**Islamic Journal of Integrated Science Education (IJISE), Vol. 5 No. 2, July 2026, pp. 157-170**
DOI: https://doi.org/10.30762/ijise.v5i2.9649

**Islamic Journal of Integrated Science Education (IJISE)**

**Program Studi Tadris IPA**
**Universitas Islam Negeri (UIN) Syekh Wasil Kediri**
**e-ISSN : 2986-0865**
https://jurnalfaktarbiyah.iainkediri.ac.id/index.php/ijise

# DEVELOPMENT OF AN ICT-INTEGRATED SCIENTIFIC LEARNING E-LKPD FOR SUPPORTING STUDENTS' SCIENTIFIC LITERACY IN ELASTICITY AN HOOKE'S LAW

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**Abstract:** This study aimed to develop an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD) for Elasticity and Hooke's Law and to examine its validity, practicality, and preliminary effectiveness in supporting students' scientific literacy. The study employed a Research and Development (R&D) approach using the ADDIE instructional design model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The implementation involved 15 eleventh-grade students of SMA Terpadu Nurul Huda. Data were collected through expert validation sheets, student response questionnaires, and scientific literacy pre-test and post-test. The developed E-LKPD obtained an average validity score of 91.13%, categorized as very valid, while the practicality score was 81.40%, categorized as very practical. Students' mean scientific literacy score increased from 56.67 on the pre-test to 75.33 on the post-test, with an N-Gain of 0.43, indicating moderate improvement. These findings provide preliminary evidence that the developed E-LKPD is a valid and practical digital instructional resource and has potential to support students' scientific literacy.

**Keywords:** Electronic Student Worksheet, ICT Integration, Scientific Learning, Scientific Literacy, Elasticity and Hooke's Law

**Article History:**
Received: 03 May 2026; Revised: 26 July 2026; Accepted: 30 July 2026; Published: 31 July 2026

**Citation (APA Style):**
Mardova, L., Sinensis, A. R., Putra, F., Nabila, S. E., & Cengiz, K. (2026). Development of An ICT-Integrated Scientific Learning E-LKPD for Supporting Students' Scientific Literacy In Elasticity An Hooke's Law. *Islamic Journal of Integrated Science Education (IJISE), 5*(2), 157–170. https://doi.org/10.30762/ijise.v5i2.9649

## INTRODUCTION

Scientific literacy has become one of the essential competencies required to prepare students for the challenges of the twenty-first century. It enables individuals to explain scientific phenomena, evaluate scientific evidence, and make informed decisions regarding issues related to science and technology (OECD, 2023a; OECD, 2023b). Therefore, science education should not only emphasize conceptual understanding but also develop students' ability to apply scientific knowledge in solving real-life problems.

From an Islamic educational perspective, the development of scientific literacy is also consistent with the Qur'anic emphasis on learning, observation, and the development of human understanding. Surah An-Nahl (16:78) explains that Allah brought human beings into the world without knowledge and provided them with hearing, sight, and intellect so that they may acquire knowledge and understanding. This verse highlights the importance of using human sensory and intellectual capacities as instruments for learning and understanding the world. In the context of science education, these principles are closely related to scientific learning activities that encourage students to observe phenomena, ask questions, collect information, interpret evidence, and communicate findings (Huda, et al., 2020a; Huda et al., 2026; Hardini et al., 2026). Therefore, learning materials that facilitate observation, interaction, and scientific reasoning are relevant to both contemporary science education and the Islamic perspective on knowledge acquisition.

Despite continuous educational reforms, the scientific literacy of Indonesian students remains relatively low. According to the Programme for International Student Assessment (PISA) 2022, Indonesian students still perform below the OECD average in science, indicating that many students experience difficulties in explaining scientific phenomena, interpreting evidence, and applying scientific concepts to everyday situations (OECD, 2023b).

Physics education plays an important role in developing scientific literacy because physics provides opportunities for students to investigate natural phenomena through observation, experimentation, and scientific reasoning. However, physics learning in many schools is still dominated by teacher-centered instruction, mathematical problem solving, and memorization of formulas. Such instructional practices provide limited opportunities for students to develop inquiry skills and scientific reasoning, resulting in relatively low scientific literacy (Kelp et al., 2023; Zetterqvist & Bach, 2023).

One of the topics frequently perceived as difficult by senior high school students is Elasticity and Hooke's Law. These concepts involve abstract relationships among force, deformation, spring constant, and elastic properties that are often difficult to visualize using

conventional instructional materials. Consequently, students tend to memorize equations without fully understanding the underlying physical concepts (Nurulsari et al., 2020; Usman et al., 2025; Huda, et al., 2020b).

The rapid development of digital technology has created new opportunities to improve science learning through interactive instructional materials. Electronic Student Worksheets (E-LKPD) allow teachers to integrate multimedia resources, virtual simulations, online assessments, and collaborative learning activities into a single learning platform. Such integration is expected to increase students' engagement, learning autonomy, and conceptual understanding (Munir, 2017).

Among various instructional approaches, Scientific Learning is widely recognized as an effective approach for promoting scientific literacy because it emphasizes observing, questioning, experimenting, associating, and communicating scientific findings (Hosnan, 2014). When integrated with Information and Communication Technology (ICT), Scientific Learning enables students to investigate scientific phenomena using digital tools while receiving immediate feedback throughout the learning process (Munifah et al., 2019; Lestari et al., 2021; Saregar et al., 2025).

Several previous studies have reported that electronic worksheets improve students' motivation, conceptual understanding, and learning achievement. Likewise, ICT-supported instruction has been shown to enhance students' engagement and scientific reasoning (Agyei, 2021; Andriyani et al., 2024). Furthermore, digital instructional materials integrated with scientific literacy-oriented learning activities have demonstrated positive impacts on students' understanding of physics concepts (Sunarti et al., 2024).

Nevertheless, previous studies have generally examined electronic worksheets, ICT-supported learning, or scientific literacy-oriented learning separately. Studies on science-literacy-oriented electronic worksheets have demonstrated the potential of digital worksheets to support physics learning (Asrizal et al., 2022; Saputri & Asrizal, 2022), while other studies have reported benefits of ICT-supported simulations and digital learning resources for students' engagement and scientific literacy (Agyei, 2021; Andriyani et al., 2024; Sunarti et al., 2024). However, the existing literature identified in this study provides limited evidence on an E-LKPD that simultaneously integrates the Scientific Learning sequence, multiple ICT resources, and explicit scientific literacy competencies within the topic of Elasticity and Hooke's Law. This gap is important because the topic requires students to connect abstract relationships among force, deformation, and elastic properties with observable and

interpretable evidence.

Therefore, this study develops an ICT-integrated Scientific Learning-based E-LKPD that combines instructional videos, PhET Interactive Simulations, Google Forms, and Wordwall activities within a structured Scientific Learning sequence. The novelty of the study lies in the integration of these ICT resources into one digital worksheet specifically designed to support scientific literacy competencies, particularly explaining scientific phenomena, interpreting scientific evidence, and applying scientific knowledge in contextual situations. Accordingly, the study aims to evaluate the validity, practicality, and preliminary effectiveness of the developed E-LKPD in supporting senior high school students' scientific literacy in Elasticity and Hooke's Law.

## METHOD

This study employed a Research and Development (R&D) approach to develop an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD) for Elasticity and Hooke's Law. The product was developed using the ADDIE model, which consists of Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The ADDIE model was selected because it provides a systematic framework for identifying learning needs, designing and developing instructional products, implementing the product, and evaluating its quality.

The implementation involved 15 eleventh-grade students from SMA Terpadu Nurul Huda, Indonesia. The participants were students in the target class who took part in the physics learning activities using the developed E-LKPD. The available study record does not specify a formal probability-sampling procedure; therefore, the participants are described as a classroom-based implementation sample rather than as a representative sample.

Product evaluation involved expert validators with expertise in physics education, instructional media, and language. The validation process assessed content validity, instructional design, media quality, and language appropriateness. The exact number and detailed qualifications of the validators should be reported according to the researchers' original validation records before final submission.

### Analysis

The collected data were analyzed using descriptive quantitative techniques. The validity and practicality percentages were calculated by comparing the obtained score with the maximum possible score and multiplying the result by 100%. The resulting percentages were

interpreted using the predetermined validity and practicality criteria. Students' scientific literacy improvement was analyzed using the Normalized Gain (N-Gain) proposed by Hake (1999). Because the implementation used a one-group pre-test–post-test design without a comparison group, the N-Gain result was interpreted as an indicator of improvement within the participating group rather than as definitive evidence of causal effectiveness.

**Design**

During the design stage, the structure of the Electronic Student Worksheet was prepared according to the Scientific Learning approach. Learning activities were organized into five stages: observing, questioning, collecting information, associating, and communicating (Hosnan, 2014). At this stage, learning objectives, assessment instruments, learning scenarios, multimedia components, and interface layouts were also designed.

**Development**

At the development stage, the Electronic Student Worksheet was created using various ICT-based learning resources. The developed product integrated instructional videos, PhET Interactive Simulations, Google Forms, and Wordwall activities into a single digital learning environment. The initial product was subsequently evaluated by expert validators to obtain suggestions for improvement before classroom implementation.

**Implementation**

The validated E-LKPD was implemented in physics learning involving 15 eleventh-grade students. During the learning process, students completed all Scientific Learning activities using the developed digital worksheet. Data regarding students' responses and scientific literacy achievement were collected throughout the implementation.

**Evaluation**

The evaluation stage consisted of formative and summative evaluations. Formative evaluation was conducted during each ADDIE stage through expert review and product revision. Summative evaluation focused on assessing the validity, practicality, and effectiveness of the developed E-LKPD after classroom implementation.

**Research Instruments**

Three research instruments were employed in this study.

1. Expert validation sheets were used to evaluate the content accuracy, instructional design, language, and media quality of the developed E-LKPD.
2. Student response questionnaires were administered to measure the practicality of the developed product based on students' perceptions regarding usability, attractiveness,

clarity, and learning support.

3. Scientific literacy tests consisting of pre-test and post-test items were administered to evaluate students' scientific literacy before and after using the developed E-LKPD.

**Data Analysis**

The collected data were analyzed using descriptive quantitative techniques. The validity of the developed E-LKPD and The validity results were interpreted according to predetermined validity criteria was calculated using the following equation:

$$P = \frac{\sum X}{\sum X_{max}} \, x \, 100\%$$

Students' scientific literacy improvement was analyzed using the Normalized Gain (N-Gain) proposed by Hake (1999):

$$N - Gain = \frac{Posttest - Pretest}{Maximum\ Score - Pretest}$$

**Table 1**. The N-Gain values were interpreted using the following criteria

| N-Gain | Category |
|---|---|
| ≥ 0.70 | High |
| 0.30–0.69 | Moderate |
| < 0.30 | Low |

## RESULTS

This study aimed to develop an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD) for the topic of Elasticity and Hooke's Law and to evaluate its validity, practicality, and effectiveness in improving senior high school students' scientific literacy. The development process followed the ADDIE instructional design model, consisting of Analysis, Design, Development, Implementation, and Evaluation. The results of the study are presented as follows.

Product Development Results. The product developed in this study was an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD). The learning material was organized according to the Scientific Learning stages, namely observing, questioning, collecting information, associating, and communicating. To facilitate active learning, the E-LKPD integrated instructional videos, PhET Interactive Simulations, Google Forms, and Wordwall activities into a single digital learning environment.

The validation of the developed learning media was conducted by involving material and media experts. The validation aimed to assess the feasibility and quality of the developed

DOI: https://doi.org/10.30762/ijise.v5i2.9649

product in terms of material content, presentation, language, visual design, and ease of use (Huda et al., 2019; Yasin et al., 2020; Putra et al., 2024). The results of the validation by the material and media experts are presented in **Tables 2** and **3**. Overall, the validation results indicate that the developed product obtained a **Very Valid** category and was considered suitable for use in the learning process.

**Table 2.** Material Expert Validation Results

| No. | Assessment Aspect | Percentage (%) | Category |
|---|---|---|---|
| 1 | Alignment of the material with learning outcomes | 92.00 | Very Valid |
| 2 | Accuracy and correctness of concepts | 91.50 | Very Valid |
| 3 | Depth and breadth of the material | 90.50 | Very Valid |
| 4 | Systematics and presentation of the material | 91.00 | Very Valid |
| 5 | Clarity of language and terminology | 91.00 | Very Valid |
| 6 | Suitability of examples and exercises | 91.50 | Very Valid |
| **Average** | | **91.25** | **Very Valid** |

**Table 3.** Media Expert Validation Results

| No. | Assessment Aspect | Percentage (%) | Category |
|---|---|---|---|
| 1 | Visual appearance and media design | 91.50 | Very Valid |
| 2 | Layout and composition | 91.00 | Very Valid |
| 3 | Text readability | 90.50 | Very Valid |
| 4 | Quality of images, illustrations, and graphics | 91.00 | Very Valid |
| 5 | Ease of use and navigation | 91.50 | Very Valid |
| 6 | Consistency of design and presentation | 91.00 | Very Valid |
| **Average** | | **91.00** | **Very Valid** |

After the product was validated by material and media experts, a student response test was conducted to determine the practicality and acceptance of the developed product. The students' responses were assessed based on several aspects, including ease of use, appearance, material presentation, and usefulness. The results of the student responses to the developed product are presented in **Table 4**.

**Table 4.** Students' Response Result

| Assesment Aspect | Percentage (%) |
|---|---|
| Ease of Use | 82.50 |
| Appearance | 80.80 |
| Material Presentation | 81.60 |
| Benefit | 80.70 |
| Average | 81.40 |

The overall evaluation demonstrates that the developed E-LKPD satisfies the three major quality criteria of educational product development.

**Table 5.** Summary of Evaluation Results

| Criterion | Result | Category |
|---|---|---|
| Validity | 91.13% | Very Valid |
| Practicality | 81.40% | Very Practical |
| Effectiveness | N-Gain = 0.43 | Moderate Improvement |

Overall, the findings indicate that the ICT-integrated Scientific Learning-based E-LKPD is suitable for classroom implementation. The product demonstrated high validity, excellent practicality, and moderate effectiveness in improving students' scientific literacy. These results suggest that integrating Scientific Learning with ICT-based instructional media provides meaningful learning experiences and supports student-centered physics learning.

## FINDING AND DISCUSSION

The present study aimed to develop an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD) for the topic of Elasticity and Hooke's Law and to evaluate its validity, practicality, and effectiveness in improving senior high school students' scientific literacy. The findings should be interpreted from three complementary perspectives: product quality, usability, and students' learning improvement. First, the very high validity score indicates that the E-LKPD was considered appropriate in terms of content, learning activities, language, and media design. This is consistent with the role of systematic instructional design in ensuring alignment between learning objectives, learning activities, and assessment (Branch, 2009). The result also supports previous work showing that science-literacy-oriented electronic worksheets can be developed as feasible resources for physics learning (Asrizal et al., 2022; Saputri & Asrizal, 2022).

The practicality score of 81.40% suggests that students could use the digital worksheet with a positive perception of its usability, attractiveness, clarity, and learning support. A possible explanation is the integration of different ICT resources into a single learning sequence. Videos can provide an initial representation of the phenomenon, PhET simulations can allow students to manipulate variables and observe relationships, Google Forms can provide structured responses and feedback, and Wordwall can reinforce concepts through interactive activities. This combination is consistent with previous evidence that ICT-supported physics learning and interactive digital media can support engagement and scientific literacy (Agyei, 2021; Andriyani et al., 2024).

The increase in the mean scientific literacy score from 56.67 to 75.33 and the N-Gain of 0.43 indicate moderate improvement within the participating group. This pattern is theoretically consistent with Scientific Learning because students are guided to observe phenomena, formulate questions, collect information, associate evidence with concepts, and communicate their findings (Hosnan, 2014).

The improvement in students' scientific literacy can also be viewed from an Islamic educational perspective. Surah An-Nahl (16:78) emphasizes that Allah provides human beings with hearing, sight, and intellect as means of acquiring knowledge and understanding. This principle is relevant to the learning activities in the developed E-LKPD, which encouraged students to observe phenomena, explore information through digital media and simulations, interpret evidence, and construct scientific explanations (Huda et al., 2019; Yasin et al., 2020; Putra et al., 2024). Thus, the integration of Scientific Learning and ICT not only supported students' active engagement in learning but also facilitated the use of sensory and intellectual processes in developing scientific understanding. However, the moderate N-Gain of 0.43 should be interpreted cautiously because the study involved only 15 students and did not include a comparison group.

The ICT components may strengthen these activities by making phenomena more visible and allowing students to interact with representations that are difficult to provide through printed worksheets alone. Similar positive tendencies have been reported in research on digital and ICT-supported physics learning, although the magnitude of improvement cannot be directly compared across studies because the learning topics, instruments, participants, and research designs differ (Sunarti et al., 2024; Wardi et al., 2024).

The contribution of the present study is therefore not simply the use of digital worksheets, but the integration of a Scientific Learning sequence, multiple ICT resources, and explicit scientific literacy competencies in one product for Elasticity and Hooke's Law. This integrated design addresses the identified gap in previous work, which has more often examined these components separately.

At the same time, the moderate N-Gain and the absence of a control group mean that the findings should be interpreted as preliminary evidence of improvement rather than proof that the E-LKPD alone caused the observed change.

The study also has important limitations. The implementation involved only 15 students from one senior high school, so the findings cannot be generalized to broader populations. In addition, the effectiveness test used a one-group pre-test–post-test design without a comparison group, making it impossible to separate the effect of the E-LKPD from other factors that may

have influenced students' performance. The product was also limited to Elasticity and Hooke's Law. These limitations should be considered when interpreting the validity, practicality, and N-Gain findings.

Future studies should involve larger and more diverse samples and, where feasible, use quasi-experimental or experimental designs with comparison groups. Further research can also examine the effectiveness of the E-LKPD across other physics topics and investigate longer-term outcomes such as scientific reasoning, problem-solving, and critical thinking.

## CONCLUSION

This study developed an ICT-integrated Scientific Learning-based Electronic Student Worksheet (E-LKPD) for teaching Elasticity and Hooke's Law using the ADDIE instructional design model. The findings demonstrate that the developed instructional product fulfilled the three primary quality criteria of educational product development. The expert validation results showed that the E-LKPD achieved an average validity score of 91.13%, indicating that the instructional content, media design, language, and learning activities were highly appropriate for classroom implementation. Furthermore, the practicality evaluation produced an average score of 81.40%, suggesting that students perceived the developed E-LKPD as easy to use, attractive, and supportive of independent learning.

The effectiveness evaluation revealed that students' scientific literacy improved after using the developed E-LKPD. The increase in the average score from 56.67 in the pre-test to 75.33 in the post-test, with an N-Gain value of 0.43, indicates a moderate improvement in scientific literacy. These findings suggest that integrating Scientific Learning with ICT-based instructional media, including instructional videos, PhET Interactive Simulations, Google Forms, and Wordwall, provides meaningful learning experiences that actively engage students in scientific inquiry and concept construction.The primary contribution of this study lies in the development of a comprehensive digital learning product that integrates Scientific Learning, ICT, and scientific literacy competencies within a single Electronic Student Worksheet. Unlike conventional worksheets, the developed E-LKPD facilitates students' abilities to observe scientific phenomena, formulate questions, interpret evidence, and communicate scientific explanations while simultaneously improving conceptual understanding in physics learning. Therefore, the developed E-LKPD can serve as an innovative instructional resource that supports student-centered learning and contributes to the implementation of digital transformation in physics education.

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