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Development of STEM-Based Digital Student Worksheet to Improve Students' Numeracy and Science Literacy

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Abstract: As a result of interviews with class VIII science teachers at SMP Negeri 15 Semarang, information was obtained that most of the teaching materials used in the Archimedes law material were still in the form of printed teaching materials (student worksheet, modules and textbooks), PPTs and learning videos. The available teaching materials are not yet fully electronic, thus preventing students from accessing learning without time and space limitations. This causes students' numeracy and science literacy skills to be low. The aim of this research is to determine the characteristics of STEM-based digital student worksheet, test the feasibility of STEM-based student worksheet, analyze the increase in numeracy and science literacy after using STEM-based digital student worksheet. This research uses research and development methods. This method can be used to develop teaching materials, namely digital student worksheet. The design of the digital student worksheet development research is based on the Thiagarajan 4D model which includes the definition stage, design stage, development stage and dissemination stage. The research results show that this digital student worksheet is designed to be interactive, containing elements such as links, moving images, audio and video which can increase students' numeracy and science literacy; the results of the digital student worksheet feasibility assessment obtained feasible criteria with a result score of 0.85 (media) and 0.84 (material). The results of this research show that there is an increase in the N-Gain value.

Keywords: Digital student worksheet; Numeracy literacy; Scientific literacy; STEM

Introduction

Literacy skills are the initial abilities possessed by students to be able to develop learning and innovation skills, as well as life skills to work and contribute to society (Ayuwara et al., 2022; Tohara et al., 2021). Entering the 21st century, Nudiati (2020) emphasize the importance of six basic literacy pillars that every individual must have. These pillars include competent reading and writing skills, numeracy sharpness, broad scientific understanding, adaptive digital skills, wise financial management, and awareness of cultural and civic values. The results of the PISA research released in 2022 explain that the scores of Indonesian students in the fields of mathematics and science literacy have decreased compared to the previous year. In 2018, the mathematics literacy score was 379, while in 2022 it fell to 366, then in the field of science, which was previously 396 in 2018 to 383 in 2022 (OECD, 2023).

As a result of interviews with science teachers who teach class VIII at SMP Negeri 15 Semarang and SMP Negeri 13 Semarang, information was obtained that most of the teaching materials used in Archimedes' legal material were still in the form of printed teaching materials (student worksheet, modules and textbooks), PPT, and learning videos. The available teaching materials are not yet fully electronic, thus preventing students from accessing learning without time and space

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limitations. This means that many students' summative assessment results are below achieving learning objectives, causing students' scientific literacy and numeracy literacy to be low. The results of research carried out by Jannah et al. (2021) and Manalu et al. (2020) shows that the low ability to understand physics regarding symbols, language and numbers is still unknown to many students. This is supported by research by Putri et al. (2018) and Abdulrahaman et al. (2020) who found that there are still many students who cannot understand the numbers and function symbols used in physics concepts, so students do not understand that the use of numbers and scientific symbols in physics is very important to communicate complex ideas more simply.

The low numeracy literacy and scientific literacy of students can also be caused by a lack of connection between the discussion topics and the real world of students, learning is more dominant with non-contextual content so that it will burden students (Fuadi et al., 2020). Contextual science learning is related to various life problems, this enables students to connect surrounding phenomena with numeracy and science concepts in solving problems (Hoogland et al., 2018; Permanasari, 2016). Contextual learning also requires the inclusion of elements of science, technology, engineering and mathematics that are integrated into learning at school. The elements included in this learning are the science, technology, engineering, and mathematics (STEM) learning model (Muttaqiin, 2023).

Entering 21st century skills, STEM is a very effective learning model to be implemented in the educational environment. The application of the STEM model makes it easy for students to relate to academic concepts in everyday life, because the STEM model adopts the application of the principles of science, mathematics, engineering and technology using an interdisciplinary approach (Kanematsu et al., 2016; Salame et al., 2019). In the early stages of its development, STEM has been implemented in several developed countries such as Japan, Singapore, Finland, Australia and the United States (Ritz et al., 2015; Wahyuni, 2021). STEM began as an idea from the National Science Foundation with the hope of making these four main fields (science, technology, engineering, and mathematics) the main choice for students (Christine, 2016; Kapila et al., 2014). The United States is facing a crisis of scientists in the STEM field, so the government is taking serious steps by creating STEM Education and increasing educational scholarships for prospective teachers who choose one of the STEM fields (Ejiwale, 2013; Jones et al., 2013). This reflects the United States government's commitment to addressing challenges in science and technology through a STEM approach.

Science material is material that studies natural phenomena and events that occur in the real world. In general, science learning at junior high school level consists of chemistry, biology and physics, not separate subjects, but combined into one subject called comprehensive science (Nuraini et al., 2017). Science is part of natural science so it is closely related to scientific literacy (Utami et al., 2016). This phenomenon, which is also a problem in life, is closely related to basic mathematics in using numbers and symbols. The ability to understand phenomena and use numbers and symbols is very necessary so that you can make appropriate decisions to face problems in real life (Li et al., 2019). This is part of numeracy literacy in science material, especially physics.

Studying physics at the junior high school level aims to equip students with the skills to master physics material and make it easier for students to connect to the real world. Physics material is often expressed through numbers, symbols, symbols and mathematical equations (Kokkonen et al., 2022). Students' ability to study symbols and carry out mathematical analysis is known as expertise in analyzing and understanding symbolic language in physics (Maulyda et al., 2020). These two abilities are included in the generic skills of science. Therefore, students who can master these two skills will more easily understand the physics concepts they are studying (Jannah et al., 2021).

In this modern era, the development of communication and information technology not only has a significant impact on various sectors, but also influences the education sector (Szymkowiak et al., 2021). One of the new innovations that has emerged in learning is research on electronic teaching materials, which aims to develop effective learning experiences for students in the school environment (Alenezi, 2020; Augustha et al., 2021). As advances in communication and information technology continue to develop, digital Student Worksheets have become an innovative form of learning (Melania et al., 2021). Digital student worksheets is a transformation from conventional worksheets into a digital or electronic format which is made possible by developments in technology and information (Lavtania et al., 2021; Sumarmi et al., 2021). The advantage of using digital LKPD is its ability to simplify and narrow the boundaries of space and time in the learning process. This contributes to learning effectiveness, which contrasts with the use of modules which often take longer because they tend to cover more material (Suryaningsih et al., 2021). Apart from that, digital student worksheet can also be an interesting tool, especially when students' numeracy literacy and scientific literacy experience a decline (Dewi et al., 2023; Syafitri et al., 2020).

Digital student worksheet as a form of innovative teaching material, functions as a guide to learning activities by presenting material summaries, assignments and learning videos that are easily accessible (Chofifah et al., 2023; A. N. Hidayah et al., 2021). With its ability to combine images, animation, audio, video, text, and others, digital student worksheet can create interactive learning activities for students (Fitri et al., 2023; Lioba et al., 2021; Sumanik et al., 2023). The development of digital student worksheet is not only limited to these elements, but will also add videos and interesting phenomena. The advantages of using digital student worksheet are not only ease of use, but also the ability to be integrated with innovative learning models, such as STEM-based learning models which are one of the innovative learning models in the 21st century (Ünlü et al., 2022). It is hoped that the integration of STEM-based learning models in digital student worksheet can create an effective learning atmosphere, helping in exploring students' literacy abilities (Pratiwi et al., 2022; Sari et al., 2021). In this way, digital LKPD is not only a modern learning tool but also supports the development of students in facing the challenges of 21st century learning.

Findings from previous research show that the application of digital student worksheet with a scientific approach in learning has very practical results, because the student worksheet is interactive (Suwastini et al., 2022). According to Ariani et al. (2020), Interactive student worksheet is seen as an alternative form of media that can help learning by providing practice questions and content that includes electronic-based media categories. This is because to use the student worksheet, electronic devices are needed that enable students to increase their understanding of the learning material independently. The research carried out differentiates itself from previous research by developing STEM-based digital student worksheet. This student worksheet not only contains content and questions, but also includes interesting elements such as phenomena, videos, images, text and audio. Uniquely, this student worksheet can not only be accessed via a computer, but also via a cellphone or PC.

The aim of this research is to determine the characteristics of STEM-based digital student worksheet, test the feasibility of STEM-based student worksheet, analyze the increase in numeracy and science literacy after using STEM-based digital student worksheet. The benefit of this research is that the results of the development of STEM-based digital student worksheet can be used as a learning supplement that can improve numeracy literacy and scientific literacy of junior high school students.

Method

This research uses research and development methods. This method can be used to develop teaching materials, namely digital LKPD. The design of the digital LKPD development research is based on the Thiagarajan 4D model Fitri et al. (2023) which includes the definition stage, design stage, development stage and distribution stage which can be seen in Figure 1.

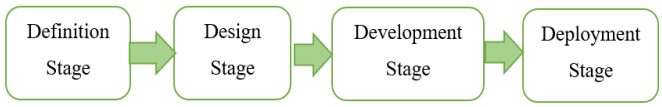

Figure 1. Thiagarajan's 4D model

The product developed and tested in the research was teaching material in the form of a STEM-based digital student worksheet on Archimedes' law material which was implemented at SMP Negeri 15 Semarang. This research uses a quasi-experimental design (Pretest-Posttest Control Group Design). This research design involved two groups of students (two classes), namely classes VIII I and VIII D of SMP Negeri 15 Semarang. The first group (experimental group) was treated with digital STEM-based student worksheet, while the second group (control group) was treated with regular LKPD. In each group, an initial test will be carried out, then treatment will be given and at the end of the activity they will be given another test (Aryani et al., 2019).

Results and Discussion

Characteristics of STEM-Based Digital Student Worksheet

The development of STEM-based digital student worksheet to improve numeracy literacy and scientific literacy begins with arranging the material, creating illustrations, and drafting the overall manuscript based on previously collected literature. Creating STEM-based digital student worksheet using the Canva application is then inserted into a live worksheet, which contains interesting phenomena accompanied by learning videos to facilitate understanding and also generate interest for students.

The digital student worksheet display consists of an introduction, main activities, summary, glossary and table of contents. The introductory section consists of a cover, foreword, table of contents, learning outcomes, indicators, learning objectives, explanation of STEM, implementation of STEM and instructions for using student worksheet. The display of learning activities in STEM-based digital student worksheet contains learning material that is STEM-based. The learning activity display contains learning materials and activities in each section, this aims to make it easier for

students to understand the material with the help of digital STEM-based student worksheet. Some of the benefits of STEM in student learning include making students easier to solve problems, independent, innovators, inventors, creators, logical thinkers and technologically literate (Suprapto, 2016). The material also provides an evaluation of each main material taught, aimed at strengthening students' understanding of the material being studied.

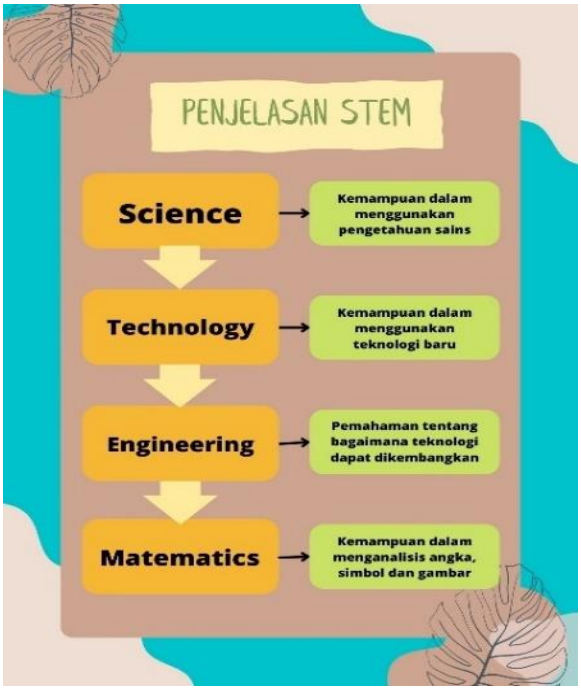

Figure 2. Stages of STEM-based digital student worksheet

Figure 3. STEM-based digital student worksheet activities

Feasibility Test for STEM-Based Digital Student Worksheet

The feasibility of the digital student worksheet product being developed was analyzed using the Aiken V formula for expert validation results. To determine the suitability of the digital student worksheet, a validation calculation formula was used by experts consisting of 6 experts (2 media+material expert lecturers and 4 media+material expert teachers) to determine the feasibility or correctness of the product being developed. Aiken (1985) stated that the results of the STEM-based digital student worksheet feasibility test by media experts and material experts can use the following formula:

$$V = \frac{\Sigma s}{n(c-1)} \quad (1)$$

Information:
Σs : Total score of validators
lo : The lowest validity assessment number (in this case = 1)
c : The highest validity assessment number (in this case = 4)
r : The score given by the assessor
s : r – lo
n : Number of validators

The feasibility of STEM-based digital student worksheet by media experts and material experts is presented in Table 1 and Table 2.

Table 1. Product Feasibility Decision Guidelines, (Lestari, et.al., 2020)

Interval	Criteria
≥ 0.80	Worthy
0.60 ≤ V < 0.80	Enough
0.40 ≤ V < 0.60	Not Worth It
< 0.40	Not feasible

Table 2. Product Feasibility Test Results

Expert Validator	V	Criteria
Media	0.85	Worthy
Material	0.84	Worthy

Based on the results of the product feasibility assessment in the form of STEM-based digital student worksheet by 6 experts (2 media+materials expert lecturers and 4 media+materials expert teachers) the results were 0.85 (media) and 0.84 (materials) respectively with appropriate criteria. The six validators stated that the product was in the appropriate category so that the product could be used in learning activities. STEM-based digital student worksheet is suitable for use in learning based on indicators in media and material validation. The feasibility results of the developed student worksheet are supported by Rahayu et al. (2021)

that a product can be included in the feasible category if the results of the Aiken V test are more than 0.71. Soit can be said that the digital worksheet developed is in the feasible category and can be given to students in class (Masithah et al., 2022).

Small Scale Test

Small-scale tests are given to students who have received learning using the designed digital student worksheet. The number of students who took the small-scale test was 10 students in class VIII of SMP Negeri 15 Semarang. The assessment of the tests and student response sheets was carried out at the end of the learning activity meeting on Archimedes' legal material. Students were asked to assess the use of digital student worksheet in the learning process. The results of the N-Gain score assessment can be seen in Table 3.

Table 3. Small Scale N-Gain Test Calculation Results

Number of Students	Aspect	Results	Criteria
10	Numeracy Literacy	0.10	Low
10	Scientific Literacy	0.30	Currently

Table 3 shows that the average N-Gain value of students' numeracy literacy results falls into the low criteria, namely 0.10. Meanwhile, the average N-Gain value resulting from students' scientific literacy falls into the currently criteria, namely 0.30. This assessment aims to see the readability and practicality of the digital student worksheet which was designed based on 14 statements from 3 assessment aspects which include the quality of the media, materials and benefits of STEM-based digital student worksheet. The results of the percentage of student responses in the small-scale test can be seen in Table 4 and Table 5.

Table 4. Student Response Criteria (Wardani et al., 2018)

Percentage %	Criteria
$80 \leq x \leq 100$	Very good
$60 \leq x < 80$	Good
$40 \leq x < 60$	Enough
$20 \leq x < 40$	Not good
$0 \leq x < 20$	Not good

Table 5. Small Scale Test Results of Student Responses

Assessment Aspects	Persentase %	Criteria
Media	86	Very good
Material	82	Very good
Benefit	88	Very good

The results of the readability and practicality test on a small scale, namely: students commented that the appearance of the STEM-based digital student worksheet was very good and interesting, easy to understand and understandable, the student worksheet added a lot of insight and was able to understand material that was not yet understood. The readability and practicality questionnaire consisted of 14 statements filled in by 10 students as a result of the readability and practicality test on a small scale, obtaining percentage results in the media aspect of 86%, the material aspect of 82% and the benefits aspect of 88% with the respective criteria. each one is very good.

Large Scale Test

Large-scale tests are given to students who have received learning using the designed digital student worksheet. The number of students who took part in the large-scale test was 32 students in class VIII of SMP Negeri 15 Semarang. The assessment of the tests and student response sheets was carried out at the end of the learning activity meeting on Archimedes' legal material. Students were asked to assess the use of digital student worksheet in the learning process. The results of the N-Gain score assessment can be seen in Table 6.

Table 6. N-Gain Test Calculation Results

Number of Students	Aspect	Results	Criteria
32	Numeracy Literacy	0.64	Currently
32	Scientific Literacy	0.66	Currently

Table 6 shows that the average N-Gain value of students' numeracy literacy results is in the medium criteria, namely 0.64. Meanwhile, the average N-Gain value resulting from students' scientific literacy falls into the medium criteria, namely 0.66. This assessment aims to see the readability and practicality of the digital student worksheet which was designed based on 14 statements from 3 assessment aspects which include the quality of the media, materials and benefits of STEM-based digital student worksheet. The results of students' responses to the small-scale test can be seen in Table 7.

Table 7. Large Scale Test of Student Responses

Assessment Aspects	Percentage %	Criteria
Media	84	Very good
Material	84	Very good
Benefit	87	Very good

The results of the readability and practicality test on a large scale, namely: students commented that the appearance of the STEM-based digital student worksheet was very good and interesting, easy to understand and understandable, the student worksheet added a lot of insight and was able to understand material that was not yet understood. The readability and practicality questionnaire consisted of 14 statements filled in by 32 students as a result of the readability and practicality test on a large scale, obtaining percentage results in the media aspect of 84%, the material aspect of

84% and the benefits aspect of 87% with the respective criteria. each one is very good.

Question Reliability Test

Reliability Test can be measured by the level of reliability using the Cronbach's Alpha technique. The following is a reliability result on numeracy literacy and scientific literacy questions, so it can be seen in Table 8.

Table 8. Reliability Decision Guidelines (Yunita et al., 2021)

Interval Reliabilitas	Criteria
0.00 < 0.199	Very low
0.20 < 0.39	Low
0.40 < 0.59	Currently
0.60 < 0.79	Tall
0.80 < 1.0	Very high

Table 9. Question Reliability Test Results

Question Aspects	Results (Cronbach's Alpha)	Criteria
Numeracy Literacy	0.72	Tall
Scientific Literacy	0.77	Tall

The reliability of numeracy and science literacy questions is analyzed based on the benchmark that if $r_{11} \geq 0.60$ then the questions tested have high reliability, but if $r_{11} < 0.60$ then the questions tested have low reliability or are not reliable. The results of the analysis of the numeracy literacy questions showed that the questions had an r_{11} of more than 0.60, namely 0.72. Meanwhile, the results of the analysis of scientific literacy items also have an r_{11} of more than 0.60, namely 0.77. Based on these results, it can be said that the numeracy and science literacy questions have high reliability.

Question Differential Power Test

Question discrimination is the ability of a question to differentiate between students with high ability and students with low ability. The number that shows the magnitude of the difference is called the discrimination index (D) (Son, 2019). The results of the differences in numeracy literacy and scientific literacy can be seen in Table 10 and Table 11.

Based on the results of the differential power test of the numeracy literacy question instrument in Table 10, it shows that 6 questions have good differential power values, 5 questions have sufficient differential power values, and 4 questions have poor differential power values. Meanwhile, the results of the different power test of the scientific literacy question instrument in Table 11 show that 2 questions have very good different power values, 4 questions have good different power values, 4 questions have sufficient different power values, and 5 questions have good different power values bad difference.

Table 10. Different Power Test Results on Numeracy Literacy Questions

Different Power	Total
Good	6
Enough	5
Bad	4
Number of Questions	15

Table 11. Different Power Test Results on Science Literacy Questions

Different Power	Total
Very well	2
Good	4
Enough	4
Bad	5
Number of Questions	15

Test the Difficulty Level of the Questions

The results of the difficulty level test on numeracy literacy and scientific literacy can be shown in Table 12 and Table 13.

Table 12. Results of Difficulty Levels for Numeracy Literacy Questions

Difficulty Level	Total
Difficult	0
Currently	8
Easy	7
Number of Questions	15

Table 13. Results of Difficulty Levels for Scientific Literacy Questions

Difficulty Level	Total
Difficult	0
Currently	8
Easy	7
Number of Questions	15

Based on Table 12 and Table 13, the results of the difficulty level of numeracy and science literacy questions can be seen that 7 questions (46%) are in the easy category, 8 (54%) questions are in the medium category, and there are no questions in the difficult category.

N-Gain Test

Kurniawan et al. (2022) stated that research is said to be successful if the resulting N-Gain value or N-Gain is ≥ 0.30. The results of the N-Gain score assessment can be seen in Table 14 and Table 15.

Table 14. Numeracy Literacy N-Gain Score Results

Class	Results	Category
Experiment	0.64	Currently
Control	0.30	Currently

Table 15. N-Gain Scientific Literacy Score Results

Class	Results	Category
Experiment	0.66	Currently
Control	0.26	Low

The results of the N-Gain test calculation show that the average N-Gain score for the numeracy literacy results of students in the experimental class (using the developed digital student worksheet) is 0.64, which is in the currently category, namely effective, while the average N-Gain value The numeracy literacy score of students in the control class (using regular student worksheet) was 0.30, which is in the currently category, namely effective. Furthermore, the average N-Gain score for the scientific literacy results of students in the experimental class (using the developed digital student worksheet) was 0.66, including the medium category, namely effective, while the average N-Gain score for the scientific literacy results of students in control class (using ordinary student worksheet) of 0.26 is in the low category, namely less effective.

The results of observations made when learning took place in class, students were generally enthusiastic and enthusiastic in the learning process and practicum, namely working on the experimental steps contained in STEM-based digital student worksheet, but the time used was very limited, so there was one student who did not answer the question, there were two students who did not formulate a hypothesis and did not analyze the data. This is what causes the N-Gain test calculation results on numeracy literacy and scientific literacy to be of moderate criteria. Kurniawan et al. (2022) stated that research results are said to be successful if the resulting N-Gain score or N-Gain is ≥ 0.30. From this explanation, it can be said that the results of research on students' numeracy and science literacy using the developed digital student worksheet show that the application of STEM-based digital student worksheet is effective in increasing students' numeracy and science literacy, so that the STEM-based digital student worksheet that has been implemented is effective in learning. This is supported by research by Hana et al. (2023) which states that digital student worksheet teaching materials have been proven to be effectively implemented in learning seen from the N-Gain results which are at around 0.55 so that the use of STEM-based digital student worksheet gets a positive response from students and is suitable for application in Learning Activities.

T Test

This test was carried out to determine whether there was an increase in the numeracy and science literacy of students in classes VIII I and VIII D at SMP Negeri 15 Semarang. The basis for decision making in this test is as follows: If the sig. (2-tailed) < 0.05, then there is a significant difference in the N-Gain score (numeracy and science literacy) between the experimental and control classes; If the sig value. (2-tailed) > 0.05, so there is no significant difference in the N-Gain score (numeracy and science literacy) between the experimental and control classes. The following are the results of the t test using SPSS.

Table 16. Independent Sample Test Results

Aspect	t	df	Sig. (2-tailed)
Numeracy Literacy	7.37	62	0.00
Science Literacy	6.52	62	0.00

Based on Table 16 of the tests above, it can be seen that the experimental class in numeracy and science literacy has a value of Sig. (2-tailed) is 0.00, namely <0.05, then Ha is accepted and Ho is rejected. So, it can be said that the use of STEM-based digital student worksheet on Archimedes' law material is effective in increasing students' numeracy literacy and scientific literacy.

The hypothesis test (t-test) used is the Independent Sample T-Test using the SPSS application on students' N-gain value data. In determining whether a hypothesis is acceptable or not, it can be seen from the SPSS output results. Hidayah et al. (2018) states that the t test results are said to be successful if the Sig value. (2-tailed) < 0.05. This is supported by Devi et al. (Devi et al., 2021)(2021) that the results of data analysis show a Sig. (2-tailed) is 0.00 < 0.05. Therefore, it can be said that the use of STEM-based physics learning videos has a significant effect on increasing student interest and learning outcomes.

Conclusion

The conclusion from this research is that student worksheet is one of the teaching materials used in learning at school. Digital student worksheet refers to student worksheet that is developed and used in digital format, namely in the form of an electronic file. This digital worksheet is designed to be interactive, containing elements such as links, moving images, audio and video that can increase students' numeracy and science literacy. This interactivity can help students become more involved and understand the material better; The validation results of media experts and material experts each obtained appropriate criteria with a score of 0.85 (media) and 0.84 (material) so that the product can be used as an alternative learning source for Archimedes' legal material in science learning in junior high schools; The results of the N-gain test calculation show that the use of digital STEM-based student worksheet in science learning is more effective in increasing students' numeracy literacy and scientific literacy compared to ordinary student worksheet.

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Conflict of Interest
The authors declare no conflict of interest.

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