Development of STEM Physics Teaching Kit on Light

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ABSTRACT

Physics education is vital in fostering critical thinking, creativity, and problem-solving skills, yet it is often perceived as difficult and abstract by high school students. This study developed a STEM Physics Teaching Kit on light for Grade 10 learners using the research and development design featuring quantitative expert validation. The kit comprised lesson plans, teacher and student guides, worksheets, and pretest–posttest assessments aligned with the K to 12 Science Curriculum Guide. Needs assessment revealed that light was the least mastered topic, with a mastery percentage of 25.67%. Expert validators, including science teachers and STEM specialists, rated the teaching kit as excellent. Their feedback emphasized contextual relevance, clarity, and integration of STEM elements. The kit's design emphasized experiential, inquiry-based, and constructivist approaches, connecting physics concepts to real-life applications and supporting Sustainable Development Goal 4 on quality education. Findings affirm that the developed instructional materials possess high content validity, are pedagogically aligned with STEM practices, and are ready for classroom field-testing.

Keywords: Physics Education, STEM Teaching Kit, Light, Mirrors and Lenses

INTRODUCTION

Physics education equips learners with essential skills such as critical thinking, creativity, and problem-solving, which are vital for navigating the complexities of the 21st century and the fourth industrial revolution [1]. Despite its importance, physics is often perceived by high school students as difficult and boring due to abstraction, multiple representations, and heavy reliance on calculation. Beyond knowledge acquisition, physics fosters deeper understanding of scientific methods and values [2]. The United Nations' Sustainable Development Goal 4 (SDG 4) emphasizes inclusive and equitable quality education, recognizing STEM education as a critical driver of sustainable development [3][4][5]. Strengthening STEM equips learners with innovative skills necessary to address global challenges and technological advancements.

Teaching light in classrooms remains challenging due to persistent misconceptions, such as beliefs about vision and color. Research consistently shows that even after formal instruction, students often retain alternative conceptions about light phenomena such as reflection, refraction, and color dispersion [6]. For example, students may wrongly believe that light rays stop at the point of contact with an object or that white light is a single color rather than a mixture of all visible wavelengths [7]. These misconceptions are often rooted in intuitive ideas formed before formal education, making them resistant to change through traditional teaching approaches. Aligning teaching with students' cognitive development and prior knowledge is essential [8]. The STEM approach, recommended for equipping 21st-century skills, encourages practical experimentation even with simple projects [9]. Thus, the development of a STEM Physics Teaching Kit on Light for Grade 10 learners a well-validated instructional design products are a necessary prerequisite before attempting to alter these deeply rooted student alternative conceptions directly will be helpful and supports SDG 4 by promoting hands-on, contextualized learning, addressing Target 4.4 on skills for employment and entrepreneurship, and Target 4.7 on education for sustainable development [10][11].

METHODOLOGY

The study was conducted in a public school in Iligan City, Lanao del Norte, Philippines, using a research and development design with quantitative support. It involved Grade 10 Basic Education Curriculum students enrolled during SY 2025–2026, with seventy-six learners participating in a 30-item multiple-choice needs assessment to identify the least mastered physics topic. The STEM Physics Teaching Kit included a lesson plan with pretest–posttest, teacher's guide, student's guide, worksheets, all aligned with the K to 12 Science Curriculum Guide.

In evaluating the STEM Physics Teaching Kit, five (5) expert validators were the respondents, three (3) of whom are STEM experts at the same time as a physics high school teacher, and two (2) are STEM experts at the same time as a college professor using rating sheets with a 4-point Likert scale, assessing aspects such as social issues, potential solutions, knowledge needs, decision-making, prototype development, testing, socialization, layout, and language accuracy. The Likert scale was applied using a four-point interval system, where 1 corresponds to Poor, 2 to Fair, 3 to Good, and 4 to Excellent. These intervals provided a structured way of capturing evaluators' judgments, ensuring that qualitative perceptions such as clarity of instructions, identification of social issues, appropriateness of strategies, readability of text, and integration of STEM elements were consistently quantified.

The instruments used in the study included a needs assessment mean, the K to 12 Science Curriculum Guide, and validator rating sheets. The needs assessment mean was used to identify the least mastered competency. The K to 12 Science Curriculum Guide served as the basis for the content of light and focus of the intervention. The validator rating sheet was used to evaluate the STEM Physics Teaching Kit components such as the STEM lesson plan, Teacher's Guide and Students Guide and the comments and suggestions also for further enhancement of the kit.

The kit development had five phases, the analyzation phase, design phase, development phase, validation phase, and enhancement phase.

Analysis Phase. During the Analysis phase, a comprehensive review of literature on STEM approach and teaching kit was conducted to examine how these methods could enhance learner engagement and deepen understanding of scientific topics. Following the literature review, the researcher conducted a needs assessment to determine the learning gap.

Design Phase. In the design phase, the content of the STEM Physics Teaching Kit was aligned with the K to 12 Science Curriculum Guide. The learning objectives for the kit were derived from grade 10 with particular emphasis on light. It incorporated relevant concepts from the grade 10 modules to ensure a comprehensive, engaging educational experience and organized using the STEM and 7E lesson plan. A STEM lesson plan with pretest-posttest, teacher's guide, student's guide, student's worksheet was designed.

Development Phase. In the development phase, the teaching kit, including the lesson plan with pretest- posttest, teacher's guide, student's guide, the corresponding student's worksheet were assembled. The STEM Physics Teaching Kit was developed based on the established design. The teaching kit was then assessed by the advisers and panels. Feedback from this phase was collected and analyzed to make necessary revisions.

Validation Phase. After the revision, version 2 underwent further evaluation and refinement. It was evaluated by five (5) evaluators, three (3) of whom are STEM experts at the same time as a physics high school teacher, and two (2) are STEM experts at the same time as a college professor using rating sheets with a 4-point Likert scale, assessing aspects such as social issues, potential solutions, knowledge needs, decision-making, prototype development, testing, socialization, layout, and language accuracy. The Likert scale was applied using a four-point interval system, where 1 corresponds to Poor, 2 to Fair, 3 to Good, and 4 to Excellent. Data were analyzed using mean scores and validator ratings to determine the content validity, clarity, and structural quality of the kit as evaluated by experts.

Enhancement Phase. After the evaluation, comments and suggestion by the evaluators were considered in enhancing the version 2 to arrive the Final STEM Physics Teaching Kit.

RESULTS AND DISCUSSIONS

A. Least Learned Topic in Grade 10 Physics

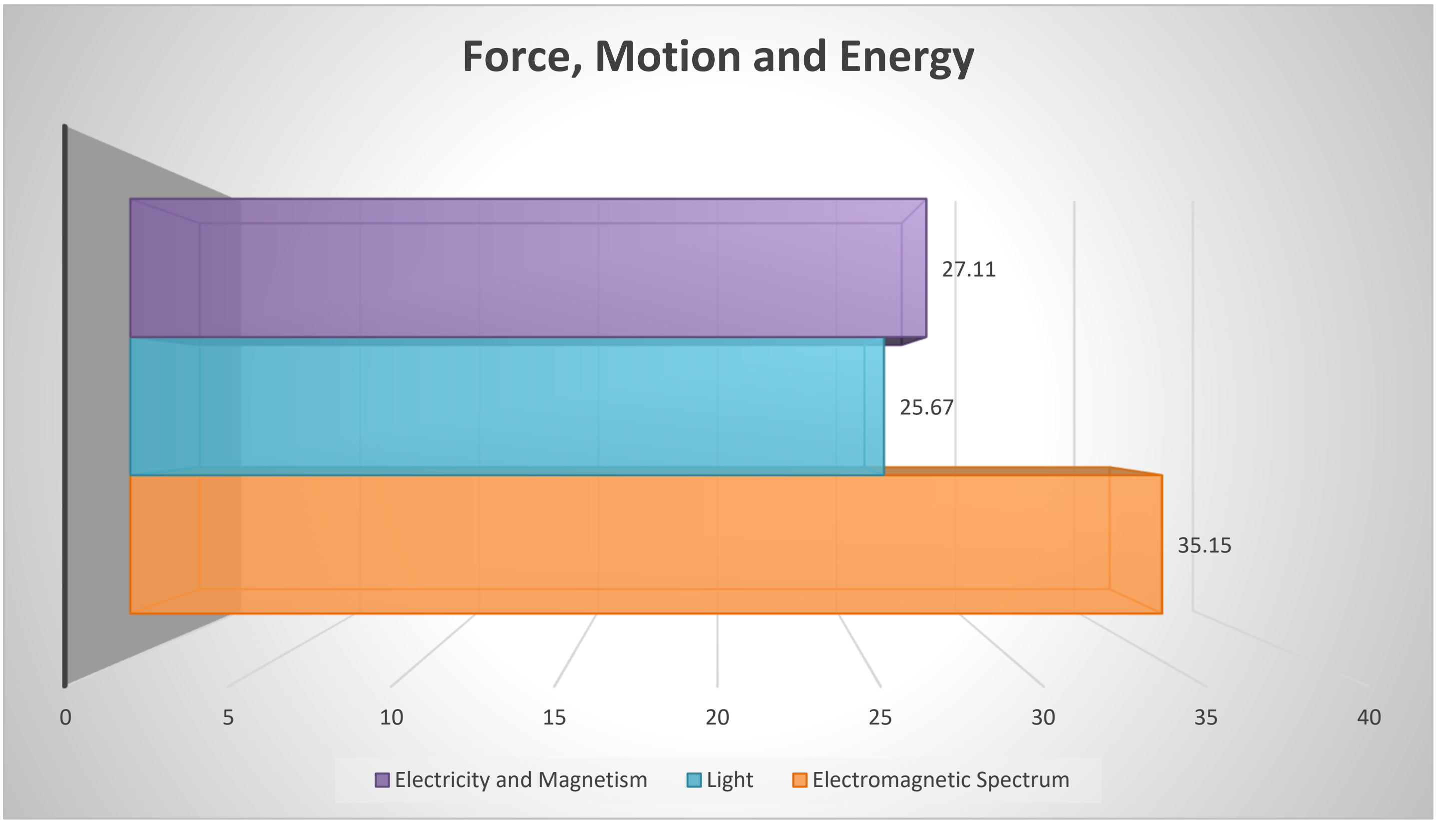

Figure 1. Mastery Percentage of Least Learned Competency

The figure 1 shows the mastery percentage of students on topics under force, motion, and energy. Light garnered the lowest percentage among the three topics. This result is consistent with previous research indicating that optics and light-related concepts are among the most difficult areas for high school students to master due to persistent misconceptions and abstract representations [12].

B. Unpacking the Learning Competency

Table 1. K-12 Curriculum Guide Utilize in STEM Physics Teaching Kit on Light

Content	Learning Competency	Objectives
2. Light 2.1 Reflection of light in Mirrors 2.2 Refraction of Light in Lenses	The learners should be able to predict the qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors and lenses.	1. Describe the qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors and lenses. 2. Solve problems involving the concept of light in real life situations. 3. Design a Do-It-Yourself (DIY) STEM project that uses mirrors and lenses as a main component and that could be used in demonstrating the concept of light.

Table 1 shows that the STEM Physics Teaching Kit is aligned with the K–12 competency on Light, particularly in explaining Reflection of light in Mirrors and Refraction of Light in Lenses. The objectives emphasize understanding qualitative characteristics (orientation, type, and magnification) of images formed by plane and curved mirrors and lenses can be applied to real-life and help solved social issues.

C. Validation of STEM Physics Teaching Kit on Light

Table 2. Consolidated Evaluation Results of STEM Instructional Materials

Material Evaluated	Average Mean	Overall Description	Key Expert Comments
STEM Lesson Plan	3.66	Excellent	- Connects topic of light to real-life problems (waste, recycling). - Activities encourage student participation. - Guide questions should be more thought-provoking.
Teacher's Guide	3.71	Excellent	- Needs clearer organization and alignment of tasks/assessments. - Improve spacing and readability. - Strengthen conceptual explanation of lens phenomena.
Student's Guide	3.81	Excellent	- Ensure proper spacing and highlight key parts. - Larger format for clarity and presentation. - Emphasizes safety in DIY STEM project.

Legend: *3.25-4.00 (Excellent); 2.50-3.24 (Good); 1.75-2.49 (Fair); 1.00-1.74 (Poor)*

The evaluation of the STEM Lesson Plan, Teacher's Guide, and Student's Guide yielded consistently excellent ratings (average means ranging from 3.66 to 3.80). Experts highlighted the contextual relevance of the lesson plan, the organizational clarity of the teacher's guide, and the safety and readability of the student's guide. These findings affirm that the developed instructional materials are pedagogically sound, engaging, and aligned with best practices in STEM education.

The Lesson Plan was commended for connecting physics concepts, particularly light, to real-life issues such as waste and recycling. This supports the findings of [13], who emphasized that contextualized STEM activities enhance student engagement and prepare learners for real-world applications. The suggestion to refine guide questions into more thought-provoking forms resonates with inquiry-based learning principles advocated by [14] where active investigation fosters deeper conceptual understanding.

The Teacher's Guide received excellent ratings but was noted to require clearer organization and stronger conceptual scaffolding. This aligns with [15], who stressed that structured, learner-centered strategies maximize student learning outcomes. Moreover, the emphasis on conceptual clarity in teaching optics echoes the work of [16] and [17], who demonstrated that analogies and models enhance comprehension of complex light phenomena. Thus, refining the guide to ensure alignment of tasks and assessments with conceptual goals will sustain its quality to improve the conceptual understanding of learners to light topic.

The Student's Guide achieved the highest mean rating, with experts highlighting its emphasis on safety and readability. This finding is consistent with the 5E instructional model [18], which integrates exploration and application while ensuring safe, student-centered learning environments. The recognition of safety in the DIY STEM project also reflects the conclusions of [19], who found that STEM education fosters hazard awareness and preparedness. Furthermore, the call for improved spacing and highlighting of key parts supports the argument of [20] that well-structured, accessible materials strengthen student process skills and comprehension.

From a theoretical perspective, Kolb's Experiential Learning Theory (1984) provides a strong foundation for these instructional materials. The lesson plan and guides encourage concrete experiences (hands-on activities), reflective observation (discussion and guide questions), abstract conceptualization (linking concepts to real-world issues), and active experimentation (prototype development and testing). The kit components were structurally mapped to encourage this cycle, providing a framework designed to help students apply knowledge meaningfully once deployed in a classroom [21].

In terms of broader implications, the findings suggest that continuous refinement of STEM instructional materials particularly in organization, inquiry-driven questioning, contextualization, and safety will sustain high levels of

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teacher endorsement and student learning outcomes. Moreover, the integration of project-based learning [22] and contextualized STEM approaches [23][24] ensures that students develop 21st-century skills such as critical thinking, collaboration, and innovation.

D. Face and Content Validation of the STEM Physics Teaching Kit

Table 3. Face and Content Validation of the STEM Physics Teaching Kit based on the validators' comment and suggestions

First Version	Comments/ Suggestions	Second Version
DAY 5-6 **6. Test and evaluation of the solution**: 1. Students will undergo test evaluation to measure the scientific concept that they learned during the whole teaching-learning process. Showcase the toy to the teacher for evaluation and assessment of the developed toy. 2. Learners will undergo tests to assess what they have learned during the teaching-learning process. 3. The developed DIY project will be presented and be assessed by the teacher based on the rubric. **7. Socialization and completion decision stage**: 1. The developed DIY project must be presented by the group inside the classroom. Five minutes will be given to the group presenter for further questions to be asked by other groups. 2. Upload the 1-minute video clip on Facebook for social awareness and encourage the viewers to do the same (recycling) in order to help the community.	*Specify what they will accomplish each day*	DAY 5-6 **6. Test and evaluation of the solution**: Day 5 1. Students will undergo test evaluation to measure the scientific concept that they learned during the whole teaching-learning process. Showcase the toy to the teacher for evaluation and assessment of the developed toy. 2. Learners will undergo tests to assess what they have learned during the teaching-learning process. Day 6 3. The developed DIY project will be presented and be assessed by the teacher based on the rubric. **7. Socialization and completion decision stage**: 1. The developed DIY project must be presented by the group inside the classroom. Five minutes will be given to the group presenter for further questions to be asked by other groups. 2. Upload the 1-minute video clip on Facebook for social awareness and encourage the viewers to do the same (recycling) in order to help the community.
ELICIT: Access prior knowledge. Ask students: *"Where do you encounter mirrors and lenses in daily life?"* (eyeglasses, cameras, vehicles, magnifying glasses).	*The question may be restructured to better stimulate students' thinking and encourage richer responses. The same consideration may also be applied to other parts of the lesson plan that contain guide questions.*	ELICIT: Access prior knowledge. Ask students: *"Where do you encounter mirrors and lenses in daily life?"* (eyeglasses, cameras, vehicles, magnifying glasses). *"What do you notice when you look into a mirror? Why do mirrors show reversed images? How do mirrors help in vehicles?"*
7. Socialization and completion decision stag e: 1. The learners will present their project which advertises the uniqueness and purpose of their device. 2. The video must be uploaded in their selected social media platform and make a statement or caption to encourage the viewers to value recycling and what benefits it is to the community. The video must earn at least 300 likes and 20 shares.	*Requiring the video to earn at least 300 likes and 20 shares may not be equitable for all learners because this depends more on social media reach than on scientific understanding or project quality. It would be better to assess the quality of the presentation, advocacy message, and reflection rather than public engagement metrics. Also provide QR codes for the links provided for physical copies.*	7. Socialization and completion decision stag e: 1. The learners will present their project which advertises the uniqueness and purpose of their device. 2. The video must be uploaded to their Facebook and TikTok and make a statement or caption to encourage the viewers to value recycling and what benefits it is to the community. QR Code of the slide: Scan me!
STAGE / ACTIVITY DAY 1 **1. Identification of social issues**: Based on the pictures shown by the teacher, brainstorm social issues that the community is facing right now. The conclusion should be the identification of problems with waste and electronic waste. **2. Identification of potential solutions**: 1. To collaborate with the group and to come up with possible solutions on the identified issue. 2. To arrive recycling easily available materials at home is a strong potential solution. DAY 2 **3. Need for knowledge**: To acquire knowledge on the topic light, what are its properties, how it works on a lens and mirrors, and to learn the concept through activities and experience in manipulating the activity materials. **4. Decision-making**: 1. To arrive with a DIY project design as a potential solution that suits the concept of light based on the knowledge learned from the discussion.	*Highlight the important parts to make them more noticeable. If possible, use a larger format to improve clarity and presentation.*	STAGE / ACTIVITY DAY 1 **1. Identification of social issues**: Based on the pictures shown by the teacher, **brainstorm social issues** that the community is facing right now. The conclusion should be the identification of problems with waste and electronic waste. **2. Identification of potential solutions**: 1. To collaborate with the group and to come up with **possible solutions** on the identified issue. 2. To arrive **recycling** easily available materials at home is a strong potential solution. DAY 2 **3. Need for knowledge**: To acquire knowledge on the topic light, what are its properties, how it works on a lens and mirrors, and to learn the concept through activities and experience in manipulating the activity materials. **4. Decision-making**: 1. To arrive with a DIY project design as a potential solution that suits the concept of light based on the knowledge learned from the discussion. 2. To identify recyclable and easily **available materials at home** to be used.

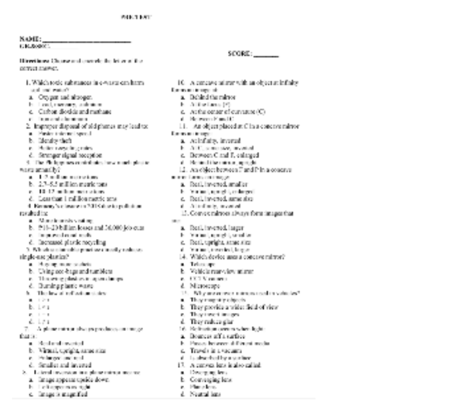
Republic of the Philippines Mindanao State University Iligan Institute of Technology College of Education - School of Graduate Studies Department of Science and Mathematics Education A COLLEGE OF EDUCATION STUDENT ACTIVITY GUIDE on "LIGHT" Prepared by: Sohainah M. Gandawali	*Remove the header*	STEM LESSON PLAN on "LIGHT" LESSON DESCRIPTION This lesson explores the concept of light and how it could be observed using some uncommon materials. GRADE LEVEL: Grade 10 ALLOTTED TIME: 6 days (45 minutes per hour meeting) LESSON OBJECTIVES
	*Be mindful of your spacing*	PRE-TEST Directions: Choose and shade the letter of the correct answer in the given answer sheet. 1. Which toxic substances in e-waste can harm soil and water? a. Oxygen and nitrogen b. Lead, mercury, cadmium c. Carbon dioxide and methane d. Iron and aluminum 2. Improper disposal of old phones may lead to: a. Faster internet speed b. Identity theft c. Better recycling rates d. Stronger signal reception 3. The Philippines contributes how much plastic waste annually? a. 1–2 million metric tons b. 2.7–5.5 million metric tons c. 10–12 million metric tons d. Less than 1 million metric tons 4. Boracay's closure in 2018 due to pollution resulted in: a. More tourists visiting b. ₱18–20 billion losses and 36,000 job cuts c. Improved coral reefs d. Increased plastic recycling 5. Which sustainable practice directly reduces 9. Which mirror is used as a car side mirror? a. Plane mirror b. Concave mirror c. Convex mirror d. Parabolic mirror 10. A concave mirror with an object at infinity forms an image at: a. Behind the mirror b. At the focus (F) c. At the center of curvature (C) d. Between F and C 11. An object placed at C in a concave mirror forms an image: a. At infinity, inverted b. At C, same size, inverted c. Between C and F, enlarged d. Behind the mirror, upright 12. An object between F and P in a concave mirror forms an image: a. Real, inverted, smaller b. Virtual, upright, enlarged c. Real, inverted, same size d. At infinity, inverted 13. Convex mirrors always form images that

Table 3 shows the evaluation of the STEM Physics Teaching Kit which revealed several areas for refinement. First, the objectives should clearly specify what learners are expected to accomplish each day to provide direction and measurable outcomes. In addition, some guide questions require restructuring to stimulate deeper thinking and encourage richer student responses, consistent with recent findings that well-designed prompts enhance critical thinking and inquiry-based learning [25]. The assessment criteria also need revision, as relying on social media metrics such as likes and shares is inequitable and does not accurately reflect scientific understanding or project quality. Instead, evaluation should focus on the quality of the presentation, the strength of the advocacy message, and the depth of reflection, aligning with authentic assessment practices that emphasize fairness and validity [26]. Furthermore, presentation enhancements such as highlighting important parts, using larger formats for clarity, and providing QR codes for accessibility can improve engagement and inclusivity, in line with universal design for learning principles that promote equitable access to educational materials [27]. Finally, minor formatting adjustments, including removing unnecessary headers and ensuring proper spacing, contribute to improved readability and professionalism. These refinements collectively strengthen the instructional design by promoting clarity, equity, and accessibility, thereby enhancing the overall quality of the STEM teaching kit.

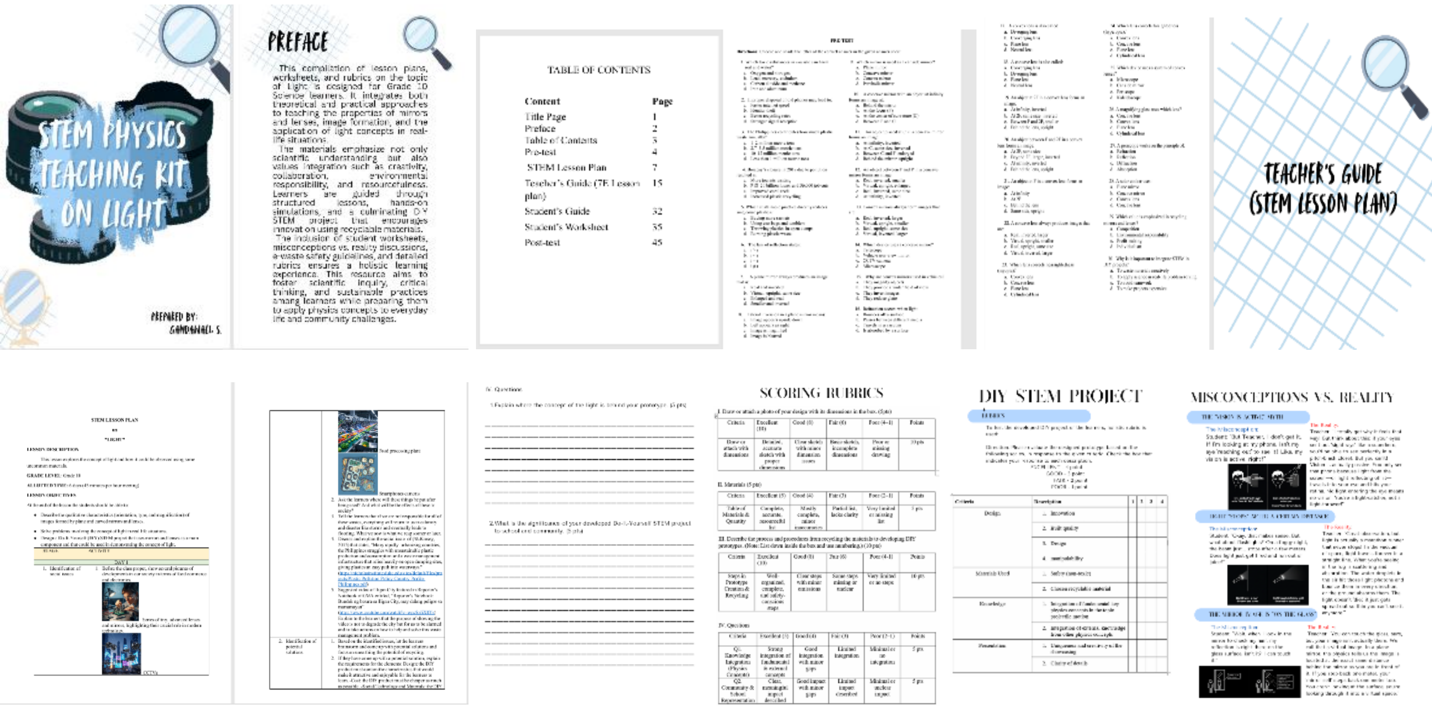


Figure 2. Sample Final Version of STEM Physics Teaching Kit

The final version of the STEM Physics Teaching Kit, as shown in Figure 4, carries several important implications for classroom practice. Its organized, visually appealing, and student-friendly design demonstrates how structured materials can enhance learner engagement and comprehension of abstract physics concepts. The integration of objectives, activities, guide questions, rubrics, and QR-based learning support reflects the principles of interactive and technology-enhanced learning, which have been shown to improve accessibility and student motivation [26]. By combining interactive learning tasks with accessible formats, the kit not only strengthens conceptual mastery of light but also promotes equity and inclusivity in STEM classrooms. These implications highlight the potential of well-designed instructional materials to bridge theory and practice, making physics more engaging and meaningful for Grade 10 learners.

CONCLUSION & RECOMMENDATIONS

This study successfully developed and validated a STEM Physics Teaching Kit on Light for Grade 10 learners using a structured research and development (R&D) design. A baseline needs assessment confirmed that light was the least mastered topic among students (25.67%), justifying the necessity for this targeted intervention. Expert evaluation demonstrated that the instructional materials including the lesson plan, teacher's guide, and student's guide possess excellent content validity, strong pedagogical soundness, and close alignment with the K to 12 Science Curriculum Guide. While the current scope focused strictly on design and expert validation without active classroom deployment, the resulting prototype stands as a rigorously refined, highly acceptable framework optimized to foster experiential and inquiry-based STEM learning.

It is recommended that future research focus on the active classroom field-testing and empirical implementation of this kit to evaluate its direct efficacy on student learning gains and the rectification of optics misconceptions. To establish broader statistical significance, effect sizes, and long-term retention metrics, future intervention studies should expand this testing across multiple, diverse schools using pretest–posttest control group designs. Furthermore, upcoming iterations of instructional material design should incorporate advanced quantitative metrics, such as the Content Validity Index (CVI) or inter-rater agreement coefficients, to further elevate the psychometric rigor of the expert evaluation phase. Finally, science educators and curriculum developers should scale this contextualized STEM framework to other abstract physics topics such as electricity or thermodynamics while providing parallel teacher training workshops to ensure the seamless operationalization of these inquiry-based materials in the classroom.

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