JelajahOptik: Bridging Gaps in Rural Science Learning with Affordable Innovation

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ABSTRACT

This paper presents the development and usability analysis of the "JelajahOptik" model, a low-cost and practical teaching aid designed for lower secondary Science in rural schools. The model was developed based on the ADDIE instructional design framework to address educational gaps caused by limited laboratory access and technological constraints in rural schools in Malaysia. The study involved 108 lower secondary students from Kuala Krai, Kelantan, and assessed usability in terms of usefulness and satisfaction. Findings indicated high validity, CVI (face validity = 0.80, content validity = 0.93) and reliability of survey with Cronbach's Alpha value of 0.86. Descriptive analysis using SPSS revealed high mean scores for usability constructs, usefulness (M=3.81, SD=0.20) and satisfaction (M=3.80, SD=0.25). The "JelajahOptik" model demonstrates strong potential for national-scale implementation and commercialization as a cost-effective, eco-friendly, and inclusive science education tool.

Keywords- Low-Cost Teaching Aid, Rural Schools, Science, Optics, ADDIE Model

INTRODUCTION

Access to quality science education remains a persistent challenge in malaysia's rural areas, primarily due to limited laboratory facilities and the high cost of scientific equipment. These infrastructural constraints hinder students' ability to engage in hands-on experiments, consequently affecting their understanding and interest in science subjects. The lack of equitable access to modern teaching resources continues to widen the learning gap between urban and rural schools. According to the malaysia education blueprint (2013–2025) [1], effective classroom teaching and learning are central to national educational progress. However, in many rural contexts, teachers face substantial barriers such as inadequate internet connectivity, limited laboratory infrastructure, and insufficient teaching aids, conditions that directly impact students' learning outcomes and engagement in science-related disciplines.

This situation has led to an increased risk of learning disparities and dropout rates among rural students, primarily due to limited access to quality learning materials and digital resources (norfarahzatul asyikin zakari, mohamad zuber abd. Majid, & muhammad hussin, 2022) [2].

To address this issue, "jelajahoptik" was conceived as a cost-effective, durable, and modular science teaching aid designed specifically for use in resource-constrained environments. The innovation aligns with national efforts [3, 4] to ensure inclusive and equitable science education by providing teachers and students with affordable yet effective alternatives to conventional laboratory-based learning.

The need for affordable STEM education in resource constrained environments is linked to the global imperative of sustainability-based pedagogy, particularly within the framework of Education for Sustainable Development (ESD). While resource limitations in rural settings are challenging, research demonstrates that these constraints can be turned into pedagogical advantages.

The study by Maslamany, Chua, and Sathasivam (2024) emphasizes that a teacher's readiness to adopt ESD-oriented approaches is significantly predicted by their self-efficacy, which in turn is influenced by their

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knowledge of Sustainable Development and school support [5]. This highlights that successful implementation of affordable, innovative teaching aids requires not just materials, but also the cultivation of teacher confidence and institutional buy-in. Furthermore, the practical integration of sustainability is exemplified by hands-on activities, such as implementing rainwater harvesting systems (Adipraja et al., 2024) [6]. This kind of project-based, real-world application, which often uses local or low-cost materials, shifts the focus from expensive equipment to contextual problem-solving, making STEM learning relevant, affordable, and actionable for students in rural areas.

In line with contemporary sustainability goals, the development of “JelajahOptik” incorporates the use of recycled and low-cost materials, representing both an educational and environmental initiative. Such practices not only reduce dependency on imported teaching equipment but also promote environmental stewardship and creativity among students (Nor Kamilah Makhtar et al., 2023) [**7**]. This approach encourages learners to recognize the interconnection between scientific inquiry and sustainable innovation, nurturing a mindset of eco-consciousness through hands-on experimentation.

Furthermore, the design philosophy of “jelajahoptik” emphasizes practical usability, teacher empowerment, and student engagement. By creating simpler and more affordable experimental apparatus, teachers are able to conduct science activities without financial strain while enhancing the quality of instruction (juliatto et al., 2024) [8]. This is especially vital for science topics that are conceptually abstract or visually complex, such as light and optics, which has been identified as one of the most challenging areas for students to master (gita ayu wandari, agus fany chandra wijaya, & rika rafikah agustin, 2018) [9].

Developed using the addie instructional design model (analysis, design, development, implementation, and evaluation) [10], the “jelajahoptik” initiative bridges the gap between theory and practice in rural science classrooms. It offers a scalable, interactive, and sustainable solution that empowers teachers to deliver meaningful, experiment-based learning experiences without dependence on expensive laboratory infrastructure. By providing a tangible and engaging way to visualize optical phenomena, the model enhances students’ conceptual understanding, critical thinking, and enthusiasm for science, ultimately contributing to malaysia’s broader vision of cultivating scientifically literate, innovative, and environmentally responsible learners.

METHODOLOGY

A quantitative research approach was adopted to develop and evaluate the usability of the “JelajahOptik” model. The model’s design followed the ADDIE framework, Analysis, Design, Development, Implementation, and Evaluation. The study population consisted of 150 lower secondary students from a rural school in Kuala Krai, Kelantan. Referring Krejcie and Morgan (1970) [11], a sample of 108 students was selected through simple random sampling. Instruments included expert validation checklists for face and content validity and a student questionnaire to measure usability perception.

RESULTS AND DISCUSSION

Table I shows that the “JelajahOptik” model achieved strong validity, with face validity at 0.80 and content validity at 0.93 [12, 13]. These results meet the acceptable threshold of CVI ≥ 0.80, confirming the instrument’s suitability. Table II presents the Cronbach’s Alpha value (0.861), indicating high reliability [14]. Table II demonstrates that both constructs, usefulness and satisfaction, achieved high mean values (3.81 and 3.80), with low standard deviations, signifying strong agreement among respondents [15]. These findings validate the usability of the model as an interactive teaching resource that enhances conceptual understanding in light and optics.

Table I Expert Agreement Values (CVI) of “JelajahOptik” model

No.	Type of Validity	Expert Agreement
1	Face	0.80

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2	Content	0.93

Table II Descriptive Statistics for Usability Perception of "JelajahOptik"

Construct	Mean	Standard Deviation
Usefulness	3.81	0.20
Satisfaction	3.80	0.25

The "JelajahOptik" model goes beyond its technical design as a teaching aid; it embodies a broader educational philosophy grounded in sustainability, inclusivity, and empowerment. One of its most distinctive features is the deliberate use of recycled and locally available materials, which not only reduces cost but also reinforces environmental stewardship among students and teachers. By transforming discarded or inexpensive items into functional scientific tools, the model fosters a sense of creativity, responsibility, and appreciation for sustainable innovation, values that align with Malaysia's commitment to the Sustainable Development Goals (SDG) (SDG 4: Quality Education and SDG 12: Responsible Consumption and Production).

Moreover, the model contributes meaningfully to inclusive education, especially in schools that lack access to standard laboratory resources. Teachers in under-resourced environments often struggle to provide meaningful hands-on experiences due to limited infrastructure. "JelajahOptik" directly addresses this challenge by offering an adaptable and user-friendly resource that can be assembled, demonstrated, and maintained with minimal cost or technical expertise. The feedback gathered from participating educators revealed that the model instilled renewed confidence in delivering practical lessons and encouraged more inquiry-driven teaching practices, a key shift from traditional, teacher-centered methods toward student-centered learning.

The affordability of "JelajahOptik" further enhances its scalability and feasibility for wide implementation. With a production cost substantially lower than conventional optical kits, the model can be reproduced in bulk and distributed through educational channels such as the Ministry of Education (KPM), local District Education Offices, or non-governmental organizations (NGOs) engaged in rural science outreach. Beyond Malaysia, this low-cost, modular approach has significant potential for adaptation in other Southeast Asian countries facing similar challenges in science education equity, where geographical and socioeconomic factors limit access to laboratory-based learning.

Equally important, the model encourages teacher agency and professional creativity. Teachers who participated in pilot testing reported that "JelajahOptik" not only simplified complex optical concepts for students but also rekindled their own enthusiasm for science instruction. Such empowerment is essential in sustaining educational innovation, as teachers become co-creators rather than mere implementers of learning materials.

In essence, "JelajahOptik" demonstrates how a locally inspired, environmentally conscious, and pedagogically sound innovation can bridge systemic gaps in rural science education. Its success underscores the transformative power of context-sensitive design, where simplicity, sustainability, and inclusivity converge to make science learning not only more accessible but also more meaningful.

Fig. 1. The "JelajahOptik" Model Structure and Components

CONCLUSION

All research objectives outlined in this study were successfully achieved. The findings affirm that the **"**JelajahOptik**"** model demonstrates high levels of validity, reliability, and usability, confirming its potential as a pedagogically sound, low-cost teaching aid for lower secondary Science in rural educational settings. The integration of **"**JelajahOptik**"** into classroom practice has proven effective in fostering active, inquiry-based learning, allowing students to explore scientific phenomena through direct observation and manipulation rather than passive instruction. This approach not only enhances conceptual understanding of topics such as light and optics but also cultivates curiosity, problem-solving skills, and scientific thinking**,** competencies aligned with the aspirations of Malaysia's STEM education and SDGs.

In addition to its educational impact, the model's design philosophy emphasizes sustainability and inclusivity. By utilizing recycled and affordable materials, "JelajahOptik" demonstrates how science education can be both environmentally responsible and economically feasible, especially in schools with limited access to laboratory infrastructure. Such innovation empowers teachers to be creative facilitators of learning while ensuring that no student is left behind due to socioeconomic constraints.

Looking ahead, the scalability of "jelajahoptik" offers significant potential for nationwide implementation and educational commercialization, particularly as part of ministry of education initiatives supporting hands-on stem learning. Future research should explore the integration of digital and interactive components, such as augmented reality (ar) or virtual simulation, to expand its pedagogical versatility and relevance in the era of digital learning. Moreover, adapting this model to other science domains, including physics, chemistry, and biology, could further enhance its contribution to malaysia's goal of producing scientifically literate, innovative, and environmentally conscious learners.

Ultimately, "jelajahoptik" exemplifies how affordable innovation, guided by sound instructional design, can transform limitations into opportunities, bridging the gap between access and excellence in science education for all.

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