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## Enhancing Filipino Students' Learning Outcomes in Physics Using Comic-Based Learning Materials

Janet T. Molina  and Edelyn A. Cadorna\* 

University of Northern Philippines  
 Tamag, Vigan City, Ilocos Sur

**Abstract.** Developing instructional materials that simultaneously enhance comprehension, stimulate interest, and foster skill acquisition is necessary to promote holistic student learning outcomes. This study developed comic-based learning materials and determined their effectiveness in enhancing learning outcomes. The study employed a combination of the developmental research and experimental research designs. The comic-based instructional materials were developed, and the quality of the materials, their acceptability to teachers, and the materials' effectiveness in enhancing students' understanding, attitude, and skills in Physics were determined. Similarly, the experiences of students using the materials were explored. Data were collected from all the STEM students and Physics teachers using evaluation instruments, and interview guides. These data were analyzed using frequency, percentage, mean, t-test, and thematic analysis. Findings revealed that the developed comics met the quality criteria regarding content, format, presentation, organization, and accuracy. It is highly acceptable to teachers for use as a learning material. Moreover, the developed comics significantly enhanced students' understanding of the topic, improved their attitude towards Physics, and effectively developed essential learning competencies required in the subject. The students gave positive feedback about the developed materials. The developed comics proved to be a high-quality instructional material that significantly improved students' understanding, attitudes, and competencies in Physics. The study recommended encouraging the use of comics as a teaching and learning tool in Physics and exploring their potential application to other challenging topics.

**Keywords:** comic-based learning; physics education; mixed-methods developmental research, learning outcomes; instructional material

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\*Corresponding Author: Edelyn A. Cadorna; [edelyn.cadorna@unp.edu.ph](mailto:edelyn.cadorna@unp.edu.ph)

## 1. Introduction

Physics is a fundamental subject in the science curriculum and is necessary for students aspiring to careers in science and technology. The importance of physics education in the 21<sup>st</sup> century is underscored by its role in equipping students with critical thinking skills and problem-solving abilities necessary for navigating a complex, technology-driven world.

Moreira (2018) emphasized the relevance of physics education to modern society. She claimed that physics underpins most contemporary technologies, making its understanding crucial for informed citizenship. Integrating physics education with global issues, such as the United Development Goals, highlights its societal relevance (Grayson, 2020). Furthermore, physics education helps develop essential skills for the 21<sup>st</sup>-century workforce (Bao & Koenig, 2019; Jamil et al., 2024; Hidayatullah et al., 2021).

However, students globally face various challenges in learning physics, which stem from educational, cognitive, socio-economic, and resource disparity factors. The abstract nature of physics, traditional teaching methods, and the lack of real-world applications in the curriculum compound these challenges. Students find physics a very difficult subject because of its abstract concepts. Physics concepts are abstract and disconnected from students' experiences, leading to misconceptions (Shrestha et al., 2023; Pospiech, 2023; Mboniyirivuze et al., 2019; Badmus & Jita, 2024). Traditional teaching methods fail to engage students effectively, hindering students' ability to understand and apply physics concepts (Verawati & Nisrina, 2025).

Meanwhile, Shrestha et al. (2023) also emphasized disparities in resources in learning physics, resulting in poor learning outcomes. In the Philippines, students' challenges in learning physics include mathematical difficulties (Laguindab et al., 2025; Olesco et al., 2024), teaching-related issues like ineffective instructional materials, and teaching approaches that connect abstract concepts with real-world applications (Shrestha et al., 2023). Additionally, students regard this subject as less engaging (Torio, 2015; Gabay, 2019). These views and experiences have significantly impacted the performance of Filipino students in national and international evaluations. More specifically, in the Philippines, students performed below the average in math and science in the 2018 Programme for International Student Assessment (PISA) (Department of Education, 2019).

To address the growing challenges in science education, particularly in physics, traditional approaches must be replaced with innovative teaching methods. Today's students require engagement beyond conventional instruction. According to Science Education workshops and reports on 21<sup>st</sup>-century skills, scientific inquiry and fresh strategies are essential, as traditional pedagogy falls short (National Research Council, 2010). It is crucial for 21st-century learners to question foundational assumptions in science and to advocate for new methods (Townley, 2018; Morris, 2025). Moreover, Roa and Fajardo (2022) highlight an ongoing gap in instructional resources that effectively transform abstract concepts

into concrete understanding, which is vital for students' success. Hence, inventive materials and methodologies are necessary.

Students' conceptual understanding and critical thinking skills in physics can be improved by developing instructional materials with multiple representations (Coil et al., 2010). Research indicates that instructional materials (IMs) are essential for student learning. Muzumdar (2016) discovered that instant messaging (IMs) directly impacts teaching and learning, while Igbo and Omeje (2014) identified that students learn more effectively with visual aids and teacher-created materials.

Comics are an example of an instructional material that uses multiple ways to show information. Comic-based instructional material is a type of storytelling that uses text and pictures to help make complicated ideas clearer by giving context to written information (Ak et al., 2020). Using comic-based teaching materials can help students remember and get more excited about their learning. This approach can improve their understanding of and attitude toward Physics (Ramesh & Padmanabhan, 2021). Comics are often enjoyable and entertaining, but they can also be useful for learning (Enteria & Pet, 2019; Tilley & Weiner, 2017). Teens enjoy comics, which have enriched Philippine culture. Comics have been part of Filipino culture since 1920. Kenkoy and Captain Barbell show how Western and native storytelling have influenced each other.

Filipino artists incorporated social criticism into Japanese occupation propaganda comics, proving their versatility (Chua, 2005). Philippine comics reflect a "glocal" identity and appeal to local and international audiences by blending Eastern and Western approaches (Gutierrez, 2014). They are now educational rather than recreational. Educational comics simplify history and textbooks for more students. Graphics and stories simplify complex subjects in educational comics. It makes reading more enjoyable. Their adaptability makes them suitable for physics instruction. Traditional teaching methods may seem irrelevant to students' lives.

Although several international studies support comic-based learning in science education, limited research exists in the Philippine context that evaluates its application in physics classrooms. Most studies have focused on other science subjects, with little emphasis on physics, which involves abstract and mathematical thinking. Researchers recommend the need for comprehensive development and validation of comic-based instructional materials tailored to the Filipino educational context.

Existing studies have validated materials in other regions, but similar efforts are required in the Philippines to ensure effectiveness and alignment with the K-12 curriculum (Febrianti et al., 2022; Utami et al., 2023; Putri et al., 2022). Moreover, other studies have explored cognitive gains (knowledge) or engagement (attitude), but very few integrate the triad of knowledge, attitude, and skills (KAS) into their assessments.

This study fills these gaps by developing comic-based learning materials in Physics, particularly in Electrostatics, and determining their effectiveness along the three dimensions of knowledge, attitude, and skills. The results of this study may serve as a basis for curriculum developers and policymakers to include alternative instructional media, such as comics, in the science curriculum. It may provide teachers with an innovative teaching aid that can supplement traditional lectures to facilitate a more interactive classroom environment. It also offers the students a more engaging and accessible method of studying physics, leading to improved comprehension and motivation. This study may lead future researchers to further investigations into the utilization of visual narratives in science education.

This study aimed to assess the effectiveness of using comic-based instructional materials in enhancing the learning outcomes of Filipino students. Specifically, it intend to 1) develop comic-based instructional materials; 2) determine their acceptability to Physics teachers as a teaching material based on clarity, usefulness, suitability, adequacy, timeliness, language, style, format, illustrations, and presentation; 3) evaluate their effectiveness in enhancing students' knowledge, attitude, and skills in physics, particularly Electrostatics; and 4) explore the students' views about the developed comics as a learning material.

## **2. Theoretical Underpinnings and Literature Review**

### **2.1 Theoretical Underpinnings**

This study is grounded in multiple educational and psychological theories that support using comic-based learning materials to enhance students' KAS in physics. Some of these theories are as follows:

#### *2.1.1 Cognitive Theory of Multiple Learning*

This theory posits that learning is more effective when verbal and visual information are presented together, leveraging dual channels in the brain for processing (Mayer, 2005). The developed comics used combined text and visuals in a coherent and engaging narrative in the study. The material reduced cognitive overload by chunking information into manageable frames, supporting conceptual clarity. Cognitive theory focuses on how thinking shapes learning, seeing students as active participants (Fleming, 2019).

#### *2.1.2 Constructivist Learning Theory*

Vygotsky (1978) emphasized that learners construct their understanding through interaction with content and social context. Comic-based materials are designed to match learners' cognitive level, using familiar contexts and language. In the developed comics, physics concepts are embedded in social and culturally relevant stories to Filipino students, making the material more relatable and meaningful. In addition, visuals and dialogue help students make sense of scientific ideas within their existing knowledge framework. This also complements the humanistic theory, emphasizing student-centered learning, where self-motivation drives success (Fleming, 2019; WGU, 2020).

#### *Social Learning Theory*

Bandura (1977) asserts that people learn through direct experience and observation, imitation, and modeling. Characters in stories and comics can be role models for behavior and thinking (Wessely, 2017). Comic characters can model scientific inquiry, problem-solving, and positive attitudes toward learning physics.

## 2.2 Literature Review

The following readings and related studies also shed light on the conduct of the study.

### 2.2.1 *The Challenge of Teaching and Learning in Physics*

Traditional teaching methods, mostly on lectures and textbooks, impede physics teaching and learning, particularly among Filipino high school students (Resurrection & Adanza, 2020). A cheerful outlook and motivation are necessary for pupils to exert effort and acquire the necessary skills (Corpuz & Lucas, 2021). As a result, there is a growing demand for new instructional approaches in physics that focus on the cognitive, emotional, and psychomotor aspects of learning.

### 2.2.2 *Comic-Based Learning in Science Education*

Educational comics are increasingly being explored as effective tools for enhancing science learning. By combining visual storytelling with educational content, comics offer both cognitive and affective benefits. Comics have shown potential to enhance students' attitudes and motivation toward science. As a result, students become more engaged and confident when learning materials are presented in familiar, fun, and less intimidating formats—contributing to improved academic outcomes (Lee, 2019). Furthermore, engaging materials like comics can make learning Physics more enjoyable (Gómez, 2012).

Research by various scholars supports the effectiveness of comics in physics education. Comics can be integrated into a scientific approach—incorporating observing, questioning, data collection, associating, and communicating—to encourage active student participation (Rahayu & Kuswanto, 2020). Priyadi et al. (2020) also highlighted that Android physics comics can enhance students' mathematical representation skills, particularly in momentum and impulse. Ramadhan et al. (2019) also emphasized that comics can help students develop physics representation skills while integrating local wisdom.

Furthermore, Yulianti et al. (2016) concluded that comics are a powerful learning tool, making science more engaging and stimulating through visual storytelling rather than relying solely on textual explanations of scientific concepts. Filipino researchers also developed comics and graphic novels to aid and help students learn effectively. The use of comics was found to enhance engagement and learning gains and conceptual understanding in physics (kinematics) (Degorio & Langub, 2025; Badeo & Koc, 2021), and increase concept comprehension (Rivamonte et al., 2025).

Based on the literature review, no study has been conducted to evaluate the effectiveness of using comic-based instructional materials in improving students'

knowledge, attitudes, and skills simultaneously. Further, its effectiveness in the concept of Electrostatics is limited, which is the content scope of the study.

Hence, this study also aimed to test the hypothesis that the use of comic-based learning materials is effective in enhancing students' knowledge, attitudes, and skills in Physics, particularly in electrostatics. In its null form, the use of comic-based learning materials is not effective in enhancing students' learning outcomes in terms of knowledge, attitudes, and skills in Physics.

### 3. Methodology

#### 3.1 Research Design

This study employed a combination of developmental research and experimental research, specifically the one-group pre-test post-test research design. It is a combination of quantitative, and qualitative methods. The developmental method was used in the development of the comic-based learning materials. Meanwhile, the quantitative method was employed to evaluate the quality of the material, its acceptability to the teachers, and its effectiveness in enhancing students' knowledge, attitude, and skills. The qualitative method was utilized to gain deeper insights into students' experiences using the comics. For the experimental part of the study, the independent variable is the use of comic-based material, and the dependent variables are the learning outcomes, including knowledge, attitudes, and skills in Physics.

#### 3.2 Respondents

The study involved all 120 STEM students from the UNP Laboratory Schools and all four (4) Physics teachers. The students were the subjects in the evaluation of the effectiveness of the material in enhancing learning outcomes, along with knowledge, attitude, and skills. The teachers assessed the level of acceptability of the comic-based instructional materials.

#### 3.3 Data Gathering Instruments

Five instruments were used in the study. The first is the *Evaluation Rating Sheet*, adopted from DepEd. This is used to evaluate the quality of the developed material in terms of content, format, presentation, organization, accuracy, and up-to-dateness of information. The second is a teacher-made, validated *conceptual test* (I-CV=83.33) used to measure the students' knowledge in Physics before and after the use of the materials.

Rahmawati et al. (2018) emphasized that well-developed and validated tests of conceptual knowledge are essential for diagnosing student difficulties and instructional improvement. The third is the *Physics Attitude Questionnaire*, adapted from the Modified Attitudes Towards Science Inventory (MATSI), which has 25 items (MATSI, 2008), and an overall alpha of 0.70. Fourth is the *Learning Competencies Checklist* (DepEd MELC in Physics, 2025) to determine specific skills developed after using the comics. Lastly, the *Acceptability Questionnaire* (Tan-Espinar & Ballado, 2017) was used to assess the comics on criteria including clarity, usefulness, suitability, adequacy, timeliness, language, style, illustrations, and presentation.

### **3.4 Data Gathering Procedure**

#### *3.4.1 Quality Evaluation*

Before developing the comic-based instructional material in Electrostatics, the researchers first determined the difficult topics found by students as assessed by Physics teachers, as a basis for developing said materials. This was followed by experts' evaluation of the material quality. They evaluated the material using the above-cited criteria.

#### *3.4.2 Acceptability of the Material*

The developed comics were also evaluated in terms of their acceptability to Physics teachers as a learning material in the earlier-mentioned eight criteria using the Acceptability Questionnaire.

#### *3.4.3 Effectiveness in Enhancing KAS*

The developed material was used in class for four (4) weeks. The four-week intervention period was based on the STEM curriculum guide for the topic of Electrostatics. The students first took the pretest before engaging with the comics and completed the posttest using different but equivalent questions afterward. Likewise, the attitude and skills of the students, using the questionnaires in the data gathering instruments section, before and after their engagements with the comics, were determined. The students' knowledge, attitude, and skills were compared before and after the intervention program.

The pre-test scores were used as baseline data for determining any improvement in students' understanding of the topics after using the material. Moreover, the researchers interviewed the students to explore their insights about the comics and their experiences using the materials, following the method of thematic analysis, such as data transcription, coding, grouping codes into potential themes or patterns, reviewing themes, and naming themes. Data collection through interview continued until saturation was reached, i.e., the interview stopped when no new codes were identified. Their responses were analyzed for common themes.

### **3.5 Ethical Considerations**

This study adhered to the research ethics, principles, and protocol to ensure integrity and ethical standards. The University Ethics Review Committee of the University of Northern Philippines reviewed the paper.

### **3.6 Data Analysis**

Quantitative data gathered in the study were analyzed using frequency and percentage to assess students' understanding of Electrostatics; mean to evaluate acceptability based on instructors' ratings; and the t-test of significant difference to measure if the use of the comic-based materials is effective in enhancing students' knowledge, attitude, and skills in Physics, Electrostatics, in particular. Qualitative data from interviews were subjected to thematic analysis (Caulfield, 2019) to identify common themes in student feedback, offering further insights into the comics' usefulness and acceptability in teaching electrostatics.

## 4. Results and Discussion

### 4.1 The Developed Comics

#### 4.1.1 Content

The developed comics were focused on Electrostatics, one of the content areas in Physics. This was divulged by the students and the Physics teachers as the most difficult area in Physics due to its abstract concepts. The material covered topics under Electrostatics, namely, electric charges, Columb's Law, electric field, and Gauss's Law. It includes a cover page, a table of contents, and a chapter description, ensuring a structured and engaging learning experience. The comic's storyline followed a structured progression: *Prologue* – Introduction of the main character and the learning challenge; *Chapter 1* – Electric charges and Coulomb's law; *Chapter 2* – Characteristics of the electric field; *Chapter 3* – Electric flux and Gauss's law; and *Epilogue* – Resolution and application of learned concepts.

#### 4.1.2 Quality of the Comics

The results of the quality evaluation of experts on the developed comics are summarized in Table 1. Quality was based on content, format, presentation, organization, and accuracy and up-to-datedness of information

**Table 1: The electrostatics comics summary of rating**

Factors	Rating	Remarks
Factor 1: Content	25.34	Passed
Factor 2: Format	64.00	Passed
Factor 3: Presentation and Organization	17.20	Passed
Factor 4: Accuracy and Up-to-datedness of Information	24.00	Passed

#### *Passing Scores*

*Factor 1: at least twenty-one (21) points out of a maximum of twenty-eight (28) points.*

*Factor 2: at least fifty-four (54) points out of a maximum of seventy-two (72) points.*

*Factor 3: at least fifteen (15) points out of a maximum of twenty (20) points.*

*Factor 4: at least twenty-four (24) points out of a maximum of twenty-four (24) points.*

The Electrostatics comics met all validation criteria, proving to be a valid supplemental learning material that improves student learning. The results indicate that the material effectively meets Electrostatics' required depth, range, and scope, affirming the absence of conceptual or factual errors, making it a reliable resource. This result is consistent with the findings of Lesmono et al. (2018). The material has a good format with an engaging and accessible structure.

A concise structure is one of the important characteristics of instructional material (Yulianti et al., 2016). Regarding presentation and organization, the materials was assessed to have well-arranged topics and smooth idea flow. Regarding accuracy and up-to-datedness of information, the material is free from conceptual, factual, grammatical, and typographical errors, and has no obsolete information that could lead to students' misunderstanding and misconceptions. Since the material needs to be accurate, Factor 4 must achieve a perfect score; otherwise, it cannot be used as a teaching material.



## 4.2. Acceptability of the Comics to Physics Teachers

Table 2 shows the Physics instructors' very high acceptance of the developed Electrostatics comics. It received a very high level of acceptability across all criteria (Mean > 4.50), suggesting that the comics are clear, useful, suitable, timely, and well-presented, meeting the needs of both instructors and students. Very high acceptance highlights the material's potential to improve teaching efficiency and student understanding, supporting its adoption in educational settings.

These results are aligned with Apostolou and Linardatos (2023), who emphasized that comics are effective in boosting engagement and learning outcomes across subjects, and Baifeto et al. (2022), who confirmed physics comics as valid, accessible teaching material for high school students.

**Table 2: Acceptability of the developed comics among Physics teachers**

Criteria	Mean Rating	Level
Clarity	4.94	Very High
Usefulness	4.84	Very High
Suitability	4.88	Very High
Adequacy	4.89	Very High
Timeliness	4.83	Very High
Language, Style and Format	4.96	Very High
Illustrations	4.90	Very High
Presentation	4.92	Very High
<b>Overall Mean</b>	<b>4.90</b>	<b>Very High</b>

*Norm:*

Mean Range	Level
4.51 – 5.00	Very High
3.51 – 4.50	High
2.51 – 3.50	Average
1.51 – 2.50	Low
1.00 – 1.50	Very Low

Furthermore, Bachri et al. (2023) revealed that implementing the Phenomenon-based Learning (PhBL) model, accompanied by digital comics, can significantly accelerate agile innovation and independence among students. A similar high acceptance of the Electrostatics comics in this study supports the notion that comic-based learning materials encourage creativity, interest, and a student-centered learning approach.

## 4.3 Effectiveness in Enhancing Knowledge, Attitude, and Skills (KAS)

### 4.3.1 On Enhanced Knowledge

Table 3 shows that using comics helped the pupils comprehend Electrostatics better. In the pre-test, 32.50% of students got "Good" grades in Electrostatics, while 66.67% got "Poor" ratings. The post-test results reveal a lot of progress from using the material: 80.83% scored "Very Good," 15.00% scored "Good," and 4.17% scored "Excellent." Results of the t-test reveal a significant improvement in the knowledge of the students in Electrostatics after using comics (t-value=40.548,  $p < .01$ ).

The students obtained a significant improvement in their mean score after exposure to the use of comics learning materials, signifying a statistically significant improvement in students' understanding of Electrostatics following the use of the developed comics. This confirms the findings of Badeo and Koc (2021), who developed comics significantly enhanced students' conceptual understanding, and Rivamonte, et al. (2025), who found that comics can effectively increase and strengthen students' knowledge and comprehension. A multimedia program that included engaging elements such as bright colors and animations helped motivate students to learn and facilitate understanding of physics concepts and problem-solving strategies (Khasawneh, 2024).

**Table 3: Enhanced knowledge of students on Electrostatics using the developed comics**

Mean Score Equivalent	Pre-test		Post-test	
	f	%	f	%
Excellent (80.01-100)	0	0.00	5	4.17
Very Good (60.01-80)	0	0.00	97	80.83
Good (40.01-60)	39	32.50	18	15.00
Poor (20.01-40)	80	66.67	0	0.00
Needs Improvement (20 and below)	1	0.83	0	0.00
<b>Total</b>	<b>120</b>	<b>100</b>	<b>120</b>	<b>100</b>
<b>Statistical Comparison</b>				
<i>Percentage Mean</i>	37.14%	<i>Poor (P)</i>	75.53%	<i>Very Good (VG)</i>
<i>Mean Difference</i>				38.39
<i>t-value</i>				40.548
<i>t-prob</i>				.000 ( $p < .01$ )
<i>Decision</i>				<i>Reject Ho</i>

Comics use visual storytelling, which simplifies complex ideas. Sample narratives and illustrations from the developed comics are displayed in Figure 1. Raaijmakers and Van Berlo (2023) noted that illustrations help students visualize electrostatic concepts like charge distribution and electric fields. The narrative format also makes learning more engaging by weaving concepts into a story, aiding retention (Kromka & Goodboy, 2018).

These findings suggest that using comics as a learning tool for Electrostatics greatly enhanced students' knowledge and interest in learning (Syarah et al., 2019). The results of the study align with the Cognitive Theory of Multiple Learning, which suggests that learning is more effective when verbal and visual information are presented together.

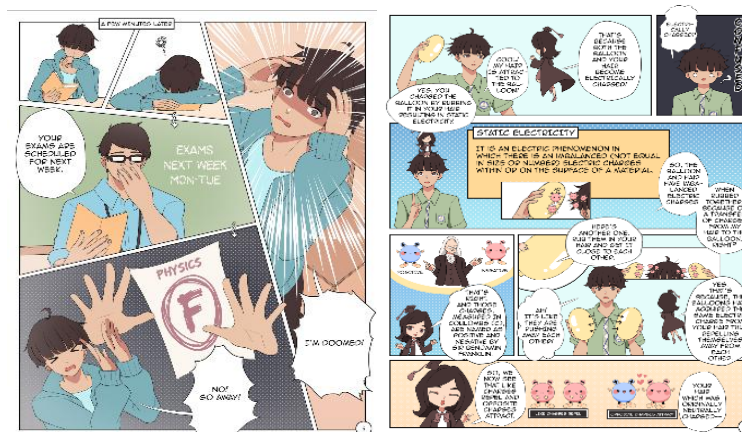


Figure 1: Sample narratives and illustrations from the developed comics

#### 4.3.2 On Improved Attitude Towards the Subject

It is evident in Table 4 that there is an improvement in the general attitude of the students towards Physics, from neutral to positive, after using the comics. There is an increase in students' enjoyment and desire to learn Physics after using the comics. Their attitude toward Physics as an enjoyable subject improved.

Table 4: Improved attitude of the students towards the subject

Item Statements	Before	After
1. Physics is useful in helping to solve the problems of everyday life.	3.96	4.39
2. Physics is something that I enjoy very much.	3.25	3.98
3. I would like to do some extra or unassigned reading in Physics.	2.88	3.62
4. Physics is easy for me.	2.59	3.51
5. When I hear the word Physics, I have a feeling of dislike.	3.21	3.82
	(2.79)	(2.18)
6. Most people should study some Physics.	3.86	4.29
7. Sometimes I read ahead in our Physics book and lessons.	2.65	3.58
8. Physics helps me in understanding today's world.	3.81	4.36
9. I feel confident about understanding the topics we discuss in Physics.	3.28	3.98
10. Physics teachers make physics interesting.	4.06	4.68
11. No matter how hard I try, I cannot understand Physics.	3.33	3.87
	(2.67)	(2.13)
12. I feel tense when someone talks to me about Physics.	3.03	3.64
	(2.97)	(2.36)
13. Physics teachers present material in a clear way.	4.03	4.59
14. I often think, "I cannot do this," when given a Physics assignment.	2.62	3.60
	(3.38)	(2.40)
15. Physics is of great importance to a country's development.	3.79	4.29
16. It is important to know Physics to get a good job.	3.23	3.86
17. I like the challenge of Physics assignments.	3.12	3.92
18. It makes me nervous to even think about doing Physics.	3.03	3.65
	(2.97)	(2.35)
19. It scares me to have to take a Physics class.	3.12	3.97
	(2.88)	(2.03)
20. Physics teachers are willing to give us individual help.	4.27	4.54

21. It is important to me to understand the work I do in Physics class.	4.01	4.46
22. I have a good feeling towards Physics.	3.24	4.06
23. Physics is one of my favorite subjects.	2.93	3.82
24. I have a real desire to learn Physics.	3.43	4.13
25. I feel I am not doing well in Physics.	3.09	3.87
	(2.91)	(2.13)
<b>Overall Mean</b>	<b>3.35</b>	<b>4.02</b>
<b>Description</b>	<b>Neutral</b>	<b>Positive</b>
<b>Statistical Comparison</b>		
<i>Mean Difference</i>	0.67	
<i>t-value</i>	15.133	
<i>t-prob</i>	.000 ( $p < .01$ )	
<i>Decision</i>	Reject $H_0$	

*Note: scores inside the parentheses are responses for negative items, and these were reversed-scored*

Comics made them more desirous to learn the subject, and they became more interested in doing more readings related to the topics. The intervention made Physics more appealing and fostered a deeper level of engagement. The change in their responses indicates a growing willingness among students to engage with the subject outside of mandatory tasks, reflecting an increased motivation, a crucial component for sustained academic interest and success.

The data also shows reduced anxiety and increased confidence among the students. These improvements suggest that students are becoming more comfortable with the subject. There is also a change in how they see Physics teachers and how they present materials in class. These further support the perception of teaching quality, highlighting the crucial role of effective teaching in shaping students' attitudes. Moreover, the students increasingly recognize the value of Physics in real-world contexts. They were made to realize the usefulness of Physics in helping solve real-life problems and its importance in societal development.

Using comics in teaching Physics, especially Electrostatics, effectively boosted students' interest and engagement. Agup and Ebojo (2022) also highlighted that engagement in STEM subjects is key to academic success. Furthermore, Cadorna et al. (2023) developed a worktext for Mathematics in the Modern World, showing that well-designed instructional materials can significantly boost student engagement by making content more accessible and relatable to learners' contexts. Results of the comparison of the mean attitude scores of the students before and after exposure to the comics reveal that the difference is statistically significant ( $t$ -value=15.133,  $p < .01$ ). There is a significant improvement in students' feelings about Physics after using the developed comics.

Students reported that the comics made learning more enjoyable. The humor, relatable scenarios, and engaging illustrations made the subject more understandable, appealing, and interesting, and they developed their confidence (Mutia et al., 2020; Badeo & Koc, 2021; Utami et al., 2023; Putri et al., 2022). Please refer to Figure 2 for the sample humor and relatable scenarios from the developed comics. Comics made the subject more relevant to students' lives by presenting electrostatic concepts in familiar, everyday contexts. Please refer to Figure 2 for

the samples. This relevance can lead to a more positive attitude toward learning the subject. (Siagian, 2024).



Figure 2: Sample humor and relatable scenarios from the developed Electrostatic comics

#### 4.3.3 On Developed Skills

Table 5 summarizes the learning competencies alongside the skills test scores of the students in Electrostatics before and after exposure to the developed comics. The table illustrates the skills developed by the students on Electrostatics after using the developed comics based on the competencies presented below. High proficiency was achieved in describing charges, calculating electric flux, and explaining Gauss's law. Overall, the percentage mean for students' skills in Electrostatics increased from 38.58% to 78.64%.

Table 5: Developed skills of students in Electrostatics after using the developed comics

Learning Competencies	Mean Percentage Scores (Before), %	Mean Percentage Scores (After), %
1. Describing the nature of charges	87.78	98.33
2. Explaining the three processes of charging using diagrams	39.17	77.50
3. Predicting charge distributions and the resulting attraction or repulsion in a system of charged insulators and conductors	33.06	70.09
4. Explaining the role of electron transfer in electrostatic charging by rubbing	33.75	77.08
5. Describing an electric field as a region in which an electric charge experiences a force	34.00	79.33
6. Describing the trajectory of a point charge in an electric field	29.00	59.83
7. Explaining and calculating electric flux	26.67	85.28
8. Explaining Gauss's law in calculating electric field due uniformly distributed charge	25.21	81.67
<b>Overall Percentage Mean</b>	<b>38.58</b>	<b>78.64</b>
Mean Difference	40.06	
t-value	7.449	
t-prob	.000 (p<.01)	
Decision	Reject Ho	

The above findings is supported by the results of statistical comparison of the mean pre and posttest scores of the students on the skills test scores of the students ( $t\text{-value}=7.449$ ,  $p < .01$ ). The use of comics significantly developed students' skills in specific electrostatics concepts, particularly in foundational and complex topics such as charge description and electric flux calculation. The comics encouraged problem-solving by presenting scenarios where students applied electrostatic principles, reinforcing learning through active engagement.

Visual explanations and step-by-step diagrams also helped students understand how to perform specific tasks, like calculating electric flux or describing electric fields (Fananta et al., 2021). The Constructivist Learning Theory, as proposed by Vygotsky (1978), supports these findings. Visuals and dialogues in the comic-based material, along with the use of familiar context and language, helped students construct their own knowledge about the topic. Moreover, the use of comic characters in the material that facilitated students' learning through observation is also related to Bandura's Social Learning Theory.

#### **4.4. Student Views on the Use of Comics as a Learning Material**

Students' interviews highlighted key themes about the Electrostatics comics. shown. These themes include enhanced knowledge, improved attitude towards the subject, and developed skills in learning. The themes indicate that innovative visual storytelling significantly improved engagement, enjoyment, and comprehension of complex topics. Students found the comics effective for learning, as the illustrations and narratives made the material more accessible and engaging.

##### *4.4.1 Enhanced Knowledge*

This theme shows how using comics made complex Physics concepts easier to understand. The visuals and narrative style made topics like Electrostatics more accessible and improved student knowledge. Some students claimed,

*"Through comics, Physics lessons have become clear, and easy to understand."*

*"The topics become easier using the comics as it arouses the interest of students."*

*"This type of learning should be used often, especially when illustrating difficult topics. In this way, students can be more motivated and can understand lessons a lot easier."*

*"In this way, students can be more motivated and can understand lessons a lot easier."*

##### *4.4.2 Improved Knowledge*

This theme reflects a positive shift in students' attitudes toward Physics. The engaging format made learning more enjoyable, reducing intimidation and boosting interest and enthusiasm. Some students said,

*"This is a good way to stay focused and enjoy while studying."*

*"A very useful and fun way of learning."*

*"I enjoyed the Electrostatics Comics a lot. They made learning about electrostatics fun and easy with cool visuals and engaging stories."*

*"The comic is a great learning tool allowing students to visualize the lessons in normal day occurrences."*

*"It is a great tool for teaching and learning."*

*"As someone who reads comics, this is an exciting way to learn about physics concepts and topics."*

#### 4.4.3 Developed Skills

This theme highlights how comics helped develop essential learning skills. The interactive mix of visuals and text improved knowledge retention and real-life application, enhancing students' overall learning abilities. Responses of students classified under this theme are as follows:

*"The illustrations and comic conversations contributed to my learning skills as I understand Physics deeper."*

*"The comics provided for us students have greatly contributed to how we easily understand the topics and apply them in real-life situations."*

### 5. Conclusions

The developed Electrostatics comics met established quality standards with respect to content, format, presentation, organization, accuracy, and up-to-datedness of information, and overall instructional soundness. The Physics teachers confirmed their acceptability and appropriateness as supplemental learning materials, validating their clarity, usefulness, suitability, and adequacy.

The study also provides evidence that the use of comics-based instructional materials in teaching Physics, particularly Electrostatics, is an effective teaching innovation. The use of comics in learning Physics, demonstrated a significant impact in enhancing learning outcomes across three domains: knowledge, attitudes, and skills. The developed comics effectively enhanced better comprehension of complex concepts in Physics, enabling the students to create mental representations, making the topics more understandable. Students' exposure to the developed comics produced a significant improvement in how the students feel towards the subject, and how they find the importance of the subject in daily lives.

The use of comics also developed the students' critical thinking, problem-solving, and application skills, which are necessary in the learning of Physics. Overall, the study suggests that comic-based learning materials can enhance educational quality by making Physics more understandable and enjoyable. It supports the integration of innovative media and technology in teaching and provides evidence for policymakers to consider creative instructional tools in curriculum design and teacher training.

### 6. Recommendations

The developed Electrostatics comics are a valuable supplemental learning tool for high school students. Educators can enhance the impact of comics by widely adopting them in classrooms to support understanding, engagement, and positive

attitudes toward Physics. Creating similar comics for other challenging Physics topics is advisable, as this can simplify complex concepts for various learning levels. Educational institutions should provide support, resources, and training opportunities to encourage the effective use of comics in classroom instruction.

This study employed a one-group pre-test post-test design; future research may utilize a true experimental research design to enhance the generalizability of the findings. In addition, the study was conducted over a short period; a long-term effect of comic-based learning material can be explored to improve the retention of higher-order thinking skills. Future evaluations should also explore other factors in different learning settings, offering more profound insights into the comics' effectiveness in Physics education.

## 7. Conflict of Interest

This study declares no conflict of interest.

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