ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Simplified Wave Energy Converter: An Apparatus for Teaching Energy Transformation

Jude Christopher R. Bolanio*[1], Dr. Rezy V. Mendaño[2]
[1] Pangdan National High School
[2] Samar State University
Corresponding Author e-mail: *judebolanio@gmail.com*

Received: 22 August 2025 **Revised**: 27 September 2025 **Accepted**: 30 September 2025

Available Online: 03 October 2025

Volume IV (2025), Issue 4, P-ISSN – 2984-7567; E-ISSN - 2945-3577

https://doi.org/10.63498/etcor471

Abstract:
Aim: This study aimed to develop and evaluate the effectiveness of a simplified Wave Energy Converter (WEC) apparatus as an instructional tool for teaching energy transformation. Specifically, it sought to design the device, assess its instructional, technical, and adaptability qualities, and compare the pre-test and post-test performance of students taught with the WEC versus traditional methods.
Methodology: A quantitative developmental research design was employed with 60 Grade 9 students from Pangdan National High School. Instruments included a researcher-developed evaluation tool for the WEC apparatus and a test questionnaire for pre- and post-tests. Data were analyzed using descriptive and inferential statistics to measure instructional impact.
Results: The WEC apparatus was developed as a functional, cost-effective, and replicable instructional tool. Expert evaluation yielded "very good" ratings for instructional quality (3.78), technical quality (3.89), and adaptability (3.86). Pre-test results showed both groups performed similarly. Post-test results revealed greater improvement in the experimental group ($M = 22.73$, $SD = 3.34$) compared to the control group ($M = 18.53$, $SD = 3.42$). Statistical analysis confirmed significant differences ($p < 0.05$), highlighting the effectiveness of the WEC in enhancing conceptual understanding.
Conclusion: The experimental group demonstrated significantly higher gains in learning performance, confirming the WEC apparatus as an effective, low-cost tool for teaching energy transformation in science education.
Keywords: *Wave Energy Converter, energy transformation, science apparatus, science education*

INTRODUCTION

Physics education is crucial in shaping students' understanding of the fundamental principles that govern the universe, including matter, energy, motion, and forces. As an integral part of science education, physics equips students with critical thinking skills, problem-solving abilities, and a foundation in scientific literacy. However, due to its abstract nature, many students find physics challenging to comprehend (Sobremisana, 2017).

Approaches and strategies used in learning environments significantly affect students' access to knowledge, while improved teaching techniques and resources can enhance participation and cognitive processing. One of the most effective approaches to physics teaching is to complement theoretical explanations with practical applications in the laboratory (Ojediran et al., 2014). Teachers can make the curriculum more relevant by incorporating locally accessible materials and real-world experiences, thereby fostering active learning and inquiry (Okori & Jerry, 2017). In this context, improvisation in teaching offers numerous benefits, including student engagement, creativity, and stronger teacher-student interaction (Holdhus et al., 2016; Bontuyan, 2025).

Improvisation empowers teachers to take control of their practice and serve as change agents in their communities. It encourages innovation, resilience, and proactive responses to educational challenges, contributing to overall instructional quality (Okori & Jerry, 2017). Supporting this view, Luza-Tabiolo (2018) concluded that improvised laboratory apparatuses positively influence student performance in science, especially in experimental

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

settings. Similarly, recent studies highlight that reflective and adaptive teaching practices enhance inclusivity and learner engagement in diverse classrooms (Bontuyan, 2024).

Despite these promising approaches, a recurring issue in the Philippine context is the inadequacy of instructional materials and laboratory facilities. The Department of Education (DepEd) has long reported a severe lack of science laboratory equipment in public elementary and secondary schools (Pacadaljen, 2024). This scarcity contributes to the underperformance of Filipino students in science, as reflected in the 2014 National Achievement Test (NAT), where only 46.38% achieved passing scores (Ambag, 2018). Recent data from the Programme for International Student Assessment (PISA) further emphasized this concern. In PISA 2022, Filipino students scored 355 in mathematics, 347 in reading, and 356 in science—consistently below the Organisation for Economic Co-operation and Development (OECD) average. Only 23% of students achieved basic proficiency in science, positioning the Philippines among the lowest-performing countries (Chi, 2023; OECD-PISA, 2022).

The findings suggest that reliance on traditional lecture-based methods limits engagement and comprehension in physics. Students often struggle with abstract concepts, especially energy transformation, where they fail to apply knowledge of kinetic and potential energy to different contexts (Becker & Cooper, 2014; Herrmann-Abell & DeBoer, 2018). These difficulties are compounded by the shortage of qualified science teachers, lack of suitable textbooks, and minimal access to laboratory resources (Sobremisana, 2017).

Pangdan National High School in Samar Province reflects these broader challenges. The absence of sufficient laboratory equipment and instructional tools hinders students' ability to fully grasp scientific concepts. Teacher observations revealed that while some students demonstrated confidence when asked about energy transformation, many were uncertain and unable to explain processes such as energy transfer. This learning gap highlights the need for innovative and low-cost instructional materials to improve physics teaching outcomes.

To address this gap, this study proposes the development of a simplified Wave Energy Converter (WEC) apparatus. This device serves as a cost-effective and replicable instructional aid designed to enhance students' conceptual understanding of energy, energy transformation, and energy transfer processes. By integrating practical experimentation with theoretical instruction, the WEC aims to provide students with meaningful learning experiences and improve science performance in resource-constrained schools.

Conceptual Framework

The present study is anchored on the principle that integrating practical instructional tools into teaching facilitates meaningful learning and improves retention of abstract scientific concepts. A simplified Wave Energy Converter (WEC) device was developed and evaluated in terms of instructional quality, technical soundness, and adaptability.

The framework follows a structured process. First, Grade 9 learners were given a pre-test to assess baseline knowledge of energy transformation. The WEC apparatus was then integrated into classroom instruction as an experimental tool. After exposure to the apparatus and its instructional application, students took a post-test to measure knowledge acquisition.

The results from pre- and post-tests were analyzed statistically to determine the effectiveness of the WEC as a learning aid. Expert validators also assessed the apparatus to ensure its instructional relevance, technical reliability, and adaptability to classroom contexts. This framework emphasizes the link between innovative instructional material development and improved student performance, reflecting broader calls for responsive and sustainable teaching practices in Philippine science education.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

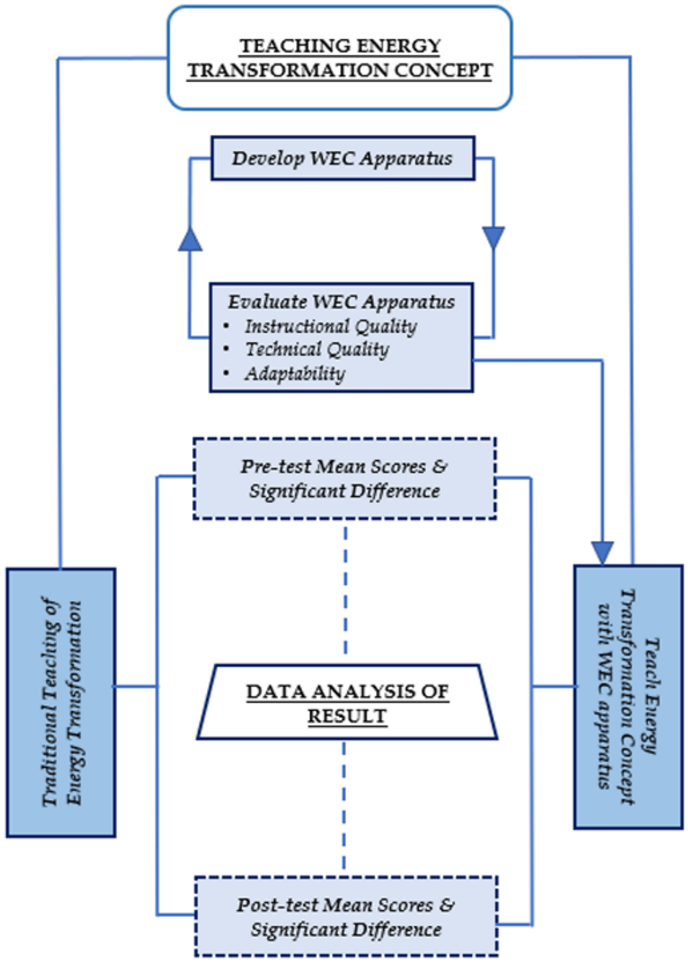


Figure 1. The Conceptual Framework of the Study

Statement of the Problem

Physics, as a core component of science education, plays a critical role in developing students' scientific literacy, problem-solving skills, and understanding of natural phenomena. However, despite its importance, many Filipino learners continue to struggle with physics concepts, particularly in energy and energy transformation, due to limited access to laboratory equipment and insufficient instructional materials. The persistent lack of science laboratory facilities in Philippine public schools, coupled with low performance in national and international assessments such as the National Achievement Test (NAT) and the Programme for International Student Assessment (PISA), highlights a pressing educational challenge. These issues are compounded by the inadequacy of locally relevant and affordable instructional tools that can bridge theoretical knowledge with practical applications. In Pangdan National High School, as in many rural institutions, these challenges manifest in students' weak grasp of energy transformation processes. This situation underscores the urgent need for innovative, low-cost, and context-appropriate instructional devices that can enhance students' conceptual understanding and engagement. Against this backdrop, the present study addresses the gap by developing and evaluating a simplified Wave Energy Converter (WEC) apparatus as an instructional tool to improve the teaching and learning of energy transformation.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Research Objectives

General Objective

- To develop and evaluate the effectiveness of a simplified Wave Energy Converter (WEC) apparatus as an instructional tool for teaching energy transformation principles.

Specific Objectives

1. To develop a Wave Energy Converter (WEC) apparatus as an instructional tool in teaching energy transformation concepts.
2. To evaluate the developed WEC apparatus in terms of instructional quality, technical quality, and adaptability.
3. To determine the mean scores of the two groups of respondents (WEC device group and traditional teaching method group) in terms of pre-test and post-test scores.
4. To examine the significant difference between the mean scores of the two groups of respondents in their pre-test and post-test results.

Research Questions

This study sought to answer the following research questions:

1. How can a Wave Energy Converter (WEC) apparatus be developed as an instructional tool in teaching energy transformation concepts?
2. How effective is the developed WEC apparatus in terms of instructional quality, technical quality, and adaptability?
3. What are the pre-test and post-test mean scores of the two groups of respondents (those taught using the WEC apparatus and those taught using the traditional teaching method)?
4. Is there a significant difference between the pre-test and post-test mean scores of the two groups of respondents?

Hypothesis

Based on the questions mentioned above, the following null hypotheses of the study were tested:

1. There is no significant difference between the mean scores of the two groups in the pre-test and post-test when taught using the improvised Wave Energy Converter (WEC) and the traditional teaching method.
2. There is no significant difference between the post-test mean scores of the two groups of respondents who were taught using the improvised Wave Energy Converter (WEC) and those who received instruction through the traditional teaching method.

METHODS

Research Design

This study employed a quantitative method utilizing a developmental research design. Developmental research is a systematic study of designing, developing, and evaluating instructional programs, processes, and products (Richey & Klein, 2014). This design was appropriate since the study intended to develop and evaluate a Wave Energy Converter (WEC) apparatus as a learning tool for teaching energy transformation in a resource-limited setting. Furthermore, a quasi-experimental pretest-posttest nonequivalent groups design was applied (Lash & Rothman, 2020). This design was deemed suitable as student-participants were grouped according to shared characteristics rather than random selection. By comparing the performance of groups exposed to the intervention with those that were not, the researchers were able to evaluate the effectiveness of the created instructional tool. The combination of developmental research with a quasi-experimental approach allowed for the systematic construction of the instructional apparatus and a robust assessment of its influence on students' learning outcomes. Such methodological integration aligns with best practices in educational research for improving instructional innovations (Amihan et al, 2023).

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Population and Sampling

The participants in this study were Grade 9 students from Pangdan National High School, under the Schools Division of Catbalogan City. The selection of participants was purposive rather than random. The researcher identified students who met the inclusion criteria based on their academic records and attendance. Qualified students were then divided into two intact groups: the control group (30 students), which received traditional instruction, and the experimental group (30 students), which received instruction using the WEC apparatus. This sampling approach allowed for a focused assessment of the WEC apparatus's impact on students' conceptual understanding of energy transformation. Ensuring equitable participation reflected the principles of inclusive and responsive classroom-based research (Bontuyan, 2025).

Instrument

Two primary instruments were employed in this study. First, a researcher-developed evaluation tool for the WEC apparatus was designed to assess its instructional quality, technical quality, and adaptability. This tool was validated by experts, including master teachers and seasoned science educators with decades of teaching experience. Second, a 30-item test questionnaire was administered during the pretest and posttest phases to evaluate students' understanding of energy transformation concepts. The questionnaire was developed based on a Table of Specifications (TOS) to ensure content validity and alignment with curriculum standards. The evaluation and validation process underscored the importance of rigorous instrument development in producing reliable findings in education research (Sanchez, 2025).

Data Collection

The data-gathering procedure was carefully planned and conducted at Pangdan National High School, with strict adherence to ethical and administrative requirements. The process involved iterative testing, modification, and refinement of the WEC apparatus based on expert feedback and preliminary trials conducted in the early months of 2025. Data collection began with the expert evaluation of the WEC, followed by the administration of a pretest questionnaire to establish baseline data on students' conceptual understanding of energy transformation at the beginning of the fourth quarter of School Year 2024–2025. The experimental group was then taught using the WEC apparatus as part of their science instruction, while the control group continued receiving conventional teaching methods. After the intervention period, a posttest identical to the pretest was administered to both groups to measure changes in students' comprehension. This phased process allowed for systematic data generation, ensuring that findings were grounded in evidence-based classroom practice (Carvajal et al., 2025).

Treatment of Data

The data collected underwent rigorous quantitative analysis to evaluate the effectiveness of the WEC apparatus. Descriptive statistics such as mean and standard deviation were employed to summarize the performance of the students. Inferential statistics, specifically independent samples t-tests, were conducted to compare the mean scores of the experimental and control groups. Statistical software was used to ensure accuracy and consistency in the analysis. This treatment of data provided both descriptive insights and inferential evidence of the WEC's impact on learning, consistent with approaches in contemporary educational impact studies (Pangilinan, 2025).

Ethical Considerations

This study adhered to strict ethical guidelines to protect the rights, safety, and well-being of all participants. Ethical clearance was obtained from the Institutional Ethics Review Board, and authorization was secured from the Schools Division Superintendent to ensure compliance with institutional and educational policies. Participation was voluntary, with informed consent obtained from both students and parents. The principles of confidentiality, transparency, and academic integrity were strictly observed throughout the research process.

RESULTS and DISCUSSION

This chapter presents the analyses of the data obtained and the corresponding interpretation in connection with the specific questions of the study.

Development of the Wave–Energy Converter Apparatus

The development started in the primary months of 2025, in which the Wave Energy Converter (WEC) apparatus followed a structured process, from conceptualization through design, material selection, assembly, and

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

testing, to ensure its functionality as an instructional tool for teaching energy transformation principles. The WEC apparatus was designed to demonstrate the conversion of wave motion into electrical energy. It consists of a float system, a mechanical linkage system, and a small generator that converts mechanical movement into electrical energy. An ammeter was integrated into the system to serve as a visual indicator of successful energy conversion.

Table 1 presents the materials used in constructing the WEC, along with their specifications and functions. The selection of materials prioritized durability, affordability, and accessibility, ensuring that the apparatus can be easily replicated in resource-limited educational settings.

Table 1. Materials and Specifications of the WEC Apparatus

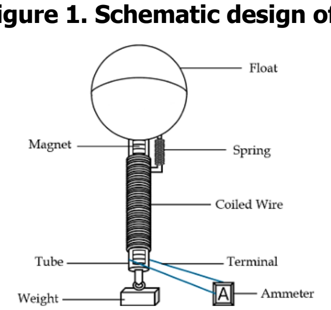
Component	Material Used	Cost	Specification	Purpose/Function
Generator	Enamel Coated Magnet Wire Glass Cylinder Rare Earth Magnet	50 php 150 php 300 php	0.5 mm thickness 1.3 cm diameter 5 mm x 3 mm & 12 mm x 5 mm	Converts mechanical energy to electrical energy
Float with Spring	Plastic and Metal	200 php	10-inch diameter	Captures the oscillating wave energy
Ammeter	Ammeter	300 php	3 amperes	Measures generated current and an indicator of energy conversion
Total Cost: 1,000 PHP				

Assembly Process

The construction process involved the installation of the float system using a buoy, which oscillates with wave motion, transferring energy through a linear tube connected to the generator system. The generated electrical energy is detected and measured by an ammeter, illustrating the principle of energy transformation from mechanical to electrical energy. The process involved the following steps:
Step 1. Prepare and measure all necessary materials.
Step 2. Weave the wire around the test tube to form a coil (approximately 150 coils). Use tape to secure the wire to the tube. Leave some length of wire available on both coil ends to create connections.
Step 3. Remove the insulation from the wire ends using sandpaper to ensure a precise flow of current to the ammeter.
Step 4. Make a ring at the bottom of the tube with hot glue to secure the weight.
Step 5. Attach the spring mechanism to the side of the buoy and drill a hole on one side of the spring to allow its hook to slide.
Step 6. Connect the other side of the spring to the tube using hot glue or tape to secure the floating mechanism and spring mechanism together.
Step 7. Secure the magnets on the bottom of the float and slide them inside the tube.
Step 8. Fasten the copper wire ends to the ammeter for measurement.

Figure 1 illustrates the schematic design of the WEC, while Figure 2 provides an image of the fully assembled prototype.

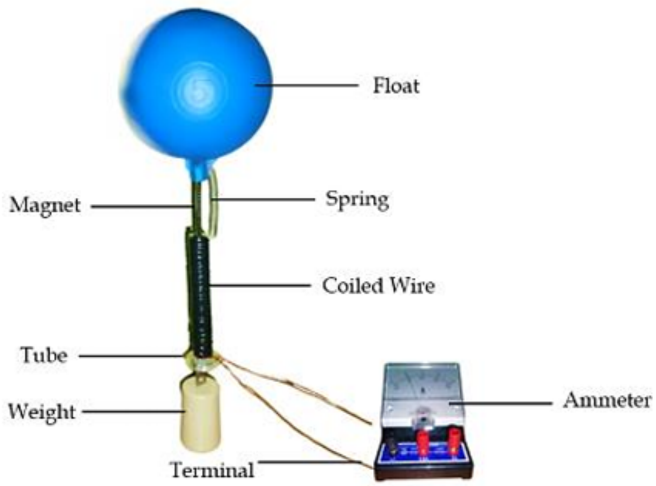
Figure 1. Schematic design of the Wave Energy Converter apparatus



ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035
Thank you for embracing the culture of research with us!

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181
RUN RESEARCHERS RUN

Figure 2. Actual Wave Energy Converter Device



Performance Testing

Initial testing was conducted to determine the efficiency of the WEC apparatus in generating electrical energy under different wave conditions. The results in Table 2 show that as the wave height increased, the number of oscillations also increased, resulting in a higher voltage output.

Table 2. Performance Testing of the WEC Apparatus

Trial	Wave Height (cm)	Number of Oscillations	Generated Currents (A)
1	5	10	0.1
2	10	6	0.2
3	15	4	0.3

According to the results, the electrical output of the WEC device is directly related to the properties of wave motion. As wave height grew, the generated current increased even though the number of oscillations reduced. This implies that even though there were fewer oscillations, more mechanical force from larger wave amplitudes resulted in higher energy conversion efficiency. All things considered, the test results confirm that the device is a useful model for demonstrating energy transformation, which helps students understand and be more interested in abstract scientific ideas.

Evaluation of the Developed Wave Energy Converter (WEC) Apparatus

The Wave Energy Converter (WEC) apparatus was evaluated based on three key criteria: instructional quality, technical quality, and adaptability. The evaluation involved science teachers and physics experts, who assessed the WEC using validated evaluation rubrics.

Table 3. Evaluation of the WEC as to its Instructional Quality

The instructional quality of the WEC apparatus was assessed based on its effectiveness as a teaching aid, clarity of the energy transformation concept, and its ability to engage students in active learning. Table 3 presents the mean ratings given by the evaluators.

Statement Indicator	Mean	Rank	Interpretation
1. The objectives of using the WEC are clear and well-defined.	4.53	4th	Excellent (E)
2. The WEC aligns with curriculum standards and learning goals	4.60	2.5th	Excellent (E)

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

3. The WEC engages students and maintains their interest.	4.70	1st	Excellent (E)
4. The WEC covers all necessary aspects of energy transformation concepts.	4.53	4.5th	Excellent (E)
5. The WEC is easy for both teachers and students to use.	4.60	2.5th	Excellent (E)
6. The WEC is cost-effective.	3.23	6th	Good (G)
7. The device provides accurate and consistent results.	3.03	7th	Good (G)
8. The WEC device offers a unique way of teaching energy transformation.	3.00	8th	Good (G)
9. The WEC device shows multiple instructional experiences to the user.	2.83	9th	Good (G)
10. The WEC device is accessible to both teachers and students.	2.77	10th	Good (G)
Grand Mean	3.78		Excellent (E)
Legend: 4.21 - 5.00 Excellent (E) 3.41 - 4.20 Very Good (VG) 2.61 - 3.40 Good (G) 1.81 - 2.60 Fair (F) 1.00 - 1.80 Poor (P)			

The overall evaluation of the WEC's instructional quality yielded a Very Good rating, with a grand mean score of 3.78, indicating that the tool generally met its intended educational objectives. However, there are areas for improvement, particularly in terms of cost-effectiveness, reliability, accessibility, and offering multiple instructional experiences.

Table 4. Evaluation of the WEC as to its Technical Quality

The technical quality of the WEC apparatus was assessed based on its durability, safety, functionality, and ease of use. This evaluation ensures that the device meets the necessary standards for classroom applications, providing a reliable and efficient tool for demonstrating energy transformation. The assessment also considered factors such as maintenance, technical support, and the device's adaptability to different instructional needs. Table 4 presents the mean ratings given by the evaluators.

Statement Indicator	Mean	Rank	Interpretation
1. The WEC is built to withstand regular use in a classroom setting.	4.83	1st	Excellent (E)
2. The WEC is safe to use and does not pose any hazards to users.	4.57	3rd	Excellent (E)
3. The WEC functions as intended and demonstrates energy transformation effectively.	4.80	2nd	Excellent (E)
4. The WEC requires minimal maintenance and is easy to repair if necessary.	4.46	4th	Excellent (E)
5. Adequate technical support and resources are available for users of the WEC.	4.43	5th	Excellent (E)
6. The WEC provides consistent results from multiple uses and conditions.	3.47	6th	Very Good (VG)
7. The WEC device is easy to set up or store.	3.30	7th	Good (G)
8. The WEC devices offer a user-friendly experience.	3.07	8th	Good (G)
9. The WEC device works seamlessly whenever it is used.	3.03	9th	Good (G)
10. Components can be easily added, removed, or replaced to adapt to different tasks.	2.93	10th	Good (G)
Grand Mean	3.89		Very Good (VG)
Legend: 4.21 - 5.00 Excellent (E)			

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

3.41 - 4.20 Very Good (VG)
2.61 - 3.40 Good (G)
1.81 - 2.60 Fair (F)
1.00 - 1.80 Poor (P)

The evaluation's findings demonstrate the WEC apparatus's great teaching potential. The effectiveness of the device as a teaching aid was confirmed by the high ratings received in areas about student involvement, consistency with curriculum requirements, and clarity of instructional objectives. These findings imply that the WEC not only illustrates the concepts of energy transformation but also piques students' interest and encourages active engagement with the material.

Table 5. Evaluation of the WEC as to its Adaptability

The adaptability of the WEC, as evaluated by the respondents, is presented in Table 5 and reflects its ability to be effectively utilized across various educational settings.

Statement Indicator	Mean	Rank	Interpretation
1. The WEC can be adapted for different instructional contexts and intended grade levels.	4.83	1st	Excellent (E)
2. The WEC allows modifications and customization to fit specific educational needs.	4.53	3rd	Excellent (E)
3. The WEC can be scaled with larger groups or different class sizes.	4.47	4th	Excellent (E)
4. The WEC can be easily integrated with other teaching tools and technologies.	4.30	5th	Excellent (E)
5. There is a mechanism for collecting and implementing user feedback to improve the WEC.	4.57	2nd	Excellent (E)
6. WEC is easy to use with varying levels of expertise.	3.57	6th	Very Good (VG)
7. The WEC device maintains performance efficiently.	3.13	8th	Good (G)
8. Minimal training is needed for effective use.	3.23	7th	Good (G)
9. The WEC device adapts to multiple types of experiments and applications.	2.97	10th	Good (G)
10. The WEC device can be upgraded or downgraded to optimally match the specific type of learning required.	3.00	9th	Good (G)
Grand Mean	3.86		Very Good (VG)

Legend:
4.21 - 5.00 Excellent (E)
3.41 - 4.20 Very Good (VG)
2.61 - 3.40 Good (G)
1.81 - 2.60 Fair (F)
1.00 - 1.80 Poor (P)

The WEC's adaptability shows its strong potential to enhance various educational settings. Its ability to adjust to different teaching contexts and grade levels makes it a versatile tool for personalized learning. While the high adaptability ratings suggest that it can support effective instruction, further improvements in ease of use and integration could make it even more accessible for educators with varying levels of expertise. Refining these features would help the WEC become a more valuable tool, better meeting the diverse needs of today's classrooms and promoting more engaging learning experiences.

Mean Scores of Respondents Using the WEC Device and Traditional Teaching Methods

The mean scores of the two groups of respondents were determined based on their learning performance before and after instruction using either the WEC device or traditional teaching methods, as presented in Table 6.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Scholar
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181
RUN RESEARCHERS RUN

Table 6. Pre-Test and Post-Test Learning Performance of the Students in Energy Transformation

Group	n	Pre-Test		Post-Test	
		Mean	SD	Mean	SD
Controlled	30	14.23	3.96	18.53	3.42
Experimental	30	14.63	3.58	22.73	3.34

The data presented in Table 6 highlights students' learning performance in energy transformation, comparing pre-test and post-test results for the controlled and experimental groups. Initially, both groups performed similarly, with the controlled group achieving a mean pre-test score of 14.23 (SD = 3.96) and the experimental group slightly higher at 14.63 (SD = 3.58). The minimal difference in pre-test mean scores (0.4) suggests comparable baseline knowledge levels between the two groups. The pre-test mean scores reflect the initial level of understanding of both groups before the implementation of the instructional methods. These scores serve as a baseline for evaluating the effectiveness of each approach in improving learning outcomes.

Following the intervention, both groups showed improvements in their post-test scores. The controlled group achieved a mean post-test score of 18.53 (SD = 3.42), reflecting moderate learning gains. In contrast, the experimental group demonstrated a significant increase, with a mean post-test score of 22.73 (SD = 3.34), indicating substantial improvement in learning. The post-test mean scores indicate the level of knowledge acquired by the respondents after instruction. These results help evaluate the impact of the WEC device and traditional teaching methods on student learning. The difference in performance gains between the two groups was pronounced, with the experimental group showing a larger mean score increase of 4.2 compared to the control group.

These results suggest that the intervention implemented with the experimental group enhanced students' understanding of energy transformation, as evidenced by their higher post-test scores and greater improvement compared to the control group.

Comparison between the Pre-Test and Post-Test Mean Scores of the Respondents

Table 7 presents a comparative analysis of the pre-test and post-test mean scores of students taught using the WEC device and those instructed through traditional teaching methods. The table also includes the statistical significance of the differences observed in each group's performance.

Table 7. Comparison of the Pretest and Post-Test Mean Scores of the Students in Energy Transformation

Group	**Means**		**Difference**	**t**	**p-value**	**Interpretation**
	Pretest	**Post-test**				
Controlled (Traditional Method)	14.23	18.53	4.30	-12.54	0.000	S/Reject Ho
Experimental (WEC-assisted)	14.63	22.73	8.1	-15.73	0.000	S/Reject Ho
Level of Significance is at 0.05; two-tailed; df= 29						

The data in Table 7 compares the pre-test and post-test mean scores of students in energy transformation, highlighting significant learning gains for both the controlled and experimental groups. The control group, which underwent traditional instruction, achieved a mean score increase from 14.23 to 18.53, reflecting a mean difference of 4.30. In contrast, the experimental group, which utilized the improvised Wave Energy Converter as an intervention in discussing energy transformation in systems, exhibited a more substantial improvement, with mean scores rising from 14.63 to 22.73, resulting in a difference of 8.10. The computed t-values for both groups, -12.54 for the control group and -15.73 for the experimental group, are statistically significant at a p-value of 0.000 ($p < 0.05$). These results led to rejecting the null hypothesis (Ho), confirming that the interventions significantly enhanced the learning performance of both groups. The greater improvement observed in the experimental group underscores the effectiveness of the improvised Waste Energy Converter in fostering a deeper understanding of energy transformation.

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Conclusions

The evaluation of the developed Wave Energy Converter (WEC) apparatus confirmed its potential as an effective instructional material in teaching energy transformation. In terms of instructional quality, the WEC achieved a grand mean of 3.78 (Very Good), with its highest ratings in student engagement (Mean = 4.70, Rank 1) and alignment with curriculum standards (Mean = 4.60). However, areas such as accessibility (Mean = 2.77) and multiple instructional experiences (Mean = 2.83) were identified as needing improvement. For technical quality, the WEC also received a Very Good rating (Grand Mean = 3.89), with durability (Mean = 4.83) and functionality in demonstrating energy transformation (Mean = 4.80) being its strongest attributes, while user-friendliness (Mean = 3.07) and adaptability of components (Mean = 2.93) were its weakest. In terms of adaptability, the WEC was rated Very Good (Grand Mean = 3.86), excelling in adapting to different instructional contexts (Mean = 4.83) but showing limitations in performance efficiency (Mean = 3.13) and versatility across different applications (Mean = 2.97).

Learning performance results further reinforced the effectiveness of the WEC. Pre-test results showed nearly identical baseline scores between the control group (Mean = 14.23) and the experimental group (Mean = 14.63), indicating comparable initial knowledge. However, post-test results revealed a more significant improvement for the experimental group (Mean = 22.73) compared to the control group (Mean = 18.53), with the experimental group's mean gain of 8.10 nearly doubling that of the control group (4.30). Statistical analysis confirmed these gains were significant, with both groups rejecting the null hypothesis ($p < 0.05$). These findings suggest that while traditional methods improved learning outcomes, the use of the improvised WEC led to deeper understanding and greater performance gains.

In sum, the WEC apparatus demonstrates strong instructional and technical qualities, adaptability across contexts, and a measurable impact on students' conceptual understanding of energy transformation. While improvements in accessibility, ease of use, and multi-functionality are needed, the WEC stands as a promising, low-cost innovation for enhancing science education.

Recommendations

Based on the study's findings, the following conclusions were drawn. The development of the Wave Energy Converter (WEC) apparatus successfully demonstrated its effectiveness as a teaching tool for energy transformation concepts, fulfilling its intended educational objectives. Performance testing revealed that the WEC efficiently converts mechanical wave energy into electrical energy, with a direct correlation observed between increased wave height and voltage output. Evaluations from science teachers indicated that the WEC apparatus scored highly in terms of instructional quality, technical quality, and adaptability. The experimental group, which utilized the WEC in classroom instruction, demonstrated a significant increase in learning performance, achieving higher post-test scores compared to the control group that received traditional instruction.

REFERENCES

Ambag, R. (2018). *Teaching science in the Philippines: Why (and how) we can do better.* https://www.researchgate.net

Amihan, S. R., Sanchez, R. D., & Carvajal, A. L. P. (2023). Sustained quality assurance: Future-proofing the teachers for an ASEAN higher education common space. *International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR),* 2(4), 276-286. https://etcor.org/storage/iJOINED/Vol.%20II(4),%20276-286.pdf

Becker, N. M., & Cooper, M. M. (2014). College chemistry students' understanding of potential energy in the context of atomic and molecular interactions. *Journal of Research in Science Teaching, 51*(6), 789–808. https://doi.org/10.1002/tea.21154

Bontuyan, J. O. (2025). Multi-Dimensional Reflective Practices of Non-SPED Teachers: Toward Inclusive, Responsive, and Growth-Oriented Teaching. *International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)*, 4(2), 1432-1443. https://doi.org/10.63498/etcor376

Bontuyan, J. O. (2024). Integrating "Super Skills" in the Teaching of MAPEH in the Selected Secondary Schools in the

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
Website: https://etcor.org
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Division of Parańaque. *International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)*, 3(1), 448-457. https://etcor.org/storage/iJOINED/Vol.%20III(1),%20448-457.pdf

Carvajal, A. L. P., Fernandez, T. M., Pangilinan, A. M., Obod, M. M., Amihan, S. R., Sanchez, R. D., Sanchez, A. M. P., Sanchez, J. J. D. (2025). Future-Proofing Teachers in Reframing Teacher Education Curriculum in the Philippines: Basis for Policy Recommendations. *International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)*, 4(2), 235-252. https://doi.org/10.63498/nxz2st271

Chi, C. (2023, December 6). The Philippines still lags behind the world in math, reading, and science, according to PISA 2022. *Philstar Global.* https://www.philstar.com/headlines/2023/12/06/2321000/philippines-still-lags-behind-world-math-reading-and-science-according-pisa-2022

Herrmann-Abell, C. F., & DeBoer, G. E. (2018). Investigating a learning progression for energy ideas from upper elementary through high school. *Journal of Research in Science Teaching, 55*(1), 68–93. https://doi.org/10.1002/tea.21411

Holdhus, K., Høisæter, S., Mæland, K., Vangsnes, V., Engelsen, K. S., Espeland, M., & Espeland, Å. (2016). Improvisation in teaching and education—Roots and applications. *Cogent Education, 3*(1), 1204142. https://doi.org/10.1080/2331186X.2016.1204142

Lash, T. L., & Rothman, K. J. (2020). Case-control studies. In T. L. Lash, T. J. VanderWeele, S. Haneuse, & K. J. Rothman (Eds.), *Modern epidemiology* (4th ed., pp. 650–667). Wolters Kluwer.

Luza-Tabiolo, C. D. (2018). Improvisation of laboratory apparatuses for general science teaching: Effects on students' performance. *International Journal of Scientific Research and Education, 6*(6), 7910–7919. https://doi.org/10.18535/ijsre/v6i6.02

Organisation for Economic Co-operation and Development (OECD). (2023). *PISA 2022 results (Volume I): The state of learning and equity in education.* OECD Publishing. https://doi.org/10.1787/53f23881-en

Ojediran, I. A., Oludipe, D. I., & Ehindero, O. J. (2014). Impact of laboratory-based instructional intervention on the learning outcomes of low-performing senior secondary students in physics. *Creative Education, 5*(14), 1257–1268. https://doi.org/10.4236/ce.2014.514141

Okori, O. A., & Jerry, O. (2017). Improvisation and utilization of resources in the teaching and learning of science and mathematics in secondary schools in Cross River State. *Global Journal of Educational Research, 16*(1), 21–28. https://doi.org/10.4314/gjedr.v16i1.3

Pacadaljen, L. M. (2024). Hurdling obstructions on instructional management of science teachers in schools with challenging laboratory resources. *Environment and Social Psychology, 9*(10), 1–12. https://doi.org/10.54517/esp.v9i10.2989

Pangilinan, A. M. (2025). Challenges and Commitment to Teaching: A Quantitative Descriptive-Correlational Study of Filipino Teachers in Select Coastal Villages. *International Journal of Open-access, Interdisciplinary and New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)*, 4(2), 1684-1692. https://doi.org/10.63498/etcor397

Richey, R. C., & Klein, J. D. (2014). *Design and development research: Methods, strategies, and issues.* Routledge.

Sanchez, R. D. (2025, August 24). To proceed forthwith: Basic rules, tips, and innovations in thesis and dissertation writing [PowerPoint slides]. https://www.facebook.com/share/p/1FUwVPnQv6/

ETCOR Educational Research Center Inc.
SEC Reg. No. 2024020137294-00
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Website: https://etcor.org
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Sobremisana, V. S. (2017). Utilization of innovative physics devices to enhance students' motivation and performance in learning selected physics concepts. *Asia Pacific Journal of Multidisciplinary Research, 5*(4), 1–9. http://www.apjmr.com