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RESEARCH ARTICLE

VIDEO-BASED INSTRUCTION AS A REMEDIATION IN TEACHING THERMODYNAMICS AMONG PROSPECTIVE SCIENCE TEACHERS

Resty Samosa[1*], Kimberly B. Castro[2], Christian Roel D. Gabriel[2], Isaiah Yvette A. Lozano[2], Christian Paul D. Paglicawan[2], Reden B. Precalin[2]
[1]Cavite State University - Naic
[2]Bulacan State University - Sarmiento

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Abstract
This study examined the effectiveness of video-based instruction (VBI) as a learning remediation strategy in teaching Laws of Thermodynamics among Prospective Science Teachers at Bulacan State University. The researchers employed – a one-group pretest–posttest design to assess the 35 prospective science teachers who were purposively selected. More so, data was gathered through researcher-made pretest-posttest achievement tests and an adapted Likert survey questionnaire. The data was treated descriptively and inferentially. The findings showed that VBI as a learning remediation strategy positively affected the preservice teachers' achievement. In addition, data shows a significant difference between the pretest and posttest in teaching the laws of thermodynamics. The ease of use of VBI as learning remediation in teaching laws of thermodynamics in terms of pedagogical content, individual learning focus, ability to work at pace, and increased engagement was very effective. The learning achievement of the prospective science teachers was significantly related to the ease of use of VBI as a learning remediation. However, it was observed to have a high positive association. Future use of VBI can enhance the prospective science teacher's competence in using VBI in teaching science subjects.

*Corresponding author: rsamosa@cvsu-naic.edu.ph

INTRODUCTION

Thermodynamics is one of the important subjects to be understood by a prospective science teacher. Thermodynamics is essential in modern science and technology (Wu & Wu, 2019). The thermodynamic topic studies energy physics related to heat, temperature change, work, processes, and entropy. However, prospective science teachers showed dissatisfaction and frustration in learning thermodynamics (Dukhan, 2016). Various applications in thermodynamics are easy to find in daily life, but there are still difficulties in learning the concept of thermodynamics (Villaruz et al., 2023). Those abstract concepts, studying cycles and processes, and thorough mathematical understanding caused thermodynamics learning to be increasingly perceived as unattractive (Fischer & Neumann, 2023). More so, Ültay et al. (2021) identified confusion between heat and energy concepts, and students often have difficulty learning thermodynamics, which was an inevitable observed misconception. Sreenivasulu and Subramaniam (2013) stressed that thermodynamics was a science full of conceptual challenges, and the students frequently failed to differentiate thermodynamics concepts such as heat, temperature, work, and internal energy.

Additionally, O'Connell (2019) enumerated problems encountered and challenges in learning thermodynamics, such as scope and level, mathematical abstraction, an incomplete discipline based only on equations, not numbers, laws are always true; models are imperfect but necessary, and solving thermodynamic problems is often complicated. This emerging problem was observable among prospective science teachers in researchers' university-based low mean performance in major examinations and classroom discussions. Hence, efforts to improve the teaching and learning process should be made by actively involving prospective science teachers in building their knowledge and understanding. It used VBIal tools to improve their achievement and competencies. Yusnanto and Rahayu (2022) mentioned that using video as a tool enhances student learning and improves student motivation in learning introductory thermodynamics courses.

Furthermore, the optimal utilization of video as an educational tool is heightened when instructors consider three key elements: managing the cognitive load of the video, maximizing student engagement with the content, and promoting active learning derived from the video (Brame, 2016). Unfortunately, however, the number of studies on thermodynamics in education that used video lessons was limited. This study aimed to fill the gaps in the effectiveness of VBI as a learning remediation strategy in teaching laws of thermodynamics among prospective science teachers.

Research Problems

This study aimed to evaluate the utilization of VBI as a learning remediation strategy in teaching laws of thermodynamics among prospective science teachers.
Specifically, the action research answered the following:

1. How effective is VBI as a learning remediation strategy in improving prospective science teachers' achievement in teaching laws of thermodynamics as revealed by their pretest and posttest mean scores?
2. Is there a significant difference between the prospective teachers' pretest and posttest mean scores?
3. What is the level of ease of use of the VBI as a learning remediation strategy in teaching laws of thermodynamics as described in terms of:
   3.1 Pedagogical Content
   3.2 Individual Learning Focus
   3.3 Ability to Work
   3.4 Increased engagement
4. Is there a significant relationship between learning achievement and ease of use of VBI as a learning remediation in teaching laws of thermodynamics?

METHODOLOGY

Research Design and Participants

The study employed a one-group pretest-posttest design to determine the effect of a treatment or intervention/remediation/innovation on a given sample. Magulod et al. (2021) characterized it as used in a single group of subjects with similar characteristics and distributed the same treatments, assessments, and innovation/remediation. This design also features linear ordering, which necessitates the measurement of a dependent variable before and after treatment. If the influence of the scores differs significantly in this design, the discrepancy can be traced to the study's independent variables. The participants comprise 35 third-year teacher education students majoring in science. Purposive sampling is used as the sample is purposively selected as the respondents have similar traits and specific characteristics to the participants, which are students who have difficulties in learning thermodynamics, specifically the laws of thermodynamics that hailed from a selected university in Bulacan, Philippines.

Research Instruments

The thermodynamics Achievement Test (TAT) was researcher-made. It contained thirty 30 multiple-choice response tests. This was administered before and after the treatment. The test was used in the pretest and posttest. The TAT measured the learners'' ability to recall, relate, and apply any information received during the treatment. The Physical Science Achievement Test followed the specifications table following the Department of Education's Curriculum Guide to ensure reliability and validity. Additionally, a researcher-made checklist-survey questionnaire was used to gather data on the ease of use of VBI as a learning remediation strategy in teaching laws of thermodynamics as described in terms of pedagogical content, individual learning focus, ability to work, and increased engagement. Each variable considered five indicators.

Data Gathering Procedures

A letter was given to the three experts in the field of physics to validate the instruments. The expert rated the questionnaire to establish its content validity. Samosa and Dantay (2022) said that content validity chiefly targets the usefulness, originality, and representativeness of the test items to assess the characteristics to look for. This is usually done when a group of experts in the field of interest has inspected the test items. Suggestions from the experts were considered for the final draft of the instrument. After establishing the validity, it was pilot-tested on 30 nonrespondents to determine its reliability, per Pentang (2022, 2023). Using Cronbach's alpha, the computed reliability was .89, thus means the instruments were reliable. Once all procedures for validity and reliability were considered, the research questionnaire and pretest-posttest were administered to select participants.

As regards data gathering procedures, the researchers would apply for approval and submit a formal letter to survey the Dean of the school, the department head of the course, and the adviser for the third-year students of Bachelor of Secondary Education major in science from a University in Bulacan, Philippines. The respondents hailed from the third year of their Bachelor of Secondary Education major in science. They were chosen using a total population sampling method as the researchers chose the specific group of people as the respondents met the requirements and specifications necessary for the researchers to gather enough data. Then, it also asked the subjects/respondents to participate in answering the questionnaire. The subjects/respondents were informed of their anonymity and confidentiality in the study, and the subjects were also informed of their rights to withdraw at any moment if any of their rights were violated. The completion of the survey is equal to consent to the participation.

Meanwhile, thermodynamics video content was selected following the intended instructional purposes and the students' characteristics and interests before learning. Another criterion for choosing thermodynamics video content as a video clip is the length of the video because shorter videos (about 10 minutes) are more engaging than longer videos. The topics covered in the implementation of the remediation of VBIs were basic concepts in thermodynamics, Work, Energy, and Heat, Ideal Gas Laws, the First law of thermodynamics, and the second law of thermodynamics. After the exposure, the collection of needed data would then be conducted in two phases, and the collected data would be processed by appropriate statistical treatment. The results would be summarized, and the data collected on each question would be tallied and tabulated.

Data Analysis

The arithmetic mean was used to assess the effectiveness of VBI as a learning remediation strategy in improving prospective science teachers' achievement in teaching laws of thermodynamics, as revealed by their pretest and posttest mean scores. In addition, assessing the ease of use of the

VBI as a learning remediation strategy in teaching laws of thermodynamics is described in terms of pedagogical content, individual learning focus, ability to work, and increased engagement. A t-test for dependent means was used to test the significant difference between the prospective teachers' pretest and posttest mean scores. Pearson Product Moment of Correlation Coefficient was used to test the significant relationship between learning achievement and ease of use of VBI as a learning remediation in teaching laws of thermodynamics. The analyses were guided by Pentang (2021a), ensuring careful procedures and accurate reports.

RESULTS AND DISCUSSIONS

Preservice Teachers' Achievement Before and After Using VBI

Table 1 presents the prospective teachers' achievements before and after using VBI as a learning remediation strategy in teaching laws of thermodynamics. The data in the table indicates that before using VBI as a learning remediation strategy, prospective science teachers' achievements in the pretest were 81.97, then in the posttest were 86.94. Hence, the prospective science teachers gain a score of 27.58. More so, it can be concluded that VBI as a learning remediation strategy positively affected the preservice teachers' achievement. It was observed that after the VBI on thermodynamics, the students displayed an increase in their posttest scores. At the same time, it was seen that compared with the pretest, the students in the posttest provided much better worded, more correct/accurate, and scientific answers. This outcome indicates that compared with pre-implementation, VBI on thermodynamics is more beneficial. In other words, it was observed that VBI has a more positive effect on student's understanding. The study confirmed the finding of Higgins et al. (2018) in a way using video-based material as a mediating artifact improved the teacher's perception of teaching instruction as presenting ideas comes in many forms and not just a regular text and teaching, using video-based material is an appealing option to teach and instruct. They are likewise learning and teaching laws of thermodynamics by using VBI.

Table 1. The preservice teachers' achievement before and after using VBI

Pretest	Posttest	Gain Scores
81.97	86.94	27.58

Significant Difference between the Prospective Teachers' Pretest and Posttest Scores

There is a significant difference in prospective teachers' pretest and posttest scores in using VBI as a learning remediation strategy in teaching laws of thermodynamics (Table 2). This result is supported by the study of Pakpahan (2021), where learning using video-based media must adapt to the taught topic and adhere to the learning process's requirements under the rules. Furthermore, while still referring to providing excellent learning resources and reaching optimal student skills, digital technology-based learning can be pushed more inventively and creatively.

Table 2: Significant difference between the prospective teachers' pretest and posttest scores

df	computed value	critical value	p-value	Decision	Statistical Inference
34	19.30	1.69	0.00	Ho is rejected	Significant

Ease of Use of VBI as Learning Remediation in Teaching Laws of Thermodynamics

Pedagogical Content. Table 3.1 illustrates a prospective assessment of the ease of utilizing VBI as a remedial tool in teaching the laws of thermodynamics among aspiring science teachers, focusing on pedagogical content. Upon analyzing the data in the table, it becomes evident that the prospective science teacher respondents achieved an overall weighted mean of 3.67. This value suggests strong effectiveness in using VBI as a learning remediation method for teaching the laws of thermodynamics regarding pedagogical content. Examining the specific indicators, it is apparent that prospective science teacher respondents found VBI to be strongly effective in various aspects.

These include enhancing content mastery (WM = 3.79), providing a better understanding of the subject matter (WM = 3.64), encouraging memory retention of the taught material (WM = 3.64), increasing the capability to actively respond to assessments within the modules (WM = 3.64), and aligning with the learning competencies (WM = 3.64).

Beyond its effectiveness in the learning process, VBI demonstrates efficacy on both sides of the classroom. Teachers can leverage it to create time and space for active learning. Video content creation allows for its reuse and updates as necessary, freeing up more classroom time for live discussions and student engagement. This study aligns with the findings of Bullo (2021), supporting the notion that integrating video lessons into the learning experience for 9th-grade science students yields superior results compared to modular learning. The impact is significant and positively influences students' learning outcomes by incorporating video lessons.

Table 3.1. Ease of use of VBI as learning remediation in teaching laws of thermodynamics in terms of pedagogical content

No	Pedagogical Content	WM	VI
1	The use of instructional videos provides a better understanding of the subject matter.	3.64	SE
2	The use of instructional video encouraged memory retention of the subject taught	3.64	SE
3	Using instructional video increases the capability to answer the assessments written in the modules actively.	3.64	SE
4	The instructional videos are aligned with the learning competencies.	3.64	SE
5	The instructional videos enhance student content mastery.	3.79	SE
	Overall Weighted Mean	**3.67**	**SE**

Legend: n = 35
1 – (1.00-1.49) - Extremely Ineffective (EI)
2 – (1.50-2.49) - Ineffective (I)
3 – (2.50-3.49) - Effective (E)
4 – (3.50-4.00) - Strongly Effective (SE)

Individual Learning Focus. Table 3.2 presents a prospective assessment conducted among science teachers, focusing on the ease of implementing VBI as a remedial tool for teaching the laws of thermodynamics, particularly in terms of individualized learning. The findings from prospective science teacher respondents indicate an overall weighted mean of 3.50, suggesting strong effectiveness in using video-based instruction for remediation in teaching thermodynamics with a focus on individual learning. Examining specific indicators, preservice teacher respondents affirmed the substantial effectiveness of VBI in teaching laws of thermodynamics for individual learning focus. Noteworthy indicators include broadening students' knowledge paradigm (WM = 3.57), seamlessly integrating instruction with assessment (WM = 3.57), offering a profoundly personalized experience (WM = 3.57), adapting in real-time within and between lessons (WM = 3.43), and providing an engaging and individualized learning experience for various student types (WM = 3.36).

Table 3.2. Ease of use of VBI as learning remediation in teaching laws of thermodynamics in terms of individual learning focus

No	Individual Learning Focus	WM	VI
1	The use of VBI helps to broaden students' knowledge paradigm.	3.57	SE
2	VBI seamlessly integrates instruction with assessment.	3.57	SE
3	The use of videos adapts within and between lessons in real time.	3.43	SE
4	VBI is deeply personalized.	3.57	SE
5	VBI is engaging and provides individualized learning experiences for every type of student.	3.36	SE
	Overall Weighted Mean	**3.50**	**SE**

Legend: n = 35
1 – (1.00-1.49) - Extremely Ineffective (EI)
2 – (1.50-2.49) - Ineffective (I)
3 – (2.50-3.49) - Effective (E)
4 – (3.50-4.00) - Strongly Effective (SE)

These indicators suggest that greater student interest, engagement, and interactive learning sessions contribute to the enjoyment, comprehension, and retention of information from video-based instruction. The flexibility of this medium, allowing students to stop, start, and rewind, proves invaluable. The ability to pause videos for challenges, predictions, elaborations, debates, and reviews enhances interactivity. Additionally, replicating activities, fostering discussions, and repeating demonstrations and experiments in the classroom further contribute to an interactive and dynamic learning environment. The study, consistent with the findings of Costley (2021), underscores the effectiveness of employing video lecture viewing tactics to enhance students' cognitive processing, even in situations of high extraneous cognitive load. The research suggests that students can leverage viewing tactics to improve their online and flipped classroom learning experiences.

Ability to Work at Their Own Pace.

Table 3.3 outlines the results of a prospective assessment conducted among science teachers, focusing on the utility of VBI as a remedial tool for teaching the laws of thermodynamics, particularly in facilitating self-paced learning. According to responses from prospective science teachers, the overall weighted mean for the effectiveness of video-based instruction in remediation for teaching laws of thermodynamics, focusing on the ability to work at one's own pace, was 3.65. This indicates a strong consensus among respondents regarding the efficacy of this instructional approach.

Specific indicators further underscored the substantial effectiveness of video-based instruction in this context. These indicators include its ability to enhance students' expression of ideas and thoughts (WM = 3.71), facilitate better retention and application of knowledge compared to text-only teaching methods (WM = 3.71), create active and engaging lessons for optimal learning experiences (WM = 3.64), increase student engagement and participation (WM = 3.64), and introduce variety in the pacing of content coverage within the videos (WM = 3.57). The study suggests that video-based instruction can bridge educational gaps by allowing teachers to adapt their teaching to students' paces. Students benefit from revisiting video content multiple times for enhanced understanding and retention. Features such as captions further extend the inclusivity of this instructional method, allowing deaf students to access the content through text. Supporting these findings, Ramachandran (2019) demonstrated a significant positive impact on student learning and the reinforcement of fundamental concepts by integrating videos in the classroom. These benefits extended to students who initially disliked video-based instruction.

Table 3.3. Ease of use of VBI as learning remediation in teaching laws of thermodynamics in terms of the ability to work at own pace

No	Ability to Work at Own Pace	WM	VI
1	The use of VBI enables students to express their ideas and thoughts better.	3.71	SE
2	Using VBI promotes active and engaging lessons for students' best learning experience.	3.64	SE
3	Teaching through videos helps learners retain content and apply knowledge more efficiently than teaching with only text.	3.71	SE
4	Provides video lesson activities to increase engagement and participation.	3.64	SE
5	There is variety in the pacing of content coverage in the videos.	3.57	SE
	Overall Weighted Mean	**3.65**	**SE**

Legend: n = 35

1 – (1.00-1.49) - Extremely Ineffective (EI)

2 – (1.50-2.49) - Ineffective (I)

3 – (2.50-3.49) - Effective (E)

4 – (3.50-4.00) - Strongly Effective (SE)

Increased Engagement.

In Table 3.4, the outcomes of a prospective assessment gauging the competencies of science teachers are detailed, explicitly examining the ease of incorporating VBI for remedial learning when teaching the laws of thermodynamics, focusing on its impact on Increased Engagement. The data, derived from prospective science teacher respondents, discloses an overall weighted mean of 3.57, indicating a high level of effectiveness in utilizing VBI for learning remediation within thermodynamics instruction, particularly in fostering Increased Engagement.

Upon closer scrutiny of individual indicators, several facets emerged as notably effective. Firstly, the application of VBI demonstrated a significant capacity for Reducing Anxiety (WM = 3.64) among pre-service science teachers. Furthermore, using instructional videos substantially enhanced motivation for engaging with Self-Directed Learning Modules (WM = 3.64). Additionally, VBI was associated with increased confidence in addressing tasks required for submission, as reflected in the indicator of Boosting Confidence in Task Completion (WM = 3.64). Moreover, the study identified VBI as a valuable tool in motivating students to learn effectively at home, as evidenced by the indicator of Promoting Home Learning Motivation (WM = 3.64). Lastly, while slightly lower, the indicator of Alleviating Tension in Learning Design (WM = 3.43) still signifies strong effectiveness in reducing tension related to learning design associated with the subject matter.

These findings resonate with Abulencia's (2013) assertions, emphasizing the significance of technology, particularly video-based communication, as a prevalent and effective instructional mode. Abulencia advocates for technology's role in enhancing instructional methods and catering to students' diverse needs. The positive outcomes observed in this study underscore the potential of VBI as a valuable tool for science teachers, enabling them to facilitate engaging and compelling learning experiences.

Table 3.4. Ease of use of VBI as learning remediation in teaching laws of thermodynamics in terms of increased engagement

No	Increased Engagement	WM	VI
1	Using instructional videos improved their motivation to work on their self-directed modules.	3.50	SE
2	The use of instructional videos reduced student's anxiety.	3.64	SE
3	Using instructional videos reduced tension in learning design related to the subject matter.	3.43	SE
4	Using VBI increases students' confidence in answering the task needed for submission.	3.64	SE
5	The use of video instructions helps to motivate students to learn at home.	3.64	SE
	Overall Weighted Mean	**3.57**	**SE**

Legend: n = 35
1 – (1.00-1.49) - Extremely Ineffective (EI)
2 – (1.50-2.49) - Ineffective (I)
3 – (2.50-3.49) - Effective (E)
4 – (3.50-4.00) - Strongly Effective (SE

Significant Relationship between Learning Achievement and Ease of Use of VBI as a Learning Remediation in Teaching Laws of Thermodynamics

The data analysis revealed a strong positive association, as indicated by the Pearson correlation coefficient (r = .971). This suggests that higher learning achievement among prospective science teachers is associated with greater ease of use of VBI as a learning remediation. Additionally, the coefficient of determination (r^2 = .94) signifies that 94% of the variation in learning achievement within the sample of 35 pre-service science teachers can be attributed to variations in the ease of use of VBI as a learning remediation. The computed t-test value of 22.92 surpasses the critical value of 2.03 at a 0.05 Alpha Level of Significance. This result provides compelling evidence for a significant relationship between learning achievement and the ease of VBI as a learning remediation in teaching the laws of thermodynamics. This conclusion aligns with the findings of Ketsman et al. (2018), who conveyed a significant correlation between learning achievement and the ease of using VBI.

Table 4. Test of significant relationship between learning achievement and ease of use of VBI as a learning remediation in teaching laws of thermodynamics

Pearson r	r^2	Relationship	computed value	critical value	Decision	Statistical Inference
.971	.94	Very high positive	22.92	2.03	Ho is rejected	Significant

Implementing interventions and innovative strategies in education proves invaluable for advancing learning outcomes and delivering high-quality, effective instruction. By incorporating tailored interventions, educators can address diverse learning needs and provide targeted student support (Pentang, 2021b; Prestoza, 2022). Innovative teaching methods, such as technology integration, project-based learning, and interactive approaches, capture students' interest and enhance their critical thinking and problem-solving skills. These dynamic strategies provide a more engaging and impactful educational experience, empowering learners to grasp complex concepts and apply knowledge in real-world contexts. Ultimately, the thoughtful integration of interventions and innovative approaches elevates the overall quality of instruction, ensuring that education remains a dynamic and responsive force for positive learning outcomes.

CONCLUSIONS

The findings yield significant insights into the effectiveness of VBI in teaching thermodynamics. The scarcity of literature on VBI underscores the importance of this research, positioning it as a pioneering contribution to the field. Notably, the study reveals that VBI, employed as a learning remediation strategy, positively impacted preservice teachers' achievement, as evidenced by a substantial increase in mean scores from the pretest to the posttest. The comparison using the t-test indicates a statistically significant difference, emphasizing the efficacy of VBI in teaching the laws of thermodynamics. The ease of implementation and the multifaceted benefits, including enhanced pedagogical content delivery, individualized learning focus, flexible pacing, and heightened engagement, underscore the robust effectiveness of VBI as a learning remediation tool. Science educators are encouraged to adopt this approach, leveraging its potential to improve students' understanding of thermodynamic concepts.

Furthermore, the study advocates for future research to delve deeper into college students' perceptions of VBI in learning thermodynamics. Acknowledging the limitations of the current research, such as a relatively narrow participant pool and the use of limited data collection instruments, underscores the need for more comprehensive studies. Recommendations for employing interviews to enrich the research scope suggest that future investigations should extend over a more prolonged period, possibly an entire semester. Additionally, exploring students' sustained engagement and improved material retention following exposure to VBI is proposed. This has potential implications for academic success, program retention, and degree completion. University faculty can benefit from these findings, gaining insights into effectively integrating VBI into their classrooms and optimizing its pedagogical advantages for an enhanced learning experience.

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