

Development and Validation of STEM-Based Science Digital Worksheet on Object Motion Material for Junior High School Students

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Abstract: In the present day, it is anticipated that students possess the ability to effectively utilize digital technology to process information and address contextual problems. One possible course of action would be to develop a STEM-based Science Digital Worksheet on the Material of Object Motion. The STEM aims to facilitate the application of contextual problem-solving techniques through the utilization of students' literacy and numeracy skills. The scope of this study encompasses the field of research and development, commonly referred to as R&D. The R&D model employed ADDIE. One of the stages defined in this model is the developmental stage, which is intended to assess and evaluate the product through expert validation tests. The validators comprised of educators in the field of Integrated Science at FMIPA Semarang State University, ICT experts at SMA Negeri 1 Kudus, and science teachers at SMP 2 Dawe Kudus. The obtained media validation results from three experts yielded a value of 95%, while material experts obtained 96.67%. As a result, both were classified as highly feasible. It can be concluded that the Science Digital Worksheet is appropriate for use in learning activities.

Keywords: Object motion; Science digital worksheet; STEM

Introduction

The phenomenon of global competition has become common across all domains in the 21st century. One potential solution involves implementing educational programs within schools to enhance the competency of human resources. According to the results of PISA 2018, a mere 25% of students in Indonesia have achieved a minimum level of reading competence or higher, while only 24% have attained a minimum level of mathematical competence or higher. Additionally, approximately 34% of students achieved a minimum level of scientific competency or higher (Kemendikbud, 2021). Indonesia has implemented ongoing educational reforms that prioritize student-centered learning in order to produce graduates who can effectively compete in the global competition. It is anticipated that students possess the skills to utilize digital technology to address contextual problems by processing information in the

21st century learning setting (Hidiroglu et al., 2021; Turhan & Demirci, 2021).

The development of a STEM-based Science Digital Worksheet on the subject of Object Motion is one potential approach to solving this problem. Worksheets for students are a form of educational material that can be regarded as essential. This is due to the fact that teachers use them to assist students in their learning, to facilitate learning that is focused on student centers, to stimulate students' interests in the subject of science education, and to carry out assessments (Utami & Aznam, 2020). Science digital worksheets in digital form offer several benefits, including an opportunity for students to access and review challenging material at their convenience. Additionally, these worksheets offer practical problems and procedures that require active engagement from students (Wibawa et al., 2018). The utilization of technology-based worksheets presents a notable benefit in the realm of science education,

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particularly in relation to technology and environmental studies. This advantage lies in the potential for such worksheets to offer practical solutions to real-life issues (Hidayah et al., 2021).

The development of the Science Digital Worksheet in this research is rooted in the principles of STEM (Science, Technology, Engineering, and Mathematics). The STEM aims to develop students' abilities to engage in contextual problem-solving through the utilization of their literacy and numeracy skills (Aydin et al., 2021). The implementation of STEM in science learning has demonstrated effectiveness in fostering students' future competence (Sukmagati et al., 2020). The integration of STEM principles into conventional student worksheets has been shown to enhance and cultivate students' 21st century skills (Prasadi et al., 2020; Yulianti et al., 2020). Technology holds significant importance in the STEM context (Selisne et al., 2021). There is a need to enhance the potential of STEM-oriented student worksheets to align with the present-day requirements.

The STEM-based Science Digital Worksheet is one of the initiatives to introduce a new learning paradigm. This is due to the fact that the STEM-based Science Digital Worksheet contains activities for students to design and create a product and utilize the project as a practical medium. Additionally, students can use their numeracy skills to design and manufacture products and conduct practicum. The STEM approach fosters the development of scientific thinking, engineering design, and numeracy skills by working together to solve problems (Uğur et al., 2020). Students will be trained and acquainted with problem-solving through scientific knowledge, design, and accurate calculations through such a learning process (Hanif et al., 2019).

Method

This research encompasses the domain of Research and Development (R&D). The R&D model employed is ADDIE. The ADDIE model encompasses a series of sequential stages that are integral to the research process, including Analysis, Design, Development, Implementation, and Evaluation (Branch, 2009). The developmental phase is designed to assess and evaluate the product through expert validation tests. The process of product validation is conducted by proficient

validators who possess expertise in their respective domains, such as material expert validators and media experts. The validators were comprised of educators from Semarang State University and science teachers. Experts were requested to complete a validation questionnaire. The sheet contains input from experts that serves as a basis for enhancing the product prior to conducting student testing (Arikunto, 2010). The following formula was used to statistically and descriptively examine the validation data acquisition.

$$P = \frac{f}{N} \times 100\% \tag{1}$$

In which: P = percentage of obtained score, F = total obtained score, N = total maximum score. The obtained validity value is then interpreted into categories according to Table 1.

Table 1. Instrument Validity Criteria

Percentage (%)	Criteria
81.25 < score ≤ 100.00	Highly Feasible
62.25 < score ≤ 81.25	Feasible
43.75 < score ≤ 62.25	Not Feasible
25.00 ≤ score ≤ 43.75	Highly Unfeasible

The feasibility of a STEM-based Science Digital Worksheet can be determined by assessing the average percentage score of each validator, which must exceed 62.50 according to the criteria of feasibility and high feasibility.

Result and Discussion

Validation Results of Media and Material Expert

The determination of the validity of Science Digital Worksheets that are based on STEM is reliant on the validation data. The study employs a panel of three media experts and three material experts to serve as validators. The validators comprised of academic professionals, including faculty members in Integrated Science at FMIPA Semarang State University, ICT experts at SMA Negeri 1 Kudus, and science teachers at SMP 2 Dawe Kudus. The outcomes of the validation process are exhibited in Table 2 and Table 3, respectively.

Table 2. Percentage of Validity of STEM-based SDW by Media Experts

Media Expert	Agency	Percentage (%)	Criteria
AMD-1	Integrated Science Lecturer, Faculty of Mathematics and Natural Sciences, Semarang State University	90	Highly feasible
AMD-2	ICT expert at SMA Negeri 1 Kudus	95	Highly feasible
AMD-3	Science teacher at SMP 2 Dawe Kudus	100	Highly feasible
Average		95	Highly feasible

Table 3. Percentage of Validity of STEM-based SDW by Material Experts

Media Expert	Agency	Percentage (%)	Criteria
AMT-1	Integrated Science Lecturer, Faculty of Mathematics and Natural Sciences, Semarang State University	90	Highly feasible
AMT-2	Integrated Science Lecturer, Faculty of Mathematics and Natural Sciences, Semarang State University	100	Highly feasible
AMT-3	Science teacher at SMP 2 Dawe Kudus	100	Highly feasible
Average		96.67	Highly feasible

According to the findings presented in Table 2, the STEM-oriented science digital worksheet was deemed highly viable by media experts, as evidenced by the validator's respective scores of 90%, 95%, and 100%. Moreover, Table 3 indicates that each validator material has received a score of 90%, 100%, and 100%, respectively. As a result, the STEM-based Science Digital Worksheet material has been classified as 'highly feasible'. According to the evaluation conducted by the media validator, it has been determined that the Digital Science Worksheets are suitable for application in learning activities. The validator's suggestions include paying close attention to the writing font's style and size, maintaining a constant background color, and ease of access.

Characteristics of STEM-based Science Digital Worksheets

Physics lessons can be related to the concept of the STEM approach (Saleh et al., 2020). STEM-oriented Science Digital Worksheets are a type of Student Worksheets, also known as LKPD, that incorporate digital technology and are aligned with the STEM approach. The use of STEM in the learning process has an important meaning because it can increase literacy and skills in managing technology (Triana et al., 2020). Science learning using the STEM approach is important to be implemented in the classroom because the learning process involving inquiry and engineering design is believed to be capable building 21st century skills and readiness for globalization (Permanasari et al., 2021). The STEM learning approach trains students to think scientifically and be able to use technology to face the future (Widiarti et al., 2022). STEM-based learning activities as a solution to provide deep experience product manufacturing process (Rahmawati et al., 2021).

The online presentation of LKPD represents a form of technological implementation in the field of education that serves as a means of supporting the competencies that students must acquire in the 21st century (Cholifah & Novita, 2022). The material presented within the Science Digital Worksheet pertains to the concept of object motion. This material is included in the curriculum for the first semester of the eighth grade. The Liveworksheet website platform is utilized by the Science Digital Worksheet. The Science Digital Worksheet encompasses basic competencies 3.2 and 4.2.

Competency 3.2 pertains to the analysis of linear motion, the influence of force on motion as per Newton's laws, and its relevance to the motion of objects and living things. Competency 4.2 pertains to the presentation of findings obtained from an investigation into the impact of force on the motion of objects. Figure 1 depicts the cover design of the Science Digital Worksheet.

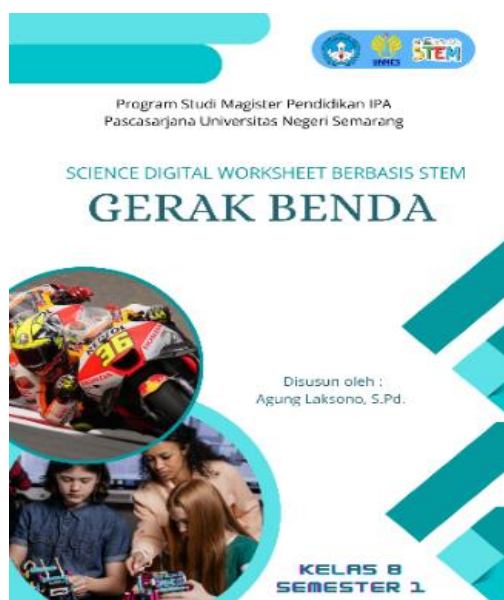


Figure 1. Cover section of science digital worksheet

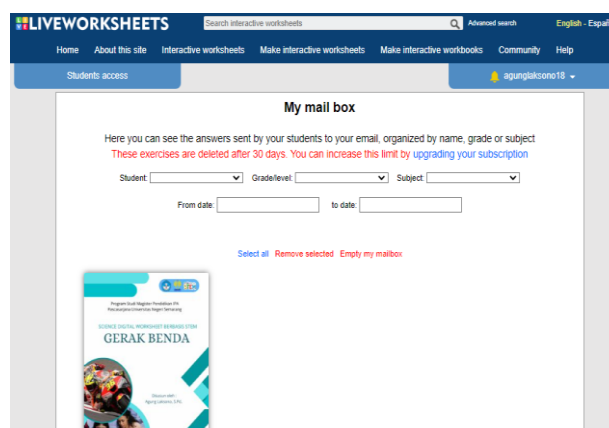


Figure 2. My mail box section

The Liveworksheet platform facilitates the implementation of educational activities utilizing the Science Digital Worksheet, thereby simplifying the process for teachers. The Science Digital Worksheet

offers a user-friendly interface that allows for combining the results of student activities into a single folder. This feature facilitates the teacher's ability to efficiently evaluate students' assignments and organize data storage. The aforementioned feature section can be found within the designated area labeled as "My mail box". The teacher has the ability to download the outcomes of student work. The use of Science Digital Worksheets have the potential to enhance collaborative skills among students during online learning as they engage in group activities (Maulidya & Ambarwati, 2022).

It is imperative for teachers to develop LKPD in science learning based on various learning approaches, methods, and models so that this approach can provide a more structured and directed learning experience for students, enabling them to discover new concepts in their learning (Bakri et al., 2020). The utilization of the STEM approach in the Science Digital Worksheet has been demonstrated to enhance students' reasoning, creativity, thinking, conceptual understanding, as well as critical thinking skills (Taufiq et al., 2020). The integration of science, technology, engineering, and mathematics objectives with other subject areas is a fundamental aspect of STEM as it is achieved through project-based learning experiences that require the application of knowledge to resolve real problems (Abdurrahman et al., 2019; Baran & Maskan, 2021).

The Science Digital Worksheet includes various STEM elements, including the study of objects motion, GLB and GLBB, distance and displacement in the field of science. Additionally, technology is utilized through the use of smartphones to search for relevant supporting information and the use of STEM-based Science Digital Worksheets. Engineering is additionally included through the creation of simple toy cars that are capable of moving without the use of batteries. Furthermore, mathematics is integrated into the learning process through the use of mathematical calculations and the consideration of project costs when creating projects. The Science Digital Worksheet contains a variety of learning activities, including the creation of project designs and the resolution of three problems by examining students' scientific literacy and conducting experiments. The Science Digital Worksheet accommodates auditory learning styles by including instructional videos. This is also an adaptation to the kinesthetic learning style as it is equipped with experimental activities that require physical activity on the part of the students (Susilawati et al., 2023). Digital worksheets provide meaningful recall because they contain visual and verbal knowledge (Wijayanti & Ernawati, 2020).

Sekilas Seputar STEM

Apasih yang dimaksud STEM?

Pendidikan STEM adalah pendidikan yang mengintegrasikan sains, teknologi, enjineri, dan matematika, dengan memfokuskan proses pendidikan pada pemecahan masalah nyata dalam kehidupan sehari-hari maupun kehidupan profesi (Firman, 2016).

Konsep STEM pada Tema Gerak Benda

- 1 SCIENCE** Materi benda bergerak, GLB dan GLBB, jarak dan perpindahan
- 2 TECHNOLOGY** Penggunaan Smartphone untuk mencari informasi pendukung yang relevan dan penggunaan Science Digital Worksheet berbasis STEM
- 3 ENGINEERING** Pembuatan mobil mainan sederhana yang bergerak tanpa baterai
- 4 MATHEMATICS** Penggunaan perhitungan matematika pada proses pembelajaran dan pembuatan proyek serta biaya yang dikeluarkan dalam pembuatan proyek.

Figure 3. Section regarding STEM

Eksplorasi Science & Technology

Video Pembelajaran Gerak Benda

Silakan amati video tersebut dan perluas literasimu dengan memanfaatkan pencarian google tentang materi Gerak Benda

Eksplorasi Mathematics

Kecepatan Rata-Rata

$$v = \frac{\Delta x}{\Delta t}$$
 Keterangan:
 v = kecepatan rata-rata (m/s)
 Δx = x akhir - perpindahan
 Δt = perubahan waktu (s)

Kelajuan Rata-Rata

$$v = \frac{\Delta s}{\Delta t}$$
 Keterangan:
 v = kelooapan rata-rata (m/s)
 s = jarak tempuk (m)
 t = waktu tempuk (s)

Memulai dengan Pertanyaan Esensial

Simaklah video berikut!

JAWABAN

Figure 4. Introduction to object motion

The Science Digital Worksheet contains explanatory video content pertaining to Object Motion, as well as formula information that may help students in comprehending the key concepts of learning this topic. The Science Digital Worksheet facilitates direct playback

of learning videos. The use of learning videos can enhance students' comprehension of abstract concepts by placing greater emphasis on real representations (Jundu *et al.*, 2020). The Science Digital Worksheet is accompanied by a user manual. The handbook has been categorized based on its intended audience, distinguishing between teachers and students. The handbook utilized by educators includes tutorials that consist of the Science Digital Worksheet and its corresponding assessment components. The guidebook exclusively comprises tutorials for accomplishing the Science Digital Worksheet, catering specifically to the needs of students. Through the Science Digital worksheet, students can utilize technology in solving contextual problems related to the concept of object motion (Wahyuni & Ariadi, 2022).

Conclusion

The application of STEM-based Science Digital Worksheets is deemed suitable for use as a learning tool for students. In addition, the Science Digital Worksheet with a focus on STEM will be integrated into the science learning for junior high school students in order to evaluate its effectiveness.

Author Contributions

Conceptualization, Agung Laksono and Ani Rusilowati; methodology, Ani Rusilowati; software, Arif Widiyatmoko; validation, Arif Widiyatmoko; formal analysis, Agung Laksono; investigation, Ani Rusilowati; resources, Agung Laksono; data curation, Ani Rusilowati; writing—original draft preparation, Agung Laksono, Ani Rusilowati, Arif Widiyatmoko; writing—review and editing, Ani Rusilowati dan Arif Widiyatmoko.

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Conflicts of Interest

The authors declare no conflict of interest. This research was conducted as an alternative solution to improve the quality of science learning.

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