging video contents that were helpful for learning. Earlier research also reported that students felt engaged and connected;
the learning environment created while using a lightboard, a faculty is recorded "facing" the camera who has the option to use gestures with the writing glows in sharp contrast, giving the impression that they are speaking to the remote, asynchronous students who access the lesson as a lecture captured video, fosters strong student-to-content and student-to-faculty engagement (Birdwell & Peshkin, 2015; Lubrick et al., 2019; VanderMolen et al., 2018; Ye, 2016).

**Lightboard Videos Facilitated Learning Satisfaction**

The lightboard videos sparked the curiosity and stimulation of the engineering student participants for my research. They thought the technology in the video looked intriguing and that lightboard technology is a useful teaching tool. Students raved about how much they enjoyed the lightboard videos and expressed a desire for more to be added for both the relevant course and other engineering courses. This view supported research finding by Rogers (2019) who investigated the impact of lightboard videos on student learning and perceptions and observed that students demonstrated a clear preference for lightboard videos in terms of learning satisfaction. Some other researchers observed that the lightboard videos were more interactive and interesting than typical online course videos (Ye, 2016) and that writing "in the air" with the markers’ neon lighting effect forges a powerful visual connection with the viewer (Malyutina et al., 2021).

Evidently, engineering students’ perceptions of learning engagement were in strong favor with video course materials created with lightboard technology. Analysis of student data for this research found that according to the students, the lightboard videos were easy to watch and understand; it helped them in identifying the major points and visualizing the content; the
technology made the videos interesting, stimulating, and engaging; and the handwritten notations and the interactive nature of the videos made it easier for the engineering students to pay attention.

Discussion of Research Question 2

Research Question 2: How do engineering faculty perceive the use of video course materials created with lightboard technology would aid in student learning engagement?

Engineering faculty participants for this research perceived that the use of video course materials created with lightboard technology would aid student learning engagement by making the content easier to understand, attractive display will help students to focus more on study, faculty’s body gesture and facial expression will facilitate in following the content for the students, and by replicating a traditional classroom experience. The themes generated by this research were summarized and depicted below to facilitate a consensus discussion on faculty’s perceived views on lightboard videos in benefitting engineering students’ engagement for learning.

Lightboard Videos Offer a Traditional Classroom Experience

My research found that according to the faculty participants, the lightboard videos provided students a traditional classroom experience. Faculty observed that students could follow along more easily because they could see and hear the faculty, and students felt as though they were having a face-to-face conversation as the faculty demonstrated concepts or procedures in front of them. This is because the lightboard videos mimicked in-person instruction. Earlier
research also found that because the presenter doesn't have to turn away from the camera, they can always maintain eye contact with the audience (or the camera), the presenter was able to deliver a presentation that is more fluid and natural with lightboard videos (Birdwell & Peshkin, 2015; Malyutina et al., 2021; VanderMolen et al., 2018; Ye, 2016) and that created an environment that is very simple and focused on teaching, simulating the traditional chalkboard or whiteboard setup and enabling online viewers to maintain eye contact with the faculty (McCorkle & Whitener, 2020; Rosasco, 2018). Technology helped in creating an impression of a recorded video that looked like an on-site course. By being able to speak and provide explanations with visual aids while using the lightboard, the lecturer can maintain an even closer connection with the students.

Faculty’s Body Gesture and Facial Expression Helps in Following the Content

The faculty participants for my research said that their facial expressions and body language enhanced the students' level of study engagement by making it simpler for the students to follow the content and understand the topic. Being able to see the faculty's face as they were writing was one extremely unique feature of lightboard videos. As a result, when watching the lightboard videos, the students felt more connected, which improved their ability to focus while studying. Earlier researches also observed that lightboard videos had an advantage over recording a traditional blackboard lecture, where the lecturer's hands and face are frequently hidden and students only see the end result rather than the actual process (Malyutina et al., 2021; Peshkin, n.d.). The lecturer can "talk with his hands" when using a lightboard (Peshkin, n.d.) and by being able to talk and demonstrate with visual aids, while also making gestures or pointing
out specific areas of the board with hands and using body language, the lecturer can maintain closer contact with the students while using the lightboard (Malyutina et al., 2021).

**Lightboard Videos Facilitate Students’ Learning Engagement**

For my research, faculty participants indicated that lightboard videos could encourage students to be engaged in their studies. Students were able to concentrate on the study material because of the lightboard videos' recording of the presenter facing the audience along with the dark background and use of neon colors for writing that makes a visually captivating learning environment. According to earlier research also, the learning environment created by light board videos promoted significant student engagement with the curriculum and with faculty because the faculty was recorded "facing" the camera when using a lightboard, giving a sense that they are talking to the distant, asynchronous students who gain access to the material as a faculty recorded video after the fact (Birdwell & Peshkin, 2015; VanderMolen et al., 2018), making the lightboard videos more engaging and interactive (Ye, 2016).

**No Preparation Required, Integration of Other Tools Are Easier with Lightboard Videos**

According to the faculty participants for my research, creating a lightboard video was really easier, it required no training, and it seamlessly integrated their documents while recording the video. Birdwell and Peshkin (2015) also advocated that real-time graphic integration with the lightboard camera stream was possible using sources like PowerPoint slides, close-up video of an experiment or demonstration, or content from a personal computer.
**Limited Space for Writing Without Any Marked Boundary**

One issue that the majority of the faculty participants for my research highlighted was that sometimes they felt like there wasn't enough space to write, especially when they were formulating logical answers as required to show the continuation from the earlier stages of the solution. According to them, it was difficult to make use of the available space even with a well-crafted document in hand. Fung (2017) also recommended before one start recording, have a script in mind for the lessons that will be covered in the video. Consider writing on a whiteboard to determine how large the writing should be. Moreover, because only a portion of the glass board will be captured by the camera, pay attention to its bounded area.

**Real Time Modification Facilities**

This study discovered that according to most of the faculty participants, it would have been preferable if real-time modification facilities had been offered because it was annoying for them if they needed to modify or edit the part that is already recorded. However, earlier research recommended being prepared with a well-scripted document before recording lightboard videos.

**Additional Software Integration**

Faculty participants also suggested some external software integration that they believed to be for the betterment of the lightboard videos. If digital writing and wiping off capabilities can be added, one of the faculty members suggested, it will benefit the recording by offering desired writing color, fonts, and font size and not wasting time while wiping off. This researcher is of the opinion that adding a digital writing facility will wipe off the essence of lightboard videos that it
mimics traditional classroom experience and students will lose interest. Software integration to facilitate the display of other integrated documents was also advised, as was the ability to toggle between showing and hiding the presenter's image when recording lightboard videos. Personally, I believe those will not bring out any significant difference, rather, it might hamper the engaging quality of lightboard videos.

It can be concluded that the lightboard videos, according to faculty, will aid in sustaining engagement among students. They assert that engaging visuals combined with the presenter's body language and facial expression will keep engineering students engaged with their studies and that watching videos will help them focus more on the subject matter. Additionally, it will make the content simpler for engineering students to understand. Furthermore, mimicking the traditional classroom experience of instructing facing towards the audience will help students follow the content easily. The most frequent response from faculty members when asked for improvement ideas for the lightboard video experience to make it simpler for the faculty to use the technology was that there should be a boundary marked on the glass board to discourage writing on the other side of it and indicate that writing beyond this point will not be captured in the recording. They also suggested making the writing space larger. It can safely be stated that with minor improvements, lightboard videos can emerge as the most important tool for engaging engineering students into learning.

Discussion of Research Question 3

Research Question 3: How do engineering students perceive the use of video course materials created with lightboard technology would aid in student learning engagement?
Engineering student participants for my research perceived the use of video course materials created with lightboard technology would aid in student learning engagement in various ways. The handwritten notes assisted in identifying the main ideas in the lecture material, and the faculty’s body language and facial expressions made the material easier to follow. By simulating typical classroom settings, it improved the content's understanding and made the videos interactive, engaging and educational. Lightboard videos have a great deal of potential to inspire engineering students' learning engagement with minor precautions taken regarding color contrast and the size of the video. To help with a consensual discussion for this research on students' perceived perspectives on lightboard videos in promoting engineering students' engagement for learning, the themes generated from my research were compiled and illustrated below.

Learning with Attractive Engaging Visuals

Student participants for this research were enthralled by the way the text covered the teachers and the dim background while using brightly colored script. They found the notes to be incredibly lucid, aesthetically beautiful, straightforward and not unduly complex, easy on the eyes, and visually captivating. They claimed that the stimulating learning environment improved their ability to retain the information they were learning. Earlier research noticed that lightboard’s writing "in the air" has the effect of grabbing attention as the neon lighting effect of markers creates a strong visual connection with the viewer; the writing in front of the students glows in stark contrast, which enhances the personal connection and engagement of the lightboard videos (Malyutina et al., 2021; Ye, 2016).
Body Gestures and Facial Expression Helped Following the Content

According to the student participants for my research, being able to simultaneously see the faculty’s writing and body language in the lightboard videos, along with the lightboard videos’ appealing aesthetic, made the material easier to follow. It was fascinating for the students to watch their faculty at work and to learn from him at the same time. Observing the faculty’s reactions when they could actually see what he was writing and pointing at was helpful for them to comprehend the content. According to researchers, the main benefit of having the faculty face the class while writing on the board was that the students could see facial expressions or even read lips and learning is more efficient when the lecturer sees the audience through the board rather than just the board (Birdwell & Peshkin, 2015; Malyutina et al., 2021; Ye, 2016). The lightboard videos were the most useful because they let students watch the teacher actually carry out a process, make gestures or point out specific areas of the board with hands and use body language, solve an equation, or draw a diagram (Lubrick et al., 2019; McCorkle & Whitener, 2020; Peshkin, n.d.; VanderMolen et al., 2018).

Imitated Traditional Classroom

My research found that the student participants felt as though they were taking a synchronous course, even though the material was pre-recorded. The lightboard videos helped the students focus on the material and were more like attending classes in-person than watching slides with voiceover recordings. Students were happy with the feature that let them see the content and hear the faculty just like they would in a regular classroom. Lightboard videos were a helpful supplement to a traditional learning environment, the lecturer can maintain a stronger
connection with the students by using the lightboard while speaking and explaining concepts with visual assistance (Birdwell & Peshkin, 2015; Malyutina et al., 2021; Peshkin, n.d.; Ye, 2016). Consistent with the view, other researchers claimed that by replicating the classic chalkboard or whiteboard configuration and allowing online viewers to retain eye contact with the faculty, lightboard videos provided a setting that was very straightforward and teaching-focused (McCorkle & Whitener, 2020; Rosasco, 2018; VanderMolen et al., 2018), the lightboard's use only differs from typical classroom board work because it enabled teachers to write on the board while facing "toward" students (VanderMolen et al., 2018).

Made Content Easier to Visualize

Students discovered that visualizing concepts became simpler after seeing lightboard videos. After the professor's screen was successfully projected onto the board prior to annotations, the material was easier to understand. With its vivid appearance, lightboard videos were more engaging to watch and easier to view and comprehend. Also, student participants claimed that these videos helped me to understand concepts better as compared to other types of live video lectures they attended earlier.

The Lightboard Videos Were Interactive

The interactive aspect of the lightboard videos and the creative use of lightboard technology were well-received by the student participants. They thought lightboard videos were very fascinating, and the interactive style made learning more engaging. Seeing the professor and his job side by side was interesting to them. Research by Ye (2016) also asserted that the
lightboard videos were interactive in nature and that quality made the videos engaging for the students.

**Writing Was Sometimes Illegible**

The writing in the lightboard videos was occasionally unreadable, as the student participants realized for a variety of reasons. Certain calculations written at the end were not visible, the handwriting wasn't clear enough, the font shade was too light, and the font color wasn't suitable for the background. It was also occasionally difficult to read because of the professor's light-colored shirt blending in some of the text. This point of view was significant because it highlights how crucial it is for the students to be able to clearly understand the recording in order for them to understand the material. It was also noteworthy to bring up this point because the researcher's prior research on other researchers’ work related to lightboard videos did not reveal this theme. One possible explanation for this could be the limited number of lightboard video research studies that were available.

**Sometimes The Presenter’s Image Created Distraction for The Writing Part**

Another trend that emerged from the student participants' perspectives was that sometimes they were distracted from the writing part by the faculty's appearance. Some texts are obscured by an uneven background because the writer is behind the text on the lightboard. It can occasionally be challenging to read what was written when the faculty was behind the text. This remark was important because when making lightboard videos, faculty members need to be aware of this. Once more, this point was not revealed by previous research findings; rather,
Malyutina et al. (2021) only suggested that faculty members refrain from wearing brightly patterned clothing during recording.

**Made Content Easier to Understand**

Student participants for my research stated that they were able to pick up the material quickly and easily because the lightboard videos helped them understand the material better and built up the concepts. Lightboard could help through interactive exercises that improve their comprehension of the subject matter. Students discovered that visualizing concepts became simpler after watching lightboard videos. It was more engaging to watch and simpler to see and comprehend. Researchers argued that the lightboard videos improved key concepts, emphasis identification and understanding on the whole for the students (Rogers, 2019; Rosasco, 2018). Rogers (2019) concluded that students seemed to enjoy the lightboard videos, and many expressed a want to see more of them in engineering classes and to share them with their peers.

**Short Duration Videos Are More Useful**

Students that took part in my study asked for video clips. They believed that since short videos aid in knowledge retention, make them engaging and brief. If needed, divide them into smaller parts. They recommended that the videos be short and divided into conceptually-based segments. Earlier researchers advised the presenters to keep their individual video segments brief with the information broken up into different sections because there is less space to write on a glass board and that wiping a glass surface is more difficult than wiping a blackboard or whiteboard (Birdwell & Peshkin, 2015; Fung, 2017; Ye, 2016). McCorkle and Whitener (2020)
shared a same sentiment, videos that must be edited from multiple takes may require more
planning and preparation than quick, one-take videos; lightboard would not be the best format
for them.

Pragmatic Use of Color Contrast

Student participants for my research realized that a practical choice regarding color
contrast was necessary as they watched the lightboard videos. It's important to choose the marker
color carefully so that it stands out against the background, doesn't match the presenter's attire,
and isn't too light. If the students fail to navigate through the lightboard videos due to any of the
reasons mentioned above, the videos will not be able to attract students. Student feedback for the
research by Rosasco (2018) from the class where the lightboard was used also mentioned that
there could be more color contrast between the background and the markers' colors.
Underpinning the opinion, some other researchers observed that certain colored attire and
patterns make themselves dissipate into the background (Malyutina et al., 2021; McCorkle &
Whitener, 2020).

It can evidently be concluded that engineering students perceived that lightboard videos
facilitated their learning engagement. Students reported that the faculty’s body language and
facial expressions made the lecture material easier to follow and the handwritten notes helped in
identifying the key concepts. It mimicked typical classroom settings, made the material more
understandable, and made the videos interactive. They also asserted that the videos had attractive
images and were engaging as well as educational. This study found that the writing was
occasionally unreadable because of problems with the markers' ink quality, color blending that
affected contrast, font size, and the writing itself. To avoid a clash between the presenter's attire and the background, they advised using a contrasting color. Additionally, they suggested shortening the videos. Two main points of view emerged when the student responses to the question of how these lightboard videos can help them in their academic learning were analyzed. The lightboard videos helped them visualize the content, which facilitated their understanding of the topic and allowed them to understand the course material more clearly. They also made learning new things simple. Moreover, students understood that using videos created with lightboard technology was a useful method for engaging them in the learning process by making it easier for them to pay attention to the material. Also, they believed that the lightboard technology was very methodical in creating attractive video materials that aided in learning. The students who participated in this study also expressed the opinion that the writing component occasionally suffers from the faculty's appearance, which has not been demonstrated by any prior studies.

Discussion of Research Question 4

Research Question 4: How does student survey data and faculty interview data help understand the use or effectiveness of video course materials created with lightboard technology?

According to Lubrick et al. (2019), there was a dearth of research on lightboard videos, making it imperative to thoroughly explore its potential and best practices. Additionally, the majority of earlier studies focused on building lightboards, developing a pilot project using lightboard technology, and gathering feedback on its use from faculty or students. However, there hasn't been any extensive research that gathered and examined data from both faculty and
students. In order to investigate the perceptions of engineering students of lightboard videos on their learning engagement, this study sought to gather and analyze data from both faculty and students. The perspectives of both faculty and students were crucial in establishing the themes that emerged from the research findings as perspectives of both were equally important to get a consensus response towards the research intent of investigating the perceptions of engineering students on lightboard videos on their learning engagement.

According to this study, the majority of the students' answers to the question about the aspect of the lightboard videos they enjoy the most were favorable. Students felt that the videos were participatory and that the faculty’s body language and facial expressions helped them follow the lecture material, the lightboard videos mimicked typical classroom settings, and made the material easier to understand. They added that the videos were engaging and encouraged learning through visually captivating content. When asked what they didn't like about the lightboard videos, students offered a variety of responses. Summary of the responses revealed that the markers' ink quality, color contrast, font size, and writing itself occasionally made it difficult to read. Additionally, the students complained that the presenter's appearance occasionally interfered with the writing tasks. To prevent the presenter's outfit and background from blending together, students recommended using contrasting colors. They also suggested preparing videos of shorter duration. Two main points of view emerged when the student responses to the question of how these lightboard videos can aid in their academic learning were analyzed. The lightboard videos helped them understand the course material more clearly and simplified learning new things.
Findings from the faculty data showed that they also shared similar sentiments regarding the lightboard videos. According to their responses to the question of whether they believe these lightboard videos might help in maintaining learners' engagement, the lightboard videos will help students be more engaged in their studies, they will make the content easier to understand, and the faculty’s body language and facial expressions will help students follow the content easily. Their opinions on the use of lightboard videos and technology can be summed up by saying that they believed that the videos will help students concentrate more on their studies, the faculty's body language and facial expressions will help students navigate the material easily, that it somewhat mimics the traditional classroom, that it is simple to use and a great tool for combining materials, but they also cautioned that the presenter's image can occasionally cause distractions. They also mentioned how challenging it was to erase. Additionally, it was found that when asked what changes they would make to the lightboard video experience to make it easier for them to use the technology, faculty most frequently said that there should be a boundary marked on the glass board indicating that anything written beyond this point will not be recorded. They also argued in favor of a bigger writing space. Improvements were also mentioned, including the ability to turn on and off showing the presenter's image while recording the lightboard videos, real-time modification, digital writing and wiping off, and software integration for simpler display of other integrated documents.

The results from both student and faculty data matched and spoke loudly for the lightboard videos, when the findings from both the groups were integrated while analyzing the findings corresponding to the research question of whether student survey data and faculty interview data help understand the effectiveness of lightboard videos. The lightboard videos
were simple to watch and understand for the students. It made learning new things simple by outlining key ideas and assisting with content visualization. The use of attractive, efficient technology in the classroom was an appropriate way to engage students. It was therefore simpler to pay attention due to the faculty's facial expressions, body language, and handwritten notations. It resembled conventional classrooms. By examining the faculty's data, all of these were enhanced. Likewise, they noticed that the engaging display and lightboard videos helped with student engagement. It helped students sharpen their study focus. Students were better able to follow the steps thanks to the faculty's body language and facial expression. It was similar to learning in a traditional classroom. Additionally, both groups expressed concern about the faculty's sometimes-distracting image over the text, supported shorter video lengths, and mentioned the need for carefully chosen contrast colors. The limited writing space and lack of a defined boundary, however, bothered the faculty. Additionally, the faculty members proposed digital write and wipe capabilities as well as real-time modification.

**Major Themes Emerged**

This study investigated how using cutting-edge, multimedia-based video course materials made with lightboard technology affects engineering students' engagement in their studies. The results of this study made it abundantly evident that adding lightboard videos increased the learning engagement of engineering students. The primary themes that arose from the discussion of the findings against each of the four research questions are shown below.
Lightboard Videos Help Students to Be Engaged

The lightboard videos captured the attention of the students, as did the way the colorful writing contrasted with the dark background and the teacher. They praised the videos for being visually appealing, simple, easy to follow and not overly complicated. Because the lightboard videos were interactive, they found it easier to stay engaged and understand the material. Students thought it was a fantastic idea to use lightboard technology for engaging them in the learning process. For the engineering students, watching lightboard videos was an engaging one overall. The similar observation was made by faculty members, who noted that employing lightboard videos significantly encouraged students to become engaged in their education. Because of their dark backgrounds and vibrant lettering colors, lightboard videos were visually appealing and aided in helping students focus on the topic being studied.

Faculty’s Gesture and Expression Facilitate Learning

Students reported that the content was easier to understand because they could simultaneously view the faculty's writing and body language in the lightboard videos. They found it intriguing to observe their professors at work when they could truly see the useful items he was pointing out and writing. Faculty participants also claimed that by simplifying the material for students to understand, their body language and facial emotions increased the students' level of study engagement. The students’ capacity for engagement in class increased when they watched the lightboard videos because they felt more connected to the subject matter.
Lightboard Videos Offered a Classroom Experience

The students experienced learning in a regular classroom because of the lightboard videos. Despite the fact that the content was pre-recorded, students had the impression that they were taking a synchronous course. Compared to seeing slides with voiceover recordings, the lightboard videos helped the students concentrate on the subject matter and they felt more like attending classes in person. Faculty members also noticed that because students could see and hear the instructors, they found it easier to follow along and felt as though they were speaking with each other face-to-face when the instructors went over ideas or procedures in front of them.

Lightboard Videos Made Content Easier to Understand

Students found that watching lightboard videos made it easier to visualize subjects. The subject was simpler to understand when the faculty's screen was successfully projected onto the board before annotations. It was easier to see and understand, and it was more engaging to watch. Students expressed appreciation for the participatory aspects of the videos and the inventive use of lightboard technology. Lightboard videos' interactive structure stimulated their curiosity and improved the learning process. The students said that because the lightboard videos clarified the concepts and helped them grasp the content better, they were able to pick up the material quickly and effortlessly. Through interactive exercises that enhance their understanding of the material, lightboard could be helpful.
Short Duration Lightboard Videos Were More Useful

Students requested to view short videos produced using the lightboard technology on several subjects. They believed that short videos are the most effective in helping viewers retain information since they are more engaging. Also, some of the students commented that for short duration videos, they can pause the video to take notes and re-watch multiple times to have a better understanding of the contents. They proposed that lengthy recordings may be divided into smaller parts based on the concept if necessary.

Recording Requires Intelligent Use of Color Contrast

The viewpoints of the student participants also revealed another trend: on occasion, the faculty's presence would divert them from the writing portion. Sometimes, when the faculty was behind the text, it was difficult to read what was written because of several factors, such as the color of the background, the markers, or the faculty's dissipating clothing. A faculty member also issued a warning, saying that occasionally, students may become distracted from reading the content by the faculty's appearance. After watching the lightboard videos, the students suggested that a decision about color contrast should be made with consideration for practicality. The marker color should be carefully chosen so that it contrasts with the background, doesn't go with the presenter's outfit, and isn't overly light.
Recommendations for Best Practices

Lightboard videos helped in better understanding. The visuals were attractive and engaging. Also, mimicking the in-person class experience along with faculty’s body gestures made it easier to follow and seemingly interactive. Faculty should be encouraged to create more lightboard videos on their course content and integrate those into the course material. This research recommends the following best practices to facilitate learning with lightboard videos.

**Lightboard Videos with Shorter Duration Are More Desirable**

Students expressed their opinion that they were more attentive towards lightboard videos of shorter duration as it helped them grasp the key concepts in a better way. Faculty members also shared their concern for shorter videos owing to the same reason and in addition, for faculty, shorter videos mean little or no wiping during recording and not to worry about the writing space. Faculty should logically arrange their material before recording in order to produce shorter duration videos. Longer videos should be divided into shorter segments.

**Lightboard Videos Blends with The Background or the Presenter’s Attire**

There were situations where the writing marker color matched the background or the dress of the presenter. When recording the lightboard videos, faculty must pay attention to the color contrast between the presenter's clothes, the background, and the marker color. In order for the presenter not to blend into the background, they shouldn't wear clothing with bold patterns or colors, such as shades of white and black. Additionally, branded apparel with logos should be
avoided since they will seem backward when the lightboard video is reversed after it has been recorded.

**Needs Wider Writing Space**

A few faculty members expressed the need for wider writing areas. Since the camera on the other side of the glass board can only capture a certain area, it was not practical. Therefore, it's best if faculty arrange their materials neatly before recording and stay away from making lightboard videos that need more room and have more text in them. Instead, record lightboard videos for courses with more formulas, diagrams or shorter steps for solving.

**Presenter’s Image Sometimes Creates Distraction for The Text**

Both students and faculty mentioned that occasionally, the presenter’s image created a distraction for the text visibility. To avoid this, the presenter should carefully select the attire and marker color. Also, the color of the integrated document needs to be selected wisely. The presenter may record a demo version of part of the content first and watch it before actual recording.

**No Marked Boundary for Writing**

Faculty members noticed after recording lightboard videos that some of the parts of their recording by the edges of the glass-board were not visible and realized that the camera did not capture the whole part of the glass-board. Some kind of marked boundary should be provided on the glass-board indicating that writing beyond that point will not be recorded.
Erasing was Difficult

Faculty members mentioned that erasing while recording was difficult and actually took screen time for recording. It would be really helpful if some kind of digital wiping facility can be integrated with the lightboard technology. Also, it is advised to create short videos where wiping off is not a concern.

Ease to Use

The ease of use of the lightboard for recording was highlighted by every faculty. The opinions of faculty can be summed up as just approach the board, take out your marker, and begin to demonstrate. A lightboard's simplicity could be considered sans-technology from the faculty's point of view. The faculty is not engaging with any computer hardware or software when utilizing the lightboard.

Facilitate Use of Lightboard Studio

Acquiring specific technical abilities in engineering education necessitates extensive practical training. My faculty participants came to the realization that lightboard technology, as a medium, has the ability to help with this technical aspect of engineering education by providing step-by-step instructions or incorporating other instructional materials into lightboard videos. Additionally, students reported that they were able to maintain focus while watching the videos on the lightboard and could follow the instructions to gain a deeper comprehension of the course material. A few of the faculty members exhibited great enthusiasm and were open to incorporating further lightboard videos into their courses, particularly those that call for
diagrammatic presentations or illustrations, such as capstone projects. Simultaneously, they assert that they would have utilized the lightboard technology more effectively had it been accessible at their campus. This would have allowed them to record lightboard videos whenever they are free and not have to worry about making schedules to use the lightboard studio. The usage of lightboard technology by engineering faculty to create instructional content could rise with institutional support and encouragement for this matter.

Conclusions

Given the lack of studies examining the influence of lightboard videos on engineering students' learning engagement, this study—which looked at both student and faculty data—provided a crucial first investigation. The study examined the following issues in order to reach the desired outcome: engineering students’ perceptions of learning engagement with lightboard videos, how engineering faculty and engineering students perceived the use of lightboard videos for students’ learning engagement, and whether the data collected from engineering students and engineering faculty facilitate in understanding the effectiveness of lightboard videos. The results evidently established that lightboard videos inspired engineering students’ learning engagement. Participants found the lightboard videos to be easy to watch and understand. By summarizing important concepts and supporting information visualization, it simplified the process of learning new topics. Using attractive and effective technology in the classroom was a good method to get students engaged and involved. The faculty's body language, facial expressions, and handwritten notes made it easier to pay attention. It looked like a traditional classroom.
Lightboard is one advanced multimedia tool for creating educational audio-video contents. The burden of learning new software has been removed, allowing more time to be allocated to the meticulous preparation and pacing of instruction. When developing instructional and supplemental learning materials, faculty should reevaluate the role of content in the classroom and work to create opportunities for active engagement with the concepts presented rather than ineffective viewing of an array of course videos.

Faculty presence is essential when using online course materials to teach students because it enhances interpersonal communication just like in-person instruction does. The lightboard videos are useful in this situation. The vast majority of students indicated that they would like to see more lightboard videos in the future, and the encouraging feedback and well-considered remarks imply that it is beneficial for the students to have the faculty present.

Lightboard video provides a dependable pedagogical framework for explaining complicated concepts. The use of lightboard videos to explain course material is a useful tool for improving the understanding of learners. A visually inventive, interactive, and engaging method of displaying material is by using lightboard video technology, that allows faculty to face directly towards the audience and illustrate sketches, calculations, or formulas.

VanderMolen et al. (2018) applied lightboard technology for medical dosimetry concepts that resulted in informative video lectures for the students. Likewise, Rulino and Fabriana (2022) implemented lightboard technology for making nursing practicum videos with the intent of inducing students’ learning, satisfaction and engagement and its proven to be fruitful. Researchers also created lightboard videos for chemistry classes and observed that it increased student engagement (Fung, 2017; Schweiker et al., 2020) and a better academic performance
Whereas, Fallas-Ramirez et al. (2022) implemented lightboard as a didactic strategy for online mathematical topics and found that it facilitated the understanding and learning for the students on the topic. My research suggested that lightboard technology can improve student engagement for engineering education also. According to student data for my research, the majority of students strongly enjoy the lightboard videos and have asked that more be made and included in all engineering courses. Based on the observations, modifications can be implemented to enhance the effectiveness of the videos based on the type of content offered and potentially the subject being taught. For educators in the health, science, math, or technology domains who frequently have to use visuals to explain complex processes, lightboard technology appears to be extremely helpful.

**Future Research Opportunities**

The study's primary exploratory design was employed. Since there hasn't been much research on how the Lightboard influences student learning. Given that the study's sole focus was on engineering students, its conclusions could not be broadly applied. By designating classes between control group and study group, researchers would ideally have greater oversight over the study variables. Given the research data, which suggests that students value the lightboard videos because they encourage their learning engagement, it would have been unethical to withhold the videos from one entire class at this time. While there was a high response rate to the student perception survey in this study, future research should look at the use of Lightboard videos over several semesters. Research should focus on to find out if adding lightboard videos to the course materials can help students perform better academically or not by dividing the
students into control and study groups. Research should also compare the learning engagement of lightboard videos with other methods of producing audio-video course materials by dividing the students into two groups and supplying lightboard videos to one group while providing another type of audio-video material for the other group on the same course content. Subsequent studies can also examine how the faculty members that frequently incorporate lightboard videos into their curricula influence their teaching by dividing their classes into control and study groups and comparing the academic performances of the two groups. In the context, it can also be looked into how the faculty are envisioning their teaching as a consequence of using lightboard technology.
REFERENCES


Schweiker, S. S., Griggs, B. K., & Levonis, S. M. (2020). Engaging health student in learning organic chemistry reaction mechanisms using short and snappy lightboard videos. *Journal of Chemical Education*, 97(10), 3867–3871. [https://doi.org/10.1021/acs.jchemed.0c00619](https://doi.org/10.1021/acs.jchemed.0c00619)


APPENDIX A

STUDENT PERCEPTION SURVEY
Student Perception Survey

The following questions relate to the lightboard videos that you have watched as part of this course and will only be used in understanding your perceptions and opinions on the lightboard videos. The researcher appreciates your honesty in answering the questions and assures you that your answers will not have any impact on your course grade. Please do not write your name anywhere on this sheet.

Part 1: Questions pertaining to the Lightboard Videos
Please use the table below in rating different aspects of the course’s lightboard video. Use the following scale for your evaluation:
1 = strongly disagree
2 = disagree
3 = neither agree or disagree
4 = agree
5 = strongly agree

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<th>2</th>
<th>3</th>
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<td>2. The video helped me visualize the content.</td>
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<td>4. Having handwritten notations helped with my understanding.</td>
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<td>5. Overall, the lightboard video improved my understanding.</td>
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<td>6. The interactive nature of the video made it easier to pay attention and follow.</td>
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<td>7. The length of the video was appropriate.</td>
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<td>8. Watching the video was an effective use of my time.</td>
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<td>9. The lightboard technology is an appropriate way to engage students.</td>
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<td>10. Overall, the lightboard video was engaging.</td>
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<td>11. I found the video interesting and stimulating.</td>
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<td>12. The video’s technology is attractive (style wise).</td>
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13. The video is an effective tool for learning.


15. I would recommend developing and using more lightboard videos for this class.

16. I would recommend developing and using more lightboard videos for other engineering courses.

17. Overall, I enjoyed and recommended the lightboard videos.

**Part 2: Questions pertaining to the lightboard videos. Please provide short answers.**

1. What did you like most about the lightboard videos?

2. Was there anything about the lightboard videos that you did not like?

3. What suggestions would you give to enhance the lightboard video experience?

4. How can these lightboard videos help you learn for this course?
APPENDIX B

QUESTIONNAIRE FOR FACULTY
Questionnaire for Faculty

1. How long have you been working as a faculty?
2. Have you taught this course previously?
3. What was your approach/ preparation for recording lightboard videos?
4. What in your experience makes it challenging to create lightboard videos?
5. What is your opinion on lightboard technology/ lightboard videos?
6. Was there anything about the lightboard videos that you did not like?
7. What improvement suggestions to the lightboard video experience do you think would make it easier for the faculty to use the technology?
8. What ways do you believe these lightboard videos might help in maintaining learners' engagement?
9. Anything else you want to specify regarding lightboard videos?
APPENDIX C

SPSS OUTPUT FOR COMBINED DATA
### SPSS Output for Combined Data

#### Frequencies

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SPSS Output for Individual Courses

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Q2

Mean = 4.77
Std. Dev. = 0.22
N = 35

Q3

Mean = 6.36
Std. Dev. = 0.08
N = 35
Q7

Mean = 4.27
Std. Dev = 1.71
N = 20

Q8

Mean = 0.56
Std. Dev = 0.82
N = 20

Q9

Mean = 4.96
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Q17

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- Std Dev = 636
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Q2:
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- Std Dev = 635
- N = 54

Q17:
- Mean = 4.46
- Std Dev = 779
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### Q1

![Histogram for Q1](image)

- **Mean**: 4.41
- **Median**: 5.00
- **Std. Deviation**: 979
- **N**: 32

### Q2

![Histogram for Q2](image)

- **Mean**: 4.47
- **Median**: 5.00
- **Std. Deviation**: 915
- **N**: 32

### Q3

![Histogram for Q3](image)

- **Mean**: 4.40
- **Median**: 5.00
- **Std. Deviation**: 914
- **N**: 32
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APPENDIX E

SPSS OUTPUT FOR UNDERGRADUATE COURSES
Frequencies

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<td>2.16</td>
<td>2.14</td>
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<td>2.10</td>
<td>2.10</td>
<td>2.16</td>
<td>2.16</td>
</tr>
</tbody>
</table>

Histogram

Q1

Q2
APPENDIX F

CONSENT FORM FOR FACULTY
CONSENT FORM FOR FACULTY

Title of Study: Perceptions of lightboard videos on engineering students’ learning engagement

Investigators
Name: Rana Sanyal          Dept: ETRA          Phone: 

Key Information

- This is a voluntary research study on understanding the perceptions of engineering students on lightboard videos on their learning engagement.
- This study involves answering survey questions by engineering students that has both short answer questions and 5-point Likert scale questions that will take around 10-15 minutes. Also, there will be one semi-structured interview sessions with engineering faculty lasting approximately 30 minutes.
- The benefits include providing insight to improve engineering students’ learning engagement with the help of video course material developed with lightboard technology.

Description of the Study

The purpose of the study is to investigate the potential of lightboard videos in inspiring engineering students’ learning engagement. The faculty recorded a lightboard video related to the course they teach and emailed an unlisted YouTube link of that lightboard video to the students enrolled for the course for watching. If you agree to be in this study, as a faculty, you will be asked to do the following things: You will join a one-to-one in-person interview session with the researcher for approximately 30 minutes. A semi-structured open-ended interview questionnaire consists of 9 questions (Appendix B) is developed for the purpose and will be supplied to the faculty before the interview date with long enough time to prepare for the responses so that they can provide rich and comprehensive faculty’s perspectives on lightboard videos. Additional follow-up questions may be asked at various points during the interview to help clarify or elaborate on responses.

Risks and Benefits

There are no reasonably foreseeable (or expected) risks.

The benefits of participation are knowledge gained from the research. The expected research finding might inspire faculty to modify their instructional strategies to include more lightboard videos in the course content. That in turn will improve learning engagement and accordingly, better academic performances by the students.
Anonymity

This study is anonymous. The researcher will not be collecting or retaining any information about your identity. The study will not include any information in any report that may publish that would make it possible to identify you.

Compensation

There is no compensation for you to participate in this research.

Your Rights

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled. You have the right to skip any question or research activity, as well as to withdraw completely from participation at any point during the process.

You have the right to ask questions about this research study and to have those questions answered before, during, or after the research. If you have any further questions about the study, at any time feel free to contact the researcher, Rana Sanyal at z1622228@students.niu.edu or by telephone at 8152174256. Also, you can contact the faculty mentor, Dr. Jason Rhode at jrhode@niu.edu or by telephone at 8157532475. If you have any questions about your rights as a research participant that have not been answered by the investigators or if you have any problems or concerns that occur as a result of your participation, you may contact the Office of Research Compliance, Integrity, and Safety at (815)753-8588.

Future Use of the Research Data

After removing all identifying information from your data, the information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from you [or your legally authorized representative, if applicable]

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

________________________________________________           _____________________
Participant’s Signature      Date
[If audio or videotaping will occur, add a second signature and date line preceded by a sentence such as I give my consent to be audio recorded (or video recorded, as appropriate) during the (insert a description of the research activities that will be recorded)]

________________________________________________           _____________________
Participant’s Signature      Date
APPENDIX G

CONSENT FORM FOR STUDENTS
CONSENT FORM FOR STUDENTS

Title of Study: Perceptions of lightboard videos on engineering students’ learning engagement

Investigators
Name: Rana Sanyal Dept: ETRA Phone: 

Key Information

• This is a voluntary research study on understanding the perceptions of engineering students on lightboard videos on their learning engagement.
• This study involves answering survey questions by engineering students that has both short answer questions and 5-point Likert scale questions that will take around 10-15 minutes. Also, there will be one semi-structured interview sessions with engineering faculty lasting approximately 30 minutes.
• The benefits include providing insight to improve engineering students’ learning engagement with the help of video course material developed with lightboard technology.

Description of the Study

The purpose of the study is to investigate the potential of lightboard videos in inspiring engineering students’ learning engagement. The faculty recorded a lightboard video related to the course they teach and emailed an unlisted YouTube link of that lightboard video to the students enrolled for the course for watching. If you agree to be in this study, as a student, you will be asked to do the following things: You need to take part in an anonymous in-class survey (Appendix A) pertaining to lightboard videos. The survey has a total of 21 questions consists of seventeen 5-point Likert questions (Part 1) and four short answer questions (Part 2). The duration to take the survey will be between 10-15 minutes.

Risks and Benefits

There are no reasonably foreseeable (or expected) risks.

The benefits of participation are knowledge gained from the research. The expected research finding might inspire faculty to modify their instructional strategies to include more lightboard videos in the course content. That in turn will improve learning engagement and accordingly, better academic performances by the students.

Anonymity
This study is anonymous. The researcher will not be collecting or retaining any information about your identity. The study will not include any information in any report that may publish that would make it possible to identify you.

Compensation

All students who complete the anonymous in-class survey will be entered into a drawing that will take place just after the collection of in-class survey responses and have the chance to receive one of 10 Amazon gift cards of $25.

Your Rights

The decision to participate in this study is entirely up to you. You may refuse to take part in the study at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled. You have the right to skip any question or research activity, as well as to withdraw completely from participation at any point during the process.

You have the right to ask questions about this research study and to have those questions answered before, during, or after the research. If you have any further questions about the study, at any time feel free to contact the researcher, Rana Sanyal at z1622228@students.niu.edu or by telephone at 8152174256. Also, you can contact the faculty mentor, Dr. Jason Rhode at jrhole@niu.edu or by telephone at 8157532475. If you have any questions about your rights as a research participant that have not been answered by the investigators or if you have any problems or concerns that occur as a result of your participation, you may contact the Office of Research Compliance, Integrity, and Safety at (815)753-8588.

Future Use of the Research Data

After removing all identifying information from your data, the information could be used for future research studies or distributed to another investigator for future research studies without additional informed consent from you [or your legally authorized representative, if applicable]

Your signature below indicates that you have decided to volunteer as a research participant for this study, and that you have read and understood the information provided above. You will be given a signed and dated copy of this form to keep, along with any other printed materials deemed necessary by the study investigators.

________________________________________________           _____________________
Participant’s Signature      Date
[If audio or videotaping will occur, add a second signature and date line preceded by a sentence such as I give my consent to be audio recorded (or video recorded, as appropriate) during the (insert a description of the research activities that will be recorded)]

________________________________________________           _____________________
Participant’s Signature      Date