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Development of Visual, Auditory, Kinesthetic (VAK) Based Student Worksheets Assisted by Liveworksheets

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Abstract: Development of Visual, Auditory, Kinesthetic (VAK) Based Student Worksheets Assisted by Liveworksheets. Objectives: This study aims to develop Visual, Auditory, Kinesthetic (VAK)-based student worksheets assisted by liveworksheets that are feasible, practical and effective to improve students' cognitive learning outcomes and science literacy abilities. **Methods:** This study is a type of research and development (R&D) with data collection techniques in the form of feasibility test questionnaires, practicality test questionnaires, and effectiveness test instruments designed in accordance with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. The sample used to test the effectiveness of the student worksheets was 32 students of class X SMA Negeri 12 Semarang with a one group pre test-post test design. The data analysis technique used in this study is Aiken's formula to analyze the feasibility of student worksheets, the percentage of practicality to analyze the practicality of student worksheets, and the n-gain equation to analyze the effectiveness of student worksheets. **Findings:** The development of Visual, Auditory, Kinesthetic (VAK) based student worksheets assisted by liveworksheets based on the feasibility test obtained a score of 0.92 with the category "feasible". Based on the practicality test obtained a score of 92% with the category "very practical". Based on the effectiveness test, the n-gain score was 0.64 for cognitive learning outcomes in the "medium" category and 0.74 for science literacy abilities in the "high" category. **Conclusion:** Visual, Auditory, Kinesthetic (VAK)-based student worksheets assisted by liveworksheets are feasible, practical and effective to improve students' cognitive learning outcomes and science literacy abilities.

Keywords: student worksheets, VAK learning model, liveworksheets.

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INTRODUCTION

One of the sectors that the government is intensifying its efforts to improve is education. One of the ways in which this is being done is by changing the curriculum. The curriculum is used to facilitate the educational process and to achieve educational goals (Vhalery et al., 2022). The curriculum change that occurred was the change of the 2013 Curriculum to the Merdeka Curriculum. The curriculum places emphasis on enhancing three key indicators: literacy, numeracy, and character (Marisa, 2021). Furthermore, the Merdeka Curriculum reorganizes educational units with the objective of enhancing cognitive and non-cognitive learning outcomes, ultimately aiming to cultivate the profile of Pancasila students (Ardiansyah et al., 2023).

One of the literacy abilities that are central to 21st-century education is science literacy (Arizah & Admoko, 2023). As defined by the

Program for International Student Assessment (PISA), science literacy is the capacity to utilize scientific knowledge, identify inquiries, and draw conclusions based on scientific evidence in order to comprehend and make decisions pertaining to the natural world and its alterations resulting from human activities (Sutrisna, 2021). In essence, science literacy is designed to enhance the quality of human resources, enabling them to flourish in the contemporary world (Hakim et al., 2023). Nevertheless, the science literacy abilities of Indonesian students remain relatively limited. The PISA scores for science literacy from 2000 to 2022 are as follows: 393, 395, 393, 383, 362, 403, 396, and 383, respectively. A comparison of the scores obtained in 2022 with those of the previous year reveals a decline. The causes of low science literacy can be attributed to various factors, including those present within the educational system, the teaching staff, and the students themselves (Yusmar & Fadilah, 2023). Furthermore, the lack of practice in answering science literacy questions may result in students becoming less accustomed to encountering such problems (Hidayah et al., 2019). The lack of orientation towards the development of scientific literacy is a common cause of this low ability (Sutrisna, 2021).

A review of the curriculum at SMA Negeri 12 Semarang revealed that teachers continue to utilize existing learning tools, including student worksheets, in the implementation of the Merdeka Curriculum. The student worksheets utilized in the classroom have been found to contain only questions and have not been shown to result in an increase in science literacy. The student worksheets is presented in printed or PDF format, which limits interactivity. Furthermore, differentiated learning, which encompasses learning styles, has not been effectively facilitated. These issues can have a detrimental effect on students' cognitive learning outcomes. It is similarly important to enhance students' science literacy abilities. Consequently, VAK-based student worksheets with liveworksheets were developed with the objective of enhancing cognitive learning outcomes and science literacy abilities.

Development research is a research method employed to generate and evaluate the efficacy of products (Sugiyono, 2017). In the field of education and learning, development research is focused on the advancement of design, manifested in the form of models and teaching materials (Prananda et al., 2020).

Student worksheets are sheets of tasks that must be completed by students (Ekantini & Wilujeng, 2018). Student worksheets can be utilized as a learning resource in the form of worksheets, task procedures, and learning evaluations that must be completed in accordance with the fundamental competencies that must be achieved (Kahar et al., 2021). Student worksheets also directs students to develop their cognitive abilities (Widyaningrum & Prihastari, 2020; Vidergor, 2018). Student worksheets is a more engaging approach to learning, as it can enhance learning outcomes and cultivate students' critical thinking abilities (Asrial & Ernawati, 2020). The utilization of student worksheets must be tailored to the individual characteristics of students, including consideration of their learning styles, to ensure that they can optimally master the material (Widyaningrum & Prihastari, 2020).

The VAK learning model is a theoretical framework that integrates visual, auditory, and kinesthetic learning modalities. In the context of visual learning, teachers employ a range of techniques, including the use of images, videos, articles, drawings, and other methods, with the objective of facilitating comprehension of the subject matter. In the case of auditory students, it is recommended that they listen attentively to the teacher during class, participate in group discussions, and listen more carefully to lectures.

In the case of kinesthetic students, the teaching approach involves participation in group discussions, conducting experiments, and making presentations in class (R. Zhang, 2023). The VAK model demonstrates that every learning process is influenced by the three modalities. Some students may focus on a single modality, while others may integrate all three modalities into their learning process (Husin & Sii, 2020). It is imperative that students assume an active role in their learning process, as this will facilitate the development of more active and effective learning (Rosdiana et al., 2022). The effectiveness of learning is contingent upon the consideration of learning styles and the utilisation of existing potential through training and development (Artha et al., 2023). The utilization of multiple modalities enhances the meaningfulness of learning (DePorter et al., 2010). The VAK learning model comprises four stages: preparation, delivery, training, and performance (Shoimin, 2014).

Liveworksheets is one of the platforms for the creation of interactive online worksheets. The advantages of liveworksheets include its user-friendly interface, the timeliness of its formative assessment tools, the variety of task types it offers, its environmentally friendly approach, and its flexibility (Ha Le & Prabjandee, 2023). The utilization of electronic student worksheets represents a potential avenue for enhancing students' comprehension of instructional materials (Choo et al., 2011). The utilization of technology in the learning process is found to be 80% engaging and easily comprehensible by students (Ghavifekr & Rosdy, 2015). Furthermore, the objective is to optimize teaching and learning activities (Yasa, 2018).

The material utilized in the development of student worksheets is global warming. Global warming is one of the science concepts included in the Programme for International Student Assessment (PISA). Arizah and Admoko (2023) found that 73.5% of students agreed that material on global warming requires science literacy abilities. Furthermore, students perceive this material as challenging due to its focus on processes in nature that cannot be directly observed, rendering it abstract (Setianita et al., 2019).

METHOD

Participants

The study population consisted of all classes X of SMAN 12 Semarang during the even semester of the 2023/2024 academic year. The sample was selected using the purposive sampling technique, with the advice of the physics teacher, and obtained class XE-9, comprising 32 students.

Research Design and Procedures

The study employed a research and development methodology. The development model employed is the ADDIE model, which comprises five stages: analysis, design, development, implementation, and evaluation. The research procedure adheres to the stages of the ADDIE model, commencing with the analysis of problems and potential by conducting interviews with physics teachers at SMAN 12 Semarang. Subsequently, the product was designed as a solution to the identified problems and potential. Subsequently, the product design is implemented and tested for feasibility and practicality. Once the product had been deemed feasible and practical, it was implemented with 32 students using one group pretest-posttest design to determine its effectiveness. Subsequently, the product was subjected to an evaluation.

Instruments

The instruments utilized in this study encompass both non-test instruments and test instruments. The non-test instruments employed in this study include the student worksheets

feasibility questionnaire and the student worksheets practicality questionnaire. The test instruments utilized in this study include cognitive learning outcomes tests and science literacy tests.

The student worksheets feasibility questionnaire encompasses both material feasibility and media feasibility. The concept of material feasibility is understood in terms of content feasibility, while the concept of media feasibility is understood in terms of presentation feasibility, linguistic feasibility, and graphical feasibility (Elvina & Dewi, 2020). The content feasibility aspect comprises six statement items, which collectively cover three indicators: the suitability of the material, the accuracy of the material, and the VAK model. The presentation feasibility aspect comprises eight statement items, which address three indicators: presentation techniques, learning presentation, and presentation completeness. The linguistic feasibility aspect contains three statement items, which collectively cover two indicators: readability and conformity with the standards of good and correct Indonesian language usage. The aspect of graphical feasibility contains six statement items covering three indicators: the size/format of the student worksheets, the design of the cover, and the design of the content. The student worksheets feasibility questionnaire comprises twenty-three statement items. The student worksheets feasibility questionnaire was adapted from research conducted by Putra (2023), with some items adjusted to align with the topic of this study.

The practicality questionnaire encompasses elements pertaining to ease of use, suitability for time constraints, and interpretability. The ten-item scale used to assess ease of use is as follows: The aspect of compatibility with time is comprised of two statement items. The aspect of ease of interpretation comprises three statement items. The student worksheets practicality questionnaire comprises fifteen statement items. The student worksheets practicality questionnaire was adapted from research conducted by Putra (2017), with some items adjusted to align with the topic of this study.

The cognitive learning outcomes test instrument is comprised of eighteen multiple-choice items designed to assess nine learning indicators, including: (1) describing the meaning of global warming, (2) identifying facts of environmental change as an impact of global warming, (3) analyzing the relationship between facts of environmental change and the sustainability of living things and ecosystems, (4) describing el niño and la niña, (5) analyzing the relationship between el niño and la niña for indonesia, (6) describing the greenhouse effect process, (7) determining human activities that cause environmental changes, (8) analyzing the relationship between illegal logging, land conversion, cfc use, and burning fossil fuels with increasing earth's temperature, and (9) evaluating global warming solutions. Each indicator is represented by two question items.

The science literacy test instrument consists of six multiple-choice items and six descriptive items. The science literacy indicators used focus on the competency aspect. The competency aspect plays an important role in influencing students' science literacy (Rini et al., 2021). The science literacy indicators in this study include: (1) explaining scientific phenomena, (2) interpreting data and evidence scientifically, and (3) evaluating and designing scientific investigations. Each indicator is represented by four question items.

Data Analysis

The feasibility of student worksheets was evaluated using the Aiken's V formula, wherein each aspect was calculated for the content validity index (Widodo et al., 2022):

$$V = \frac{\sum s}{[n(c-1)]}$$

Description:

S : $r - I_o$

r : the number assigned by the validator
I_O: the lowest validity assessment number
n : number of validators
C : number of rating scales

The result of V count is compared with the value of V table. If V count> V table, then the student worksheets is declared valid.

The practicality of the student worksheets was evaluated by calculating the percentage value of the practicality test results according to Akbar (2013):

$$P = \frac{Number\ of\ scores\ gained}{Total\ scores} \times 100\%$$

The results of the calculation are classified according to the criteria of practicality as outlined by Akbar (2013), which can be seen in Table 1.

Table 1. Practicality criteria

Percentage (%)	Criteria
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Practical Enough
21 – 40	Less Practical
0 – 20	Not Practical

The efficacy of student worksheets was evaluated through the use of the n-gain equation, which enabled the determination of the extent to which cognitive learning outcomes and science literacy abilities of students had been enhanced. Prior to administering the n-gain test, the data pertaining to cognitive learning outcomes and science literacy abilities were subjected to a normality test and a t-test, respectively. The normality test is employed to ascertain whether the distribution of data is normally distributed. In this case, the paired sample t-test was employed to ascertain the discrepancy between the mean values of two paired samples. The normality tests and t-tests were analyzed using the Statistical Product and Service Solutions (SPSS) program. The n-gain score was calculated using the formula proposed by Hake (2002):

$$\langle g \rangle = \frac{\langle S_{po} \rangle - \langle S_{pe} \rangle}{S_{id} - \langle S_{pe} \rangle}$$

Description:
$\langle g \rangle$: n-gain score
$\langle S_{po} \rangle$: posttest score
$\langle S_{pe} \rangle$: pretest score
S_{id} : ideal score (100)

The calculation results are classified based on the n-gain criteria which can be seen in Table 2.

Table 2. N-*gain criter*ia

N-Gain Score	Criteria
$\langle g \rangle < 0.3$	Rendah
$0.3 \leq \langle g \rangle \leq 0.7$	Sedang
$\langle g \rangle > 0.7$	Tinggi

■ RESULT AND DISCUSSION

Analysis Stage

At this stage, researchers analyzed problems related to the need for development as well as analyzing their potential. From the analysis conducted, student worksheets is needed that can accommodate the three learning styles and can improve science literacy abilities. The material that requires this ability is global warming. In addition, the school has the potential to implement technology-based learning because students have smartphones and Wifi is available at school.

Design Stage

At this stage, the activities carried out are designing the student worksheets. Design of student worksheets can be seen in Table 3.

Table 3 presents the structure of the developed student worksheets. The student

Table 3. Design of student worksheets

Structure	Description
Cover	Contains title, subject, class, curriculum, students identity.
Preface	Contains gratitude and expression from the author with the completion of the student worksheets development.
Table of Contents	Make it easy for students and teachers to know the things discussed in the VAK-based student worksheets.
Instructions for Use	Contains instructions for using student worksheets for teachers and students.
VAK Learning Activities	Contains an explanation of the stages of the VAK learning model.
CP and TP	Contains learning outcomes and objectives.
Concept Map	Contains sub topics to be studied which are arranged systematically as a reference in carrying out the learning process.
Learning Activities	Contains VAK learning steps which include materials, questions, practicum and other activities.
Glossary	Contains important definitions arranged in alphabetical order.
Bibliography	Contains references to the readings / contents in the student worksheets.

worksheets is comprised of three sections: an introduction, content, and closing. The introduction section comprises a cover, a preface, a table of contents, instructions for using the student worksheets, an explanation of VAK-based learning activities, learning outcomes and objectives, and a concept map. The content section comprises a series of student activities. The concluding section includes a glossary and bibliography.

Development Stage

At this stage, the activity carried out is to realize the draft design of the student worksheets. The science literacy abilities was then tested for feasibility and practicality. The results of the student worksheets development are shown in Figure 1.

The student worksheets is developed in digital form with the assistance of liveworksheets. The appeal and user-friendly nature of

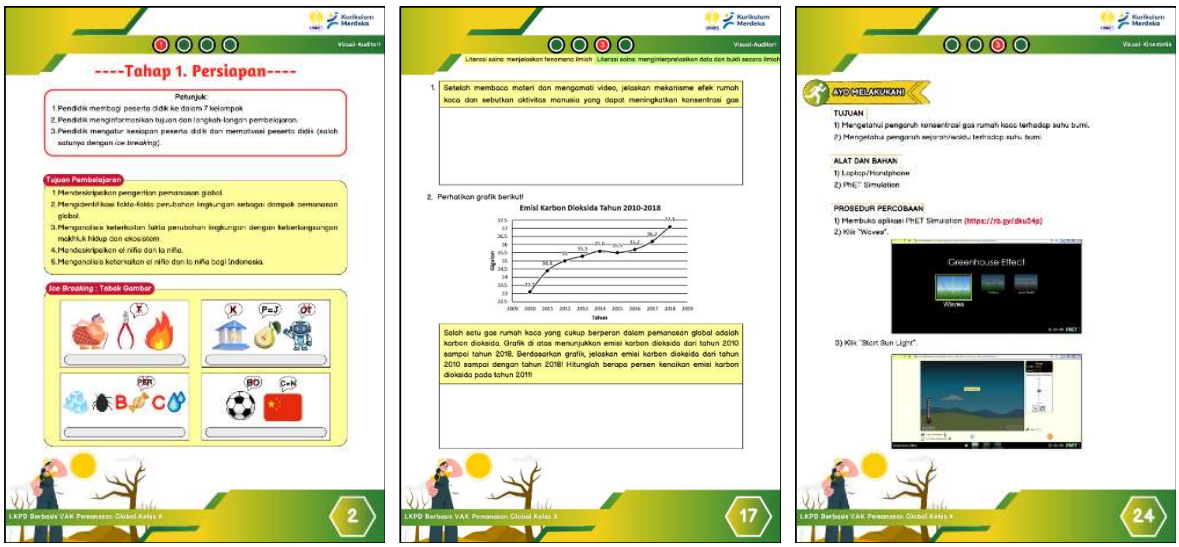

Figure 1. Results of student worksheets development

liveworksheets serve as a motivating factor for students (Madden et al., 2023). The advantages of liveworksheets include accessibility at no cost, practicality, accessibility via smartphones and laptops, suitability for use as media, and lack of storage space requirements (Paspania & Susilawati, 2024).

The student worksheets was created using the Canva application. This student worksheets is comprised of 47 pages, which include the introduction, content, and closing sections. The content section contains student activities, which are divided into three distinct activities or subtopics. The first activity, entitled "Facts of Environmental Change," addresses the phenomenon of global warming and its causes. The second activity, "Increasing CO_2 Levels in the Atmosphere," examines the impact of carbon dioxide emissions on the environment. The third activity, "Solutions to Overcome Global Warming," presents potential solutions to combat global warming. The three activities are structured according to the stages of the VAK model, namely the preparation stage, the delivery stage, the training stage, and the results display stage.

In the preparation stage, students are prepared for learning and provided with motivation to stimulate their interest in the subject matter. The preparation stage, students are invited to engage in singing or ice-breaking activities with the objective of fostering positive feelings and interest in learning (Rustianingsih & Nisa, 2020). In the student worksheets stage, students engage in reading learning objectives and ice-breaking activities. Ice-breaking has a beneficial and significant impact on the learning process, including influencing student interest in learning, student absorption, student motivation, and their learning outcomes (Rusman, 2022). The ice-breaking activity is related to the subject of global warming.

In the delivery stage, students are introduced to the material to be learned in the form of visual aids, such as images, videos, and props, and invited to engage with the material in a hands-on manner. This stage is designed to facilitate the acquisition of new knowledge through various means, including reading, listening to explanations, and discussion (Santhi et al., 2020).

In the training stage, students are encouraged to engage in collaborative problem-solving activities, utilizing the worksheet as a resource. The problems at this stage are tailored to the learning indicators and objectives and are structured in a manner that facilitates the development of science literacy abilities. At this stage, the content is divided into three sections: "Let's Practice," "Let's Know," and "Let's Do." The "Let's Practice" content comprises questions accompanied by images. The questions are organized according to the learning indicators and science literacy indicators. Furthermore, the "Let's Practice" content comprises material presented in the form of readings and videos. The "Let's Know" content comprises readings on local wisdom pertinent to the subject matter under discussion. The objective of the "Let's Know" content is to incorporate students' insights pertaining to local wisdom. The "Let's Do" content contains activities that encourage students to engage in practical work or activities that encourage students to move (kinesthetic).

In the result display stage, students present the results of their group discussions and the teacher provides feedback on the presentation and reinforces the material. At this stage, the content is divided into two sections: "Let's Listen" and "Let's Reflect" content. The "Let's Listen" content is comprised of activities designed to facilitate the reinforcement of material by the instructor. The "Let's Reflect" content prompts students to express their opinions regarding the learning material.

In essence, each stage of the VAK model encourages students to integrate their learning modalities. VAK learning is predicated on the

premise of providing direct experience, namely learning by visual, auditory, and means (Ferreira & Rodríguez, 2022; Kusumawarti et al., 2020).

Feasibility Test of Student Worksheets

A feasibility test of student worksheets was conducted by a team of six validators, comprising three physics lecturers and three physics teachers. The feasibility of student worksheets is evaluated in terms of its suitability for use with various materials and media. The results of the feasibility test of student worksheets in terms of material and media, as evaluated by the validators, are presented in Table 4.

Table 4. Results of feasibility test analysis

No	Feasibility	V count	V table	Criteria
1.	Material	0.91	0.79	Valid
2.	Media	0.93		Valid
	Average	0.92		Valid

Table 4 presents the results of a feasibility test conducted by six validators. The test yielded a V-count of 0.91 for material feasibility and 0.93 for media feasibility. The V-count was then compared with the V-table. Given that there are six validators and five rating scales, the V-table value serves as a reference with a 5% significance level, resulting in a value of 0.79. The V-count was found to be greater than the V-table, indicating that the developed student worksheets was deemed valid and suitable for use in learning. The results of this study are consistent with those of several previous studies, including those conducted by Safitri et al. (2023) and Andriani et al. (2022), which indicate that the student worksheets based on the VAK model is a viable option for use in learning.

In addition to providing assessments, the validators also provided comments and suggestions for further product development. The comments and suggestions provided by the validators are presented in Table 5.

Table 5. Validator comments related to student worksheets

No	Comments	Improvements
1.	Graph description is incomplete	Completing the graph caption
2.	Problem identification needs to be added before the experiment objective	Added problem identification before experiment objective
3.	Anticipate if the signal is not good	Typed the answer elsewhere first

The comments pertaining to the student worksheets in Table 5 will be taken into consideration in order to enhance the developed student worksheets. The graphic description of the student worksheets has been completed, and questions pertaining to the identification of problems have been incorporated. With regard to the issue of signal problems, the recommended solution is to instruct students to write their answer before transferring them to live worksheets.

Practicality Test of Student Worksheets

The practicality test is designed to assess the practicality of the developed student worksheets for use in learning activities. The practicality of the student worksheets was evaluated through the administration of a practicality instrument to three physics teachers at SMAN 12 Semarang. The results of the student worksheets practicality test analysis are presented in Table 6.

Table 6. Results of practicality test analysis

No	Aspects	Percentage (%)	Criteria
1.	Ease of use	94	Very Practical
2.	Appropriateness to time	87	Very Practical
3.	Easy to interpret	96	Very Practical
	Average	92	Very Practical

Table 6 indicates that the average percentage of practicality test results for VAK-based student worksheets student worksheets assessed by teachers was 92%, with very practical criteria. This indicates that the VAK-based physics student worksheets, when used in conjunction with liveworksheets, is highly practical for use in learning. The results of this study align with those of several previous studies, including research conducted by Safitri et al. (2023), which demonstrated that student worksheets based on the VAK model was deemed highly practical for use in learning. The findings of Khofia and Chotimah's (2023) research indicate that the student worksheets, when accompanied by live worksheets, is a practical tool for learning.

Implementation Stage

Experts had previously declared student worksheets to be feasible and practical. These were then tested in class XI, which had previously studied global warming material. In addition to product trials, test instruments were also subjected to testing. The deficiencies identified in the trial were subsequently addressed to develop an effective and efficient form of learning media, in this case, the student worksheets (Zhang et al., 2018). Following the revision of the student worksheets and test instruments, the student worksheets was implemented in the context of physics learning in class XE-9 for a total of four meetings. These meetings were structured as follows: meeting 1 consisted of a pretest, meeting 2 and meeting 3 involved learning with the student worksheets, and meeting 4 consisted of a posttest.

Evaluation Stage

Evaluation is a continuation of the results of validation and implementation that has been done. At this stage, the advantages and disadvantages of the developed student worksheets can be identified. The advantages and disadvantages of student worksheets can be seen in Table 7.

Table 7. Advantages and disadvantages of student worksheets

No	Advantages	Disadvantages
1.	Liveworksheets facilitate greater flexibility in student worksheets.	Student worksheets is accessed online, if the connection is bad, it can cause answers to be lost.
2.	The learning modalities are integrated in a single, unified format.	Student worksheets focuses on improving learning outcomes only on the cognitive aspect.
3.	Student worksheets provides comprehensive content, encompassing materials, questions, practicums, and other elements.	Practical activities are conducted online.

The advantages and disadvantages of student worksheets as presented in Table 7 can serve as a reference point for further research, with the objective of developing more effective student worksheets.

Moreover, the results of the effectiveness of student worksheets were evaluated through cognitive learning outcomes tests and science

literacy abilities tests. Prior to conducting the n-gain analysis, the test results were subjected to a normality test and a t-test to ensure their suitability for the analysis.

Normality Test

The results of the normality test for cognitive learning outcomes are presented in Table 8.

Table 8. Normality test results cognitive learning outcomes

Type of Test	Sig. Saphiro-Wilk	Criteria
Pretest	0.023	Not Normally Distributed
Posttest	0.110	Normally Distributed

Table 8 indicates that the pretest data is not normally distributed, as evidenced by the significance value of the Shapiro-Wilk test being less than 0.05. Conversely, the posttest data is normally distributed, as demonstrated by the significance value of the Shapiro-Wilk test being greater than 0.05.

The results of the normality test for science literacy abilities are presented in Table 9.

Table 9. Normality test results science literacy abilities

Type of Test	Sig. Saphiro-Wilk	Criteria
Pretest	0.060	Normally Distributed
Posttest	0.000	Not Normally Distributed

Table 9 indicates that the pretest data is normally distributed, as evidenced by the significance value (Sig). The Shapiro-Wilk test yielded a value greater than 0.05, indicating that the data were not normally distributed. The posttest data is not normally distributed, as indicated by the significance value. The Shapiro-Wilk test yielded a p-value less than 0.05.

Paired Sample T-Test

A paired sample t-test was conducted with the Wilcoxon non-parametric test method as an alternative to the paired sample t-test test due to the presence of data that was not normally distributed. The results of the Wilcoxon test for cognitive learning outcomes are presented in Table 10.

Table 10. Wilcoxon test results cognitive learning outcomes

Data	Asymp. Sig. (2-tailed)	Criteria
Posttest-Pretest	0.000	There is a significant difference

Based on Table 10, it is known that there is a significant difference in students' cognitive learning outcomes between before and after the application of science literacy abilities because the Asymp. Sig. (2-tailed) < 0.05

The Wilcoxon test results for science literacy abilities are presented in Table 11.

Table 11. Wilcoxon test results science literacy abilities

Data	Asymp. Sig. (2-tailed)	Criteria
Posttest-Pretest	0.000	There is a significant difference

Based on Table 11, it is known that there is a significant difference in science literacy abilities between before and after the application of student worksheets because it obtained a significance value <0.05.

N-Gain Test

Following the completion of the normality test and t-test stages, the data were subjected to analysis using the normalized gain equation in order to determine the improvement of cognitive learning outcomes and science literacy abilities. The improvement of cognitive learning outcomes is illustrated in Table 12.

Table 12. Improvement of cognitive learning outcomes

Average Pretest Score	Average Posttest Score	N-Gain Score
46	69	0.42

Table 12 indicates that cognitive learning outcomes exhibited a 0.62-point increase in the "moderate" category. The observed increase in cognitive learning outcomes aligns with the findings of previous research by Dahliana et al. (2022) and Safitri et al. (2023), which indicate that the VAK model can enhance learning outcomes. This is because the VAK model encourages students to engage fully in the process of identifying and comprehending a concept (Andriani et al., 2022). Students learn holistically by combining visual, auditory, and kinesthetic aspects and involving real examples and practical applications that facilitate the integration of subject matter into everyday life (Malvigie et al., 2023).

The results of the n-gain analysis for each learning indicator are presented in Figure 2.

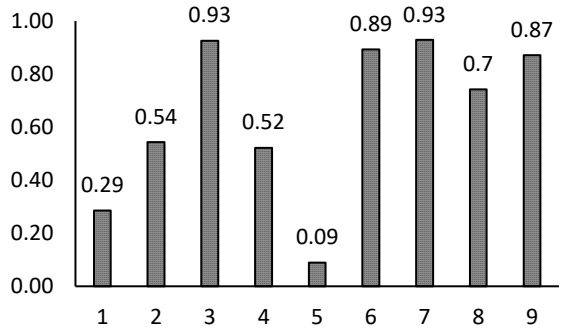

Figure 2. Improvement of cognitive learning outcomes for each learning indicator

Figure 2 indicates that the increase in the high category occurred in the 3rd, 6th, 7th, 8th, and 9th indicators. This suggests that the developed science literacy abilities has strengths in these indicators. The improvement of science literacy abilities is illustrated in Table 13.

Table 13. Improvement of science literacy ability

Average Pretest Score	Average Posttest Score	N-Gain Score
16	78	0.74

The results of the n-gain test, as presented in Table 13, indicate that there was an increase in science literacy abilities of 0.74, with a "high" category. The observed increase in science literacy abilities can be attributed to the fact that the training stage in the science literacy abilities presents questions that can effectively train science literacy abilities. The incorporation of science literacy-based questions at the training stage has been demonstrated to enhance science literacy abilities (Khofifa et al., 2023). The science literacy abilities, when equipped with science literacy questions, facilitates the enhancement of students' science literacy abilities (Rohmaya et al., 2023). The utilization of e-student worksheets has been demonstrated to enhance cognitive and science literacy learning outcomes (Paspania & Susilawati, 2024). The results of the n-gain analysis for each science literacy indicator are presented in Figure 3.

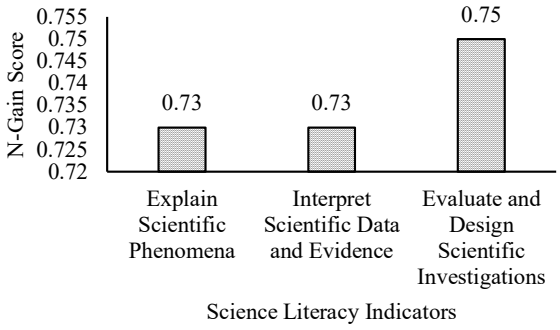

Figure 3. Improvement of science literacy ability of each indicator

The indicator of explaining scientific phenomena necessitates that students recall and utilize pertinent knowledge in specific contexts. In this indicator, there was a 0.73-point increase in the proportion of students in the "high" category. The observed increase can be attributed to the training stage of the science literacy abilities, which facilitated the application of the material learned. The training stage in the VAK model facilitates the absorption of increasingly meaningful information and the application of the material learned (Aprilia et al., 2022).

The indicator of interpreting data and scientific evidence requires students to interpret and draw conclusions related to data and scientific evidence. In this indicator, there was a 0.73-point increase, with the category being designated as "high." The observed increase can be attributed to the inclusion of questions related to this indicator within the training stage of the science literacy abilities, in addition to the incorporation of discussion and practicum activities. The observed increase in indicators of interpreting data and scientific evidence can be attributed to the incorporation of discussion and practicum activities in which practicum data are analyzed (Anggraeni et al., 2020).

The objective of this indicator is to assess students' abilities to evaluate and design scientific investigations. In this indicator, there was a 0.75-point increase, with the category being rated as "high." The observed increase can be attributed to the inclusion of questions related to this indicator in the training stage of the science literacy abilities. Furthermore, there are practicum videos and practicum activities that utilize PhET simulations. The incorporation of video media into the learning process has been demonstrated to enhance its efficacy (Jundu et al., 2020). The utilization of PhET Simulation in educational settings has been demonstrated to enhance scientific literacy (Aina & Hariyono, 2023)

■ CONCLUSION

The results of the research indicate that the VAK-based science literacy abilities assisted by liveworksheets, based on the feasibility test, obtained a score of 0.92 in the valid/worthy category. The practicality test conducted by the teacher yielded a percentage of 92% in the very practical category. The developed science literacy abilities was found to be an effective tool for improving cognitive learning outcomes, with an effect size of 0.62, and for effectively improving science literacy abilities with an effect size of 0.74. Consequently, the VAK-based science literacy abilities, which incorporates liveworksheets, is a viable, practical, and efficacious approach to enhance cognitive learning outcomes and improve science literacy.

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