Thabiea : Journal of Natural Science Teaching
Vol. 5(2), pp. 98-117, 2022
Available online at
http://journal.iainkudus.ac.id/index.php/Thabiea
p-issn: 2580-8474, e-issn: 2655-898X

Development of Vodcast on Thermodynamics embedded with PhET Simulation for Enhanced Learning

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Keywords:
Develop
Vodcast
Thermodynamics
Phet Simulation
STEM

Abstract

The study was conducted intentionally to develop, evaluate, and do small-scale implementation of vodcast on thermodynamics as supplementary material. The study employed Research & Development framework of ADDIE model which includes the stages: Analysis, Design, Development, Implementation, and Evaluation. The sample size involved 12 in-service teachers who made the evaluation and 24 students in an online class during pandemic as the implementation part. The subsequent iterations produced significantly improved vodcast output, which was ultimately divided into three parts and made available to students via an unlisted YouTube account as the implementation platform. Teacher evaluations earned an overall score of 3.98, which is satisfactory, with an average grade of 4.36 (very satisfactory) for content, 3.65 (satisfactory) for delivery, and 3.94 (satisfactory) for technical production. All descriptive comments were accommodated into the final version of the vodcast and the Department of Education-approved required module was supplemented with the vodcast by volunteer respondents who participated in the online implementation. The enactment yielded an average pretest percentage of 40.833% and post-test percentage of 73.467% that correspond to a normalized gain of $\langle g \rangle = 0.55$ that is a medium gain. Reflection of in-service teachers revealed that the vodcast can be a stand-alone material in learning thermodynamics. As conclusion, using properly calibrated vodcasts can efficiently augment learning in difficult physics courses. It is recommended that vodcast be made on other topics in order to come up with an archive of readily-implementable vodcast in physics as well as other science subjects for a very effective STEM learning.

To cite this article:
Villaruz, M.M., Mahinay, C.J.D., Tutor, K.J.B., Malayao Jr, S.O. (2022). Development of Vodcast on Thermodynamics embedded with PhET Simulation for Enhanced Learning. *Thabiea : Journal of Natural Science Teaching*, 5(2), 98-117.

Introduction

This study incorporates interactive learning demonstrations into Thermodynamics. Thermodynamics is a branch of physics that deals with heat, work, temperature, and their relation to energy, radiation, and physical properties of matter. The learning of this subject requires prior knowledge of General Mathematics and Physics. According to experts, it is a subject that requires understanding and a conceptual training of the mind that requires a great deal of thought. Within Physics Education Research, great attention has been paid to students' difficulties in understanding the concepts and Laws of Thermodynamics. McClure (2021), stated that the concepts in thermodynamics tend to be fairly complex, and there's a good amount

of elaborate math involved. As a result, it can be kind of hard to keep up if you lose track of how the math relates to the concepts and vice versa. Studies by H. Aguilar et. al (2019), articulated thermodynamics is hard, according to a widely extended opinion of students that major in engineering, chemistry or science, and of many instructors, around the world. The difficulties in learning the subject have different sources pertaining to the contents, the textbooks, the students, the instructors, the academic institutions, etc. Such common pitfalls associated with problem-solving can result in difficulties as problems become more complicated.

Consequently, online technology is increasingly used in higher education and training. Recent advances in information and communication technologies (ICTs) have enabled the implementation of an array of tools, such as online tutorials, videos, podcasts and vodcasts, which are utilized within the education and business sectors. According to Fahimeh et. al (2014), in recent years they have witnessed the emergence of certain audio and visual recordings known as 'podcasts', which can be created and downloaded from certain Internet websites. Video podcasts (hereafter vodcasts) were used to manifest the audiovisual medium for eliciting the learners' incidental gains. In addition, vodcast is a type of podcast that contains full motion video where VOD, the first three letters of vodcast are an acronym for "video on demand" – but when coupled with podcast subscription is better described as a "vodcast." (IGI Global Publisher, 2022).

With the use of an e-Learning simulation course in Physics that employs distinct, simulated scenarios in a controlled setting can prepare learners for real-life problems. Hence, the use of simulation software, tools, and serious games is to enhance teaching and learning. Educators and researchers are now working to find and improve the usage of PhET (Physics Education Technology), particularly in the subject of Physics Education. While the bulk of PhET simulations (Sims) are used for Physics training, they are now being utilized for Chemistry, Biology, Arithmetic, and other disciplines. Hence, the researchers will demonstrate the application of PhET simulations on Thermodynamics to learners with a final product to be evaluated by the panel of teachers and experts who shall assess the quality and condition of the output produced. Since the prevailing opinion of students about physics is that it is boring, too abstract and completely irrelevant to everyday life, and as such useless which makes it not worth to learn, Freedman, R. A. (2014). Our study intends to prepare and provide Grade 12 STEM Learners with an effective learning material that will develop their digital literacy and critical thinking skills as to what time demands. A previous study from Forian, et al. (2014), stated that they have already shown that secondary school physics textbooks don't give enough emphasis on accurate presentation of idealizations and simplifications, which they usually assume when dealing with problems in secondary school physics. Hence, the researcher would like to develop a vodcast, particularly on Thermodynamics embedded with PhET simulation to enhance the learning of the students and for them to be more engaged in doing so.

Method

The study was descriptive in nature with a developmental paradigm utilizing the ADDIE (Analysis, Design, Development, Implementation, Evaluation) framework. From existing literatures about vodcast to success stories of classroom practices utilizing media served as the input. A single group of students served as the student respondents that underwent pretest,

implementation, and post-test. The evaluation phase is comprised of measures in the normalized gain and intrinsic motivation of the student respondents. Both achievement tests and intrinsic motivation were disseminated through google forms. The participants consisted content experts and students. And were limited only to 24 Grade 12 STEM students who were taking physics subject/courses and are officially enrolled for the School Year 2021-2022.

This study has utilized four research instruments which are:

Achievement test in Thermodynamics. A set of questions are used in this study for the assessment of the prior knowledge/pretest and posttest. The researchers used the data result for the analysis of the conceptual understanding of the respondents on Thermodynamics through normalized gain.

Adapted CTML-based Survey Questionnaire. Used to evaluate the perception of the teachers on the usefulness of vodcast in teaching and learning Thermodynamics. This was adapted from Ullah (2021).

Vodcast Perception Questionnaire. Used to evaluate the students' perception of the usefulness of the vodcast in Thermodynamics teaching-learning. This was adapted from Liwanag's (2021) Student Perception Questionnaire.

Research-made Vodcast. The researchers used a laptop and video editing software like Wondershare Filmora, Krisp, Elegant Teleprompter, as well as interactive and educational simulation-based software called Phet Interactive Simulations to create a vodcast on thermodynamics that could be used as comprehensive learning material.

The following steps are the process of gathering the data for the study.

Step 1: Analysis Stage

Before conducting the study, the researchers chose a science topic that is aligned with the curriculum guide, that students have a hard time understanding. The researchers choose the topic Ideal Gas law, The First Law of thermodynamics and The Second law of thermodynamics. Part of the Analysis was the literature review of studies making digital resources in science learning.

Step 2: Design Stage

The researchers planned a storyboard on the vodcast, and identified the tools to be used and used an adapted CTML-based survey questionnaire for the evaluation.

Step 3: Development Stage

Based on the design stage, the development stage involved the actual animation of the plans. The developed vodcast was evaluated by the content experts. Then, the researchers used the data on the average evaluation rating to improve the vodcast further.

The table 1 provides a 5-point Likert Scale-scoring guide for the evaluator's responses.

Table 1. Vodcast Evaluation Mean Rating Scale for Teachers

Interval	Description
4:20 – 5.00	Very Satisfactory
3.40 – 4.19	Satisfactory
2.60 – 3.39	Fairly Satisfactory
1.80 – 2.59	Unsatisfactory
1.00 – 1.79	Very Unsatisfactory

Step 4: Implementation Stage

During the implementation stage, the student took the pretest, watch the 3 installments of vodcast, then took the post-test.

Step 5: Evaluation Stage

Evaluation of the vodcast by the user was through the perception survey questionnaire. This was the measure of the intrinsic motivation of the students in using the vodcast. The normalized gain was also computed as the measure of the extent of learning that the vodcast can engender.

The following table provides a 5-point Likert Scale-scoring guide for the respondent's responses.

Table 2. Vodcast Perception Scale for Students

Interval	Description
4:20 – 5.00	Very Useful
3.40 – 4.19	Useful
2.60 – 3.39	Fairly Useful
1.80 – 2.59	Unuseful
1.00 – 1.79	Very Unuseful

The following methods are used to analyze the observational data that the researchers collected.

a.) Normalized Gain

To better understand the influence of the vodcast on the achievement of the grade 12 STEM students, the normalized gain score (g) was computed. The normalized gain score was the difference between the respondents' posttest and pretest percentage mean scores divided by the difference between the maximum possible percentage score and the respondents' pretest percentage mean score (Coletta & Steinart, 2020). This is shown in the following equation:

$$< g >= \frac{(post\ test\ score - pre\ test\ score)}{(perfect\ score - pre\ test\ score)}$$

The normalized gain score and criteria table was cited from Rani et al. (2017) and was adopted in this study and is shown in Table 3 below. The normalized gain score was also computed using an Excel spreadsheet.

Table 3. Normalized Gain Score and Criteria

Normalized Gain Score <g>	Criteria
0.70<g	High
0.31<g<0.70	Medium
g<0.30	Low

b.) Mean

To determine the usefulness of the vodcast. The **Department of Education Grading Scale** was used to measure the grade scale of the pretest and posttest results.

Table 4. Descriptors, Grading Scale and Remarks

Descriptors	Grading Scale	Remarks
Outstanding	90-100	Passed
Very Satisfactory	85-89	Passed
Satisfactory	80-84	Passed
Fairly Satisfactory	75-79	Passed
Did not meet expectations	Below 75	Failed

Results and Discussion

This part presents the results and discussion according to the overall procedure of the study following the ADDIE framework.

Step 1: Analysis Stage

Below was the MELC chosen for this study.

Table 5. K to 12 Basic Education Curriculum (STEM) Specialized subject

Content	Content Standard	Learning Competencies	Code
Ideal Gases and the laws of thermodynamics	Ideal Gas Law	Enumerate the properties of an ideal gases.	STEM_GP12GLTIIh-57
	First Law of Thermodynamics	State the relationship between changes internal energy, work done, and thermal energy supplied through the First Law of Thermodynamics.	STEM_GP12GLTIIh62
		Explain how entropy is a measure of disorder.	STEM_GP12GLTIIi-69
	Second law of thermodynamics	State the 2nd Law of Thermodynamics.	STEM_GP12GLTIIi70

The topic was supported by numerous research, each of which asserted a distinct theory concerning vodcast. The researchers read the publications listed in Table 6 below to aid in the production of the topic thermodynamics vodcast.

Table 6. Information Gleaned from Articles

Title	Author	Source	Findings
Difficulties in learning thermodynamics that have their origin in the subject matter.	H. Aguilar et.al (2019)	https://library.iated.org/view/AGUILAR2019DIF	The study stated that Thermodynamics is hard, according to a widely extended opinion of students that major in engineering, chemistry or science, and of many instructors, around the world. The difficulties in learning the subject have different sources pertaining to the contents, the textbooks, the students, the instructors, the academic institutions, etc.
Difficulties of Teaching and Learning the Concepts of Thermodynamics in the Secondary Education in Algeria	Douadi, Z., Sidali, R., Djaafar, D. (2018)	http://www.lajpe.org/dec18/12_4_01.pdf.	Researchers found many difficulties facing teachers in teaching some concepts such as heat and work, etc. and other difficulties facing students such as the existence of alternative perceptions to the students (eg: not differentiating between heat and temperature, absence of exchange of heat in the isothermal transformation). It has been shown that the reasons for these difficulties were diverse and the most important one is the lack of previous knowledge acquisition of students because they were not dealt with during the previous school years.
Difficulties of students from the faculty of science with regard to understanding the concepts of chemical thermodynamics.	Sokrat, H., Tamani, S., Moutaabbid, M., & Radid, M. (2014).	https://www.sciencedirect.com/science/article/pii/S1877042814002249 doi:10.1016/j.sbspro.2014.01.223	Found that the difficulties encountered in association with chemical thermodynamics may be due to several factors: - The nature of the concept studied in terms of the difficulty of understanding. Inadequate basic knowledge, especially in mathematics. - The ability of low and middle level students with regard to the French language impedes their ability to follow the explanations of the teacher. - Curriculum overload. - Lack of concentration during the course. - Lack of motivation of students.

Step 2: Design Stage

The researchers' schematic diagram for the video presentation Ideal Gases and the First and Second Laws of Thermodynamics is provided below.

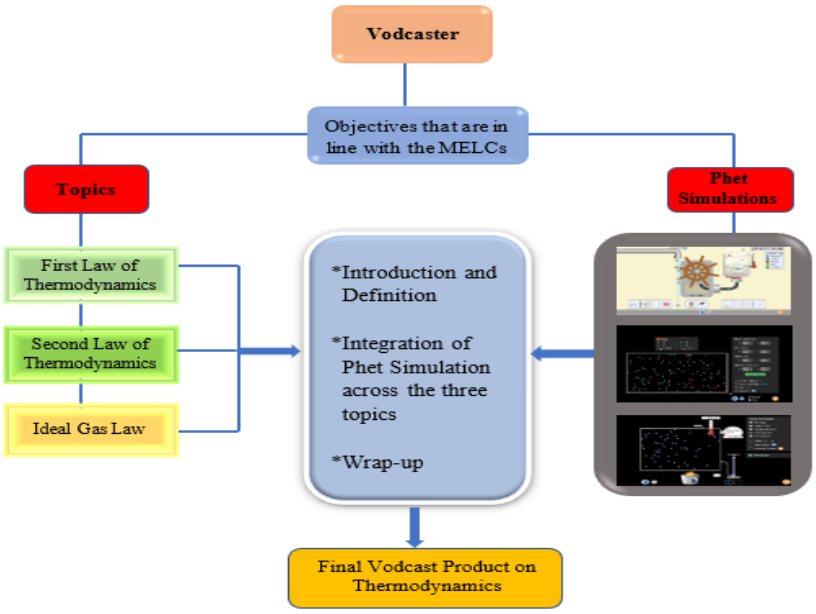


Figure 1. Schematic Diagram of the Developed Vodcast

As shown in Figure 1, the flow of vodcast can be pictorially summarized wherein each segment started with the vodcaster introducing the concept as based on DepEd MELCs then immediately followed by the PHET Simulation strategically calibrated to minimize the time while maximizing the content input. This flow can be further enhanced every completed cycle by studies that will utilize this protocol.

Step 3: Development Stage

During this stage, the first version of the vodcast was produced. This first version of the vodcast was essentially the functional form of prototype. The duration of the first version of the vodcast was 17 minutes and 51 seconds. Below (Figure 2) are the sample shoots of the first version of vodcast.

Figure 2. Sample Shoots of the First Version of Vodcast

After showing the version to the evaluators through an online modality, the researchers took note of the comments and suggestions of the content/ICT experts so as to provide a better

version of the vodcast on Thermodynamics. Thus, the following are the comments for improvements by the evaluators/content experts with their anonymous code (Table 7).

Table 7. Evaluators' Comments and Suggestions on Content

Code	Content	Action Taken
ST1/TCT1	Set a clear learning goal for your video (mention the expectations/goals). This objective is your guiding light for the rest of the video creation process. The content is bulky: Divide modules/video into smaller related chunks. Develop a separate vodcast for Ideal Gases.	The researchers dissected the video into smaller related chunks according to the three topics they had. The first video was the first law of thermodynamics, the second video was the second law of thermodynamics, third video was the Ideal Gases.
ST2/ICT2	Good example at the end with the basketball. Need to summarize content. Research as to how many minutes will a video/audio hold an audience's attention. I suggest you benchmark on TED Talks regarding this. What makes this vodcast different from a video? Since it has both audio and visual, isn't this considered a video as well?	What made this vodcast distinct from other videos was because of the embedded simulation therein particularly a Phet (Physics Education Technology) simulation wherein students can learn and picture the things that are hard to visualize and hard to explain by the teachers, especially in the field of thermodynamics. The content was being summarized and the video is now quite good for the attention span of the students. First Law was trimmed into 6 minutes and 49 seconds, second Law was trimmed into 5 minutes and 14 seconds, and Ideal Gases was trimmed into 13 minutes and 25 seconds.
ST3/ICT3	Objective should be revised. Objective could be stated in this way, demonstrate and explain the concepts of the First and Second Law of Thermodynamics, and the Ideal Gas Law using simulations. Remove the word interactive because only the teacher is interacting the simulation, the students cannot interact with those.	The objective was revised by the researchers to "Explain and demonstrate the particularly in the concepts of the first and second law of thermodynamics as well in the concepts of Ideal Gas Law using interactive simulation" into "Demonstrate and Explain the concepts of the First and Second Law of Thermodynamics, and the Ideal Gas Law using Phet Simulation." Bookmarks already eliminated.
ST4/ICT4	Please hide the bookmarks when you use a browser during a recording session. If you have enough time to add a "closed	The researchers worked their script beforehand to eliminate unnecessary words.

Code	Content	Action Taken
	caption" on your video, that would be great. Our intention is to capture the attention of our students specially we used different terms during the video. Close captions will be a good option to keep their attention. Also, you can work on your script beforehand to eliminate unnecessary words and be consistent with the lesson delivery. It is an advantage that you use a PHET simulation, but don't hurry the execution. You can prepare the slide with a consistent template, making it more presentable. Visit your EdTech lesson. Formulas must be properly expressed to avoid confusion. Use the "Insert" equation feature in MS Power point. Keep your camera level to your eyes, think that you are looking at the students.	The slide was in a consistent template and it was way more presentable than the first vodcast we made. Researchers properly expressed the formulas in the final vodcast. The researchers kept the camera level to their eyes like how they look at the students.

The evaluators' remarks and recommendations regarding the content were displayed in Table 7. The responses mostly dealt with a list of goals that should maybe be highlighted on the vodcast. The researchers took action by eliminating pointless topics from the outline and increasing the use of diagrams and simulations. Less verbose and centered on the simulations and graphs that complemented the MELCs, the PowerPoint was less verbose. The vodcast conversation was toned down and narrowed down on the particular goals chosen in the MELCs.

The opinions and recommendations of the assessors on the delivery portion of the vodcast were displayed in Table 8. Voice modulation and interactive difficulties received the majority of the responses. The researchers took action by enhancing voice modulation, making the narration more engaging for viewers, and used an elegant teleprompter to discuss the topic well.

Table 8. *Evaluators' Comments and Suggestions on Delivery*

Code	Delivery	Action Taken
ST7/ICT7	The presentation is more like a plain lecture. It can be improved by: Embedding questions in your instructional video (using programs) can improve student interaction and provide you with invaluable formative assessment data. Formulating guide questions. Facial expression and the voice quality (pitch, force, rate), enthusiastic tone.	The researchers embedded a question in the instructional video, as well the facial expression and voice quality was improved with enthusiastic tone.
ST8/ICT8	Questions given allow the audience to think. However, the tone of the speakers wasn't friendly or engaging. They seem	Researchers allowed the audience to think. The tone was quite friendly or engaging and researchers utilized

Code	Delivery	Action Taken
	to be just be reading a report and there's a lot of background noise. I suggest you utilize noise cancelling apps or devices to do this (example: Loom) and try to make it seem like you are talking to a friend.	noise cancelling apps or devices in the final vodcast. And researchers tried to talk like a friend.
ST9/ICT9	Try to have the tone or modulation to be accommodating to listeners. Some presenters were too serious in speaking. Try to ask questions during the simulation so that students can think. Don't spoon feed a lot. Show the questions as a caption when asked so that students have something to look at.	Researchers didn't spoon feed a lot in the final version we showed pictures and questions so students have something to look at.
ST10/ICT10	When you ask Q's, hold for few seconds before you give the explanation/the answer.	The researchers hold for few seconds before they gave the explanation or the answer.
ST11/ICT11	Improve enunciation.	The researchers improved their enunciation in the final vodcast.

The evaluator's comments and recommendations on the technical aspects of the vodcast production were displayed in Table 9. Responses focused primarily on the vodcast's length, presentation, and background noises. In order to reduce unneeded noise, the researchers used an isolated space, revised with a shorter runtime, and used a uniformed background.

Table 9. *Evaluators' Comments and Suggestions on Technical production*

Code	Technical Production	Action Taken
ST1/ICT1	The narration matches what is shown on the screen. Refrain from using too much effects and use better graphics. Instead of using PowerPoint presentation, I suggest you use Google Slides. Check out www.slidesgo.com or www.canva.com for appropriate and modern-style templates.	The researchers thus far refrained from using too much effects and used better graphics, instead of using power point researchers used slidesgo.com for appropriate and modern-style templates.
ST2/ICT2	Look for a more conducive space for recording of audio.	Researchers looked for a more conducive space for recording of audio.
ST2/ICT2	Background noise (e.g., vehicles passing by, chickens crowing, etc.) should be avoided. Background of the PPT should be consistent.	Researchers removed the background noise and the background of the ppt in the final version was already consistent.

Code	Technical Production	Action Taken
ST3/ICT3	Watch out for grammatical and pronunciation errors (example: Charles' or Charles's Law are accepted. It should not be Charle's Law). Video is too long. Try to focus vodcast on one topic such as only Ideal Gas Law, or only Laws of Thermodynamics.	Researchers watched out for grammatical and pronunciation errors, they changed Charle's Law to Charles's Law. Also, researchers attempted to focus vodcast on one topic such as only Ideal Gas Law, or only Laws of thermodynamics.
ST4/ICT4	The technical production was good.	NONE.
ST5/ICT5	3:42-3:46 and 4:28-4:44 - missing audio - After or before the simulation, you can add a visual representation on how energy transforms from one form to another. - In the 'Ideal Gas' PhET simulator, you can click the "width" button to show a numerical value of V in nm unit. - aside from presenting each gas law concepts in the simulator, might as well show an expression and/or graph that will represent/show the relationship of the properties involved - If the app you're using allows you to write texts as subscripts, write the numbers 1 and 2 (initial and final condition) as subscripts in each gas law eqn. You can also write Charles', Avogadro's and Gay-Lussac' equations in fraction form.	3:45-4:10 researchers indulged the audience with an audio as well in the clip of 4:28-4:44. Researchers added visual representations before and after the simulation. Researchers showed an expression or graph that will represent the relationship of the properties involved. Researchers revised the subscripts in each gas law equation.
ST12/ICT12	The voice of narrator is somehow strong visaya intonation need to practice in speaking fluent. But the rest are very good.	The researchers improved their intonation and spoke fluently.
ST8/ICT8	Work on having a clear and smooth transition from one subtopic to another. (Check 1:00 on your video). In one conference I have attended, a study was presented where audio quality is really important even over video. Hence, I am suggesting you use krisp.ai to remove background noise. It is free (until a month I guess).	Researchers worked on having a clear and smooth transition from one subtopic to another. Also, they used Krisp.ai for removing background noise
ST9/ICT9	[04:37] – Work on removing dead air or sudden gaps in audial output. I suggest adding transitory music on those parts.	Researchers added transitory music for the entire video.

As a result, the researchers' study panel and a few chosen teacher-colleagues evaluate and validate all of the early versions of the vodcast, achievement exam, and survey questionnaire. Their early comments formed the basis of the revision, which is now taken into account. Hence, the sample first version of the vodcast is shown in the following figures below in contrast to the sample final version.

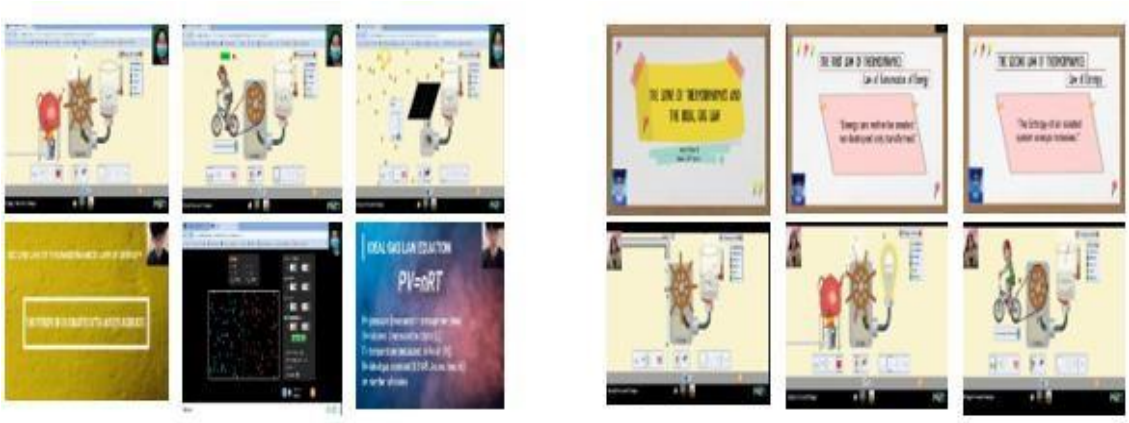


Figure 3. Comparison of First and Second version of Vodcast

As shown in Figure 3, the content of the vodcast is divided into three parts: The First Law of Thermodynamics, Second Law of Thermodynamics, the Ideal Gas Law. The final version of the vodcast already had the same background throughout the clip. It has a runtime shorter than the first version; we had split it into three chunks following the three topics that researchers had. After the revision, the unnecessary noise is removed. The PowerPoint was less wordy and focused on the simulations and diagrams aligned with the MELCs. The enunciation of the speakers was improved. The vodcast discussion is lessened and focused entirely on the specific objectives selected in MELCs. The shorter duration primarily addresses the short attention span of students, it also works compatible with the unreliable internet data access of the students and the relatively low storage capacity typical of the smartphones they are using. The vodcast is edited for the final version with the feedback from the research panel and selected teachers during the design stage. This version of the vodcast was trimmed into 6 minutes and 49 seconds for the Law of Conservation of Energy, 5 minutes and 14 seconds for the Law of Entropy, and 13 minutes and 25 seconds for the Ideal Gas Law.

Moreover, the researchers have used data on the average evaluation rating of the vodcast as obtained from the researcher-developed vodcast evaluation survey result. Based on the five-point Likert scale-response, the following table provides the vodcast evaluation survey result and its descriptions from the content/ICT expert-evaluators.

As shown in the table 10, the content of the vodcast was rated as very satisfactory at an average mean of 4.36. It showed that the target of the vodcast in discussing the specific MELC was aimed.

Table 10. Vodcast Evaluation Survey Result for Content

Content The vodcast I watched….	Mean Rating	Description
Is targeted according to the Most Essential Learning Competency (MELC).	4.50	Very Satisfactory
Will help students learn better on the properties and characteristics of the Ideal Gases as they will be able to "see" or visualize the concept which is otherwise difficult with just the module alone.	4.17	Satisfactory
Will help students learn better on the topic "First law of thermodynamics" as they will be able to "see" or visualize the concept which is otherwise difficult with just the module alone.	4.50	Very Satisfactory
Will help students learn better on the topic "Second law of thermodynamics" as they will be able to "see" or visualize the concept which is otherwise difficult with just the module alone.	4.25	Very Satisfactory
AVERAGE MEAN	**4.36**	**Very Satisfactory**

Into the bargain, evaluators accorded that the Vodcast embedded with Phet Simulation was one way to creatively present the concept and properties of Ideal Gases and the laws of Thermodynamics, as they will be able to "see" or visualize the concept which is otherwise difficult with just the module alone.

The component delivery garnered a satisfactory rating with an average mean of 3.65, as indicated in table 11. Additionally, reviewers agreed that the vodcast's amiable tone or narration helped viewers understand the subject. It could be because the vodcast was much more interactive to keep the students' attention and they were more at ease watching it than listening to the teacher discuss it in person in the classroom.

Table 11. Vodcast Evaluation Survey Result for Delivery

Delivery The vodcast I watched….	Mean Rating	Description
Made the topic easier to understand with its friendly language/narration.	3.75	Satisfactory
Will hold the attention of students throughout the duration with its conversational voice/narration.	3.42	Satisfactory
Will make students feel like their teacher is there with them keeping them company and helping them in learning the content/topic.	3.67	Satisfactory
Featured guide questions that will get students "thinking critically" about the topic.	3.75	Satisfactory
AVERAGE MEAN	**3.65**	**Satisfactory**

Technical production received a satisfactory rating with an average mean of 3.94, as indicated in table 12. The most important aspects of creating a vodcast were the audio and visual components. The researchers shot their portions of the first vodcast in their individual houses as it was being produced throughout the pandemic. Before implementing the vodcast from the respondents, the researchers worked on revising the remarks from the assessors in the content, delivery, and technical production component.

Table 12. Vodcast Evaluation Survey Result for Technical Production

Technical production **The vodcast I watched….**	**Mean Rating**	**Description**
Is clear and free from unnecessary or distracting texts, images, or scenes.	3.92	Satisfactory
Have clear audio/voice/narration and is free from distracting noise.	3.67	Satisfactory
Have matching on-screen visual information (texts, images, or scenes) and audio/voice/narration.	4.33	Very Satisfactory
Is not too long or too short in duration that students will be able to watch from start to end.	3.83	Satisfactory
AVERAGE MEAN	**3.94**	**Satisfactory**

As shown in Table 13, the first version of the vodcast was evaluated as satisfactory in all three indicators, with an overall mean rating of 3.98. This is interpreted, that evaluators found the vodcast satisfactory as a modification of the DepEd module on thermodynamics. Hence, recommended for use under MDLM (Modular Distance Learning Modality). Although background noise and voice modulation issues that were rectified in the version caused certain delivery and technical production to receive the lowest ratings. The post-assessment test, however, was given to the STEM students in grade 12 from the same school concurrently with the vodcast evaluation.

Table 13. Overall Mean of Vodcast Evaluation Survey Result

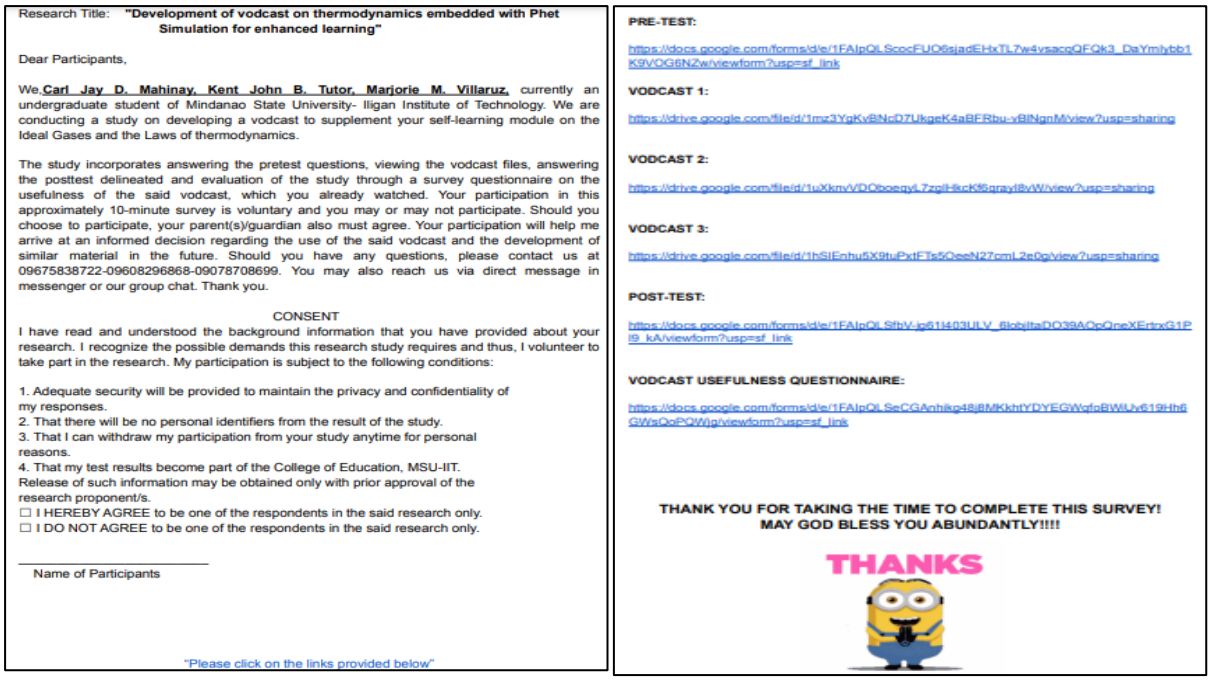
Indicators	**Average Mean**	**Description**
Content	4.36	Very Satisfactory
Delivery	3.65	Satisfactory
Technical Production	3.94	Satisfactory
Overall Mean	**3.98**	**Satisfactory**

As a result, the final decisions of the researchers were to divide the vodcast into 3 segments corresponding to First Law of Thermodynamics, Second Law of thermodynamics, and Ideal Gas Law. The segments were uploaded in an unlisted YouTube channel.

Step 4: Implementation Stage

The stages of implementation involved pretest, implementation, and post-test. To effectively facilitate the implementation the researchers made a google docs link that served as a portal for the pretest answerable in a google form link, vodcast link, and post-test link. Besides, to know the perception of the respondents, a separated google form link of the usefulness survey questionnaire is produced.

Below are the screenshots of how we conducted and reached our respondents through online survey modality.



Research Title: **"Development of vodcast on thermodynamics embedded with Phet Simulation for enhanced learning"**

Dear Participants,

We, **Carl Jay D. Mahinay, Kent John B. Tutor, Marjorie M. Villaruz,** currently an undergraduate student of Mindanao State University- Iligan Institute of Technology. We are conducting a study on developing a vodcast to supplement your self-learning module on the Ideal Gases and the Laws of thermodynamics.

The study incorporates answering the pretest questions, viewing the vodcast files, answering the posttest delineated and evaluation of the study through a survey questionnaire on the usefulness of the said vodcast, which you already watched. Your participation in this approximately 10-minute survey is voluntary and you may or may not participate. Should you choose to participate, your parent(s)/guardian also must agree. Your participation will help me arrive at an informed decision regarding the use of the said vodcast and the development of similar material in the future. Should you have any questions, please contact us at 09675838722-09608296868-09078708699. You may also reach us via direct message in messenger or our group chat. Thank you.

CONSENT

I have read and understood the background information that you have provided about your research. I recognize the possible demands this research study requires and thus, I volunteer to take part in the research. My participation is subject to the following conditions:

1. Adequate security will be provided to maintain the privacy and confidentiality of my responses.
2. That there will be no personal identifiers from the result of the study.
3. That I can withdraw my participation from your study anytime for personal reasons.
4. That my test results become part of the College of Education, MSU-IIT. Release of such information may be obtained only with prior approval of the research proponent/s.

☐ I HEREBY AGREE to be one of the respondents in the said research only.
☐ I DO NOT AGREE to be one of the respondents in the said research only.

_____
Name of Participants

"Please click on the links provided below"

PRE-TEST:

https://docs.google.com/forms/d/e/1FAIpQLScocFUO6sjadEHxTL7w4vsacqQFQk3_DaYmlybb1K9VOG6NZw/viewform?usp=sf_link

VODCAST 1:

https://drive.google.com/file/d/1mz3YgKvBNcD7UkgeK4aBFRbu-vBlNgnM/view?usp=sharing

VODCAST 2:

https://drive.google.com/file/d/1uXkmVDOboeqyL7zgHkcKf6qray18vW/view?usp=sharing

VODCAST 3:

https://drive.google.com/file/d/1hSIEnhu5X9tuPxtFTs5OeeN27cmL2e0g/view?usp=sharing

POST-TEST:

https://docs.google.com/forms/d/e/1FAIpQLSfbV-jp61I403ULV_6lobjltaDO39AOpQneXErtxG1PI9_kA/viewform?usp=sf_link

VODCAST USEFULNESS QUESTIONNAIRE:

https://docs.google.com/forms/d/e/1FAIpQLSeCGAnhlkg48j8MKkhtYDYEGWqfpBWiUv619Hh6GWsQoPQWjg/viewform?usp=sf_link

THANK YOU FOR TAKING THE TIME TO COMPLETE THIS SURVEY!
MAY GOD BLESS YOU ABUNDANTLY!!!!

THANKS

Figure 5. Screenshots of the Study's Online Survey

The assent and consent form for our respondents to participate in a research study is displayed on the left side, and the links' proper entry order is displayed on the right side.

Step 5: Evaluation Stage

The outcomes of the pretest and posttest were further examined to produce better results at this level. Knowing how the vodcast affected the respondents' performance on the test, Thermodynamics. The normalized gain score includes the outcomes of the pretest and posttest calculation as thoroughly covered in the evaluation stage.

As shown in Table 14, eight (8) got a high normalized gain, eleven (11) got medium and five (5) had a low normalized gain. Overall, the respondents posted a uniform medium gain score on the topic Thermodynamics. The overall pretest mean score was 12.25 while the overall posttest mean score was 22.04. Using the normalized gain score formula shown in chapter 2, the overall normalized gain score is computed to be 0.54 and is level as medium.

Table 14. Normalized Gain Score Analysis

Respondents No.	Pretest Raw Score	Posttest Raw Score	Normalized Gain	Description
1	15	24	0.60	Medium
2	18	25	0.58	Medium
3	6	24	0.75	High
4	13	27	0.82	High
5	17	30	1.00	High
6	16	20	0.29	Low
7	18	29	0.92	High
8	16	22	0.43	Medium
9	10	14	0.20	Low
10	7	23	0.70	High
11	13	14	0.06	Low
12	8	24	0.73	High
13	9	25	0.76	High
14	8	20	0.55	Medium
15	12	21	0.50	Medium
16	12	13	0.06	Low
17	11	21	0.53	Medium
18	11	20	0.47	Medium
19	12	27	0.53	Medium
20	13	22	0.53	Medium
21	7	23	0.70	High
22	8	20	0.55	Medium
23	17	18	0.08	Low
24	15	23	0.53	Medium
Overall Mean	**12.25**	**22.04**	**0.54**	**Medium**

Moreover, during this stage, the vodcast usefulness survey result was further analyzed towards a better understanding of the influence of vodcast from the respondents' perception. Hence, the following Table 15 is the vodcast usefulness survey result of the students.

The vodcast was perceived as very useful by the same 24 student-respondents who took the achievement test in both pre- and post- vodcast instructions. Therewith, the respondents found the vodcast very useful as a complete learning material for the concepts of Ideal Gas Law and on the covered Laws of Thermodynamics. All vodcast indicators were perceived as very useful with an overall rating of 4.56.

Table 15. Vodcast Usefulness Survey Result

Statements	Mean Rating	Description
I believe that watching the vodcast made me more interested with the lesson.	4.71	Very Useful
I believe that the vodcast enabled me to relate to real life situations.	4.50	Very Useful
I felt like the vodcast I watched and interacted with is helping me develop good conceptual understanding and even good communication skills.	4.33	Very Useful
I enjoy learning from the lessons presented in the vodcast.	4.54	Very Useful
For me, the vodcast embedded with PhET simulation is important for my improvement because it encourages me to find more information and ask questions.	4.75	Very Useful
The vodcast allows us to develop and acquire good values and character.	4.42	Very Useful
I believe that the question and-answer activities in the vodcasts challenge me to succeed and do my very best.	4.50	Very Useful
I gained new self-regulated learning strategies and techniques through the vodcast such as taking down notes, sharing ideas with others, and having further research.	4.58	Very Useful
I watched and learned from the vodcast because I wanted and liked it.	4.54	Very Useful
I think that the vodcast motivated me to perform better because I believe it is not about having good grades but it is in learning that I could use in the future.	4.46	Very Useful
The vodcast makes me feel that the teacher is there with me, helping me in learning the content/topic.	4.58	Very Useful
The vodcast is not too long or too short in duration that I can watch from start to end.	4.58	Very Useful
I find the topic easier to understand by watching the vodcast.	4.38	Very Useful
I can control the rate and sequence of vodcast and to review the topic anytime.	4.71	Very Useful
The vodcast cleared out my misconceptions on the laws of thermodynamics and the ideal gas law.	4.75	Very Useful
Overall Mean	**4.56**	**Very Useful**

Adapted from Liwanag's (2021) Student Perception Questionnaire which she adapted from Deci and Ryan (1994)

1= Not all true; 2=Occasionally true; 3=Somewhat true; 4=Frequently true; 5= Very true

Utilizing legitimately calibrated vodcasts can productively expand learning in difficult physics courses. Through vodcast understudies can effectively learn and get it the subject by fair clicking and rewinding the video in the event that they were not able to comprehend expeditiously. Vodcast can motivate and inspire learners who are determine to learn physics

subject and can help instructors to clarify the thing that cannot be explained through words. In any case, the essential reason for the vodcast notoriety to understudies was that they felt that it helped to improve their learning (Kay, 2012). Hence, the impact of vodcast to learners had a more prominent affect towards their understanding that made them choose vodcast as very useful.

As such, a study from Čubrilo et.al (2014) stated that multimedia teaching has statistically significant increase in the retention of knowledge quality compared to the traditional teaching method in the category of applying that leads to the conclusion that the use of multimedia had the greatest effect on the highest level of knowledge. Hence, in arrange to upgrade the educating and learning of Thermodynamics, the approach to instructing thermodynamics must be advanced from the conventional strategy to a more advanced strategy such as utilizing computer innovation and interactive media since learning could be a process of acquiring and synthesizing thoughts and ideas. The method not as it were includes getting data but too full support by the learner (student-centered learning).

Conclusion

Based on the findings of this study, the vodcast was developed and was segmented into three topics: First Law of Thermodynamics, Second Law of Thermodynamics, and the Ideal Gas Law which made accessible to understudies through an unlisted YouTube account as the usage stage. The vodcast was rated satisfactory with an overall mean rating of 3.98 (satisfactory) by the content/ICT expert-evaluators. Earning this rating, the vodcast is prescribed as a total learning fabric for utilization on the subject previously mentioned above. Moreover, the usefulness level was at “very useful” with a mean rating of 4.56 as perceived and rated by the chosen public senior high school, particularly from the Grade 12 STEM student-respondents. Subsequently, the “satisfactory” rating from the 12 content and ICT expert evaluators and the “very useful” rating of the same vodcast from the 24 student-respondents corroborate the positive influence of the vodcast on the achievement level of the student respondents for the topics Ideal Gas Law, and the Laws of Thermodynamics in coverage of grade 12 STEM learners under the MDLM. Along with, the enactment yielded an average pretest percentage of 40.833% and post-test percentage of 73.467% that correspond to a normalized gain of $\langle g \rangle = 0.55$ that is a medium gain. Therefore, this shows that the vodcast had a positive impact on the student-respondent's understanding of the subject matter. Besides, the reflection of in-service teachers revealed that the vodcast can be a stand-alone material in learning thermodynamics. For this reason, using properly calibrated vodcasts can efficiently augment learning in difficult physics courses, and is recommended that vodcast be made on other topics in order to come up with an archive of readily-implementable vodcast in physics as well as other science subjects for a very effective STEM learning.

Acknowledgment

The researchers would like to extend their profound gratitude and appreciation to everyone who contributed to the completion of this study and helped make it successful through their inspiration, support, and direction. The successful completion of this study would not have been possible without the invaluable contribution of: **Asst. Prof. Ellen J. Castro, MSciEd**, and **Mr. Kim P. Diate, MSciEd**, for their significant input towards the improvement of this study and also for facilitating the submission/retrieval of the work-in-progress versions of the manuscript; The **teachers** and **expert-evaluators** who contributed to the development of the instruments of this study; and **all of the Grade 12 STEM respondents** in the selected pubic school as the participants. We shall be grateful to them.

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