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The Effect of Science and Technology-Based LKPD on Material and Its Changes on Student Motivation and Learning Outcomes

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Abstract: This study aimed to develop Science, Technology, and Society (STS)-based student worksheets (LKPD) on the topic of substances and their changes and to examine their effectiveness in improving the motivation and learning outcomes of tenth-grade students at SMKN 1 Timpeh. This development research employed the Plomp Model, which consists of Preliminary Research, Prototyping Phase, and Assessment Phase. The participants were 32 tenth-grade students, comprising 21 students in the experimental class and 11 students in the control class. The instruments included validation sheets, practicality questionnaires, a learning motivation questionnaire, and a learning outcomes test. The data were analyzed using descriptive and inferential statistics. The results indicated that the worksheets were valid, with Aiken's V scores of 0.86 for content, 0.90 for presentation, 0.88 for language, and 0.88 for contextual aspects, with an average of 0.88. The worksheets were also very practical, with teacher and student practicality scores of 93%. In the Assessment Phase, the experimental class showed significantly higher motivation and learning outcomes than the control class ($p = 0.012$). Therefore, the developed worksheets are valid, practical, and effective for chemistry learning.

Keywords: Learning motivation; Learning outcomes; Practicality; Science technology and society; Student worksheets

Introduction

Twenty-first century education requires students to develop holistic competencies, particularly critical thinking and problem-solving skills, to respond to the rapid development of science and technology. In Indonesia, the implementation of the Merdeka Curriculum emphasizes student-centered, contextual, and flexible learning, while encouraging teachers to design innovative teaching materials that support meaningful learning, including Student Worksheets (LKPD) (Abdal et al., 2022).

However, the implementation of these ideals in PIPAS learning on the topic of Substances and Their Changes at SMKN 1 Timpeh has not yet been optimal. Initial observations showed that only 36% of students achieved mastery learning, while most students still demonstrated low conceptual understanding. This condition was influenced by learning practices that remained dominated by lectures, limited practical activities, inadequate teaching materials, and limited laboratory facilities. As a result, students found it difficult to connect scientific concepts with real phenomena, vocational contexts, and workplace applications. This condition also weakened students' learning motivation, even though motivation is a key factor influencing academic success because students with strong intrinsic and extrinsic motivation are more likely to engage actively and achieve better learning outcomes (Emda, 2018).

This issue is particularly important in vocational education because vocational high school students tend to have kinesthetic characteristics and need learning experiences that emphasize psychomotor engagement, hands-on activities, and relevance to everyday life and the world of work (Prabowo et al., 2024). In the Grade X vocational curriculum, Substances and Their Changes is a fundamental topic in Natural Sciences because it

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covers physical and chemical properties, physical and chemical changes, and their applications in daily life and industry. For vocational students, mastery of this topic is essential because it underpins the understanding of applied processes in their fields of expertise. For example, in automotive studies, chemical changes can be observed in fuel combustion processes, while in culinary studies, physical and chemical changes occur during cooking, fermentation, and food preservation. Therefore, this topic should not be taught merely as abstract theory, but should be linked to authentic contexts that are relevant to students' vocational experiences.

One approach that is relevant to these needs is the Science, Technology, and Society (STS) approach (Apriana et al., 2020). STS emphasizes the relationship between scientific concepts, technological applications, and social issues, enabling students to understand science as meaningful knowledge closely related to real life (Nisa et al., 2026). This approach is in line with the Merdeka Curriculum because it promotes contextual, exploratory, and problem-based learning while supporting the development of higher-order thinking skills (Nabila et al., 2026; Susilawati et al., 2025). For vocational high school students, STS is particularly appropriate because it facilitates active learning through investigation, discussion, experimentation, and problem solving related to real situations. In this context, STS-based LKPD can function as contextual teaching materials that guide students to construct concepts independently and remain actively involved in meaningful learning (Hidayati et al., 2024). In addition, LKPD can help address limited laboratory facilities by providing structured learning activities that still promote psychomotor involvement and contextual understanding (Mushthofa et al., 2021; Wati et al., 2025; Widowati et al., 2025).

The importance of this study lies in its response to both practical and pedagogical needs. Practically, this research is needed because students at SMKN 1 Timpeh still face low mastery, low motivation, and limited opportunities for contextual and practical learning. Pedagogically, this study supports the implementation of the Merdeka Curriculum by providing teaching materials that are not only student-centered but also relevant to vocational characteristics and workplace contexts. The novelty of this research lies in the development of STS-based LKPD specifically for the PIPAS topic of Substances and Their Changes in a vocational high school context, while simultaneously evaluating its validity, practicality, and effectiveness in improving both learning motivation and learning outcomes. Thus, this study does not merely apply the STS approach in general, but offers a contextual teaching material designed for vocational students' needs and tested in a real classroom setting. Based on this rationale, this study aims to develop STS-based student worksheets on the topic of Substances and Their Changes that meet the criteria of validity and practicality, and to examine their effectiveness in improving the learning motivation and learning outcomes of tenth-grade students at SMKN 1 Timpeh.

Method

This study was classified as development research and is closely related to Educational Design Research (EDR), which focuses on developing and testing educational products in real learning contexts rather than merely verifying theories (Ismail et al., 2026). The study adopted the Plomp model (2013), which consists of Preliminary Research, Prototyping Phase, and Assessment Phase. In the Preliminary Research phase, the researcher conducted needs analysis, curriculum analysis, literature review, and analysis of student characteristics. The curriculum analysis was carried out to identify the relevance of the learning outcomes in the Merdeka Curriculum to the topic of Substances and Their Changes, while the analysis of student characteristics focused on the vocational students' kinesthetic tendencies, learning difficulties, and need for contextual and practice-oriented learning. In the Prototyping Phase, the STS-based student worksheets were designed and developed, followed by formative evaluation through self-evaluation, expert review, and limited trials to improve the quality of the product before classroom implementation. In the Assessment Phase, the revised product was implemented in the field to examine its practicality and effectiveness in improving students' learning motivation and learning outcomes.

The research subjects were tenth-grade students at SMKN 1 Timpeh. The study involved two purposively selected classes, namely class X TAB 1 as the experimental group and class X TKJ as the control group. Because the two classes came from different majors, their equivalence was first examined using pre-test data before treatment. This procedure was intended to ensure that there was no significant difference in the students' initial ability prior to the implementation of the developed worksheets. If you already have the result, you can add a sentence such as: The pre-test results showed no significant difference between the experimental and control classes, indicating that both groups were comparable at the outset.

The instruments used in this study included validation sheets, practicality questionnaires, a learning motivation questionnaire, and a learning outcomes test. The validation sheets were completed by expert validators consisting of lecturers and teachers to assess

the content, presentation, language, and contextual aspects of the developed worksheets. The practicality questionnaires were administered to the teacher and students after implementation to evaluate the ease of use, clarity, attractiveness, and usefulness of the worksheets. Student motivation was measured using a Likert-scale questionnaire. To strengthen the research design, the motivation questionnaire should be clearly stated as being administered before and after the treatment, or at least after the implementation if only post-test data were collected. The learning outcomes test was used to measure students' cognitive achievement after the learning process.

The validation data were analyzed quantitatively using Aiken's V coefficient and qualitatively through suggestions from validators for product revision. The Aiken's V formula is expressed as:

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

With explanation: (s = r - l_0); (r) = value provided by the validator; (l_0) = lowest value on the scale; (c) = highest score; (n) = number of validators.

Table 1. STS-based LKPD Validation Level Categories (Emilya et al., 2023)

Achievement Level	Category
≥ 0.86– 1.00	Valid
< 0.86	Invalid

Practicality Test

According to Sudjiono (2016), the data obtained was analyzed using the following formula:

$$\text{Practical Value} = \frac{\sum \text{The score obtained x } 100\%}{\sum \text{Maximum score}} \quad (2)$$

Table 2. Practicality Category of STS-based LKPD (Emilya et al., 2023)

Achievement Level (%)	Category
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Less Practical
<20	Not Practical

T-test

The effectiveness of the developed worksheets was analyzed using descriptive and inferential statistics. Before hypothesis testing, the data were first examined for normality and homogeneity. If the data were normally distributed and homogeneous, an independent samples t-test was used to determine whether there was a significant difference between the experimental and control groups. The t-test formula is as follows:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (3)$$

If the assumptions of normality and homogeneity were not met, a non-parametric test, namely the Mann–Whitney U test, was used as an alternative. All statistical analyses were conducted at a significance level of 0.05.

Result and Discussion

Preliminary Research Stage
Contextual Needs Analysis

The contextual needs analysis was conducted using an interview sheet administered to educators at SMKN 1 Timpeh. The interview results revealed that students' motivation to learn the topic of substances and their changes had not yet reached an optimal level. Most students tended to be passive and showed limited enthusiasm during the learning process. Teachers explained that students would be more interested and motivated if the learning material was connected to examples from daily life, such as changes in substances found in household activities and in the surrounding community environment.

The teachers also considered the implementation of STS-based LKPD highly relevant for vocational high school students. This approach was perceived to help students understand the concepts of substances and their changes more concretely, increase their engagement in learning, and foster learning motivation because the material was seen as directly useful in everyday life. Therefore, the results of this contextual needs analysis support the development of STS-based LKPD as an alternative teaching material with the potential to improve the motivation and learning outcomes of Grade X students at SMKN 1 Timpeh.

Reviewing the Literature

The literature review in this study focused on the theoretical foundations of Science, Technology, and Society (STS)-based student worksheets, the concepts of learning outcomes, contextual learning, and student learning motivation. This review was used as the basis for designing teaching materials that are relevant to vocational students' characteristics and to the demands of contextual learning in the Merdeka Curriculum.

Development Stage
Prototype Design

The prototype was designed based on the results of the preliminary study, namely the contextual needs

analysis and literature review. The product developed in this study was an STS-based LKPD on the topic of substances and their changes. The first page of the LKPD contains the cover, followed by the first learning session page, and then the materials page. The design of the worksheet was developed to support contextual, structured, and student-centered learning activities.

The first page of the LKPD is the cover. Then, after the cover page, the next page is the LKPD session 1 page. The page that appears after LKPD Meeting I is the Materials page.

Figure 1. Cover page

Figure 2. LKPD session I

Formative Evaluation and Prototype Revision
Self-evaluation

Self-evaluation is an assessment process carried out by the researchers before the product is validated by the expert team. At this stage, the researchers re-examined the completeness and quality of each component of the prototype and revised any weaknesses identified. The aspects evaluated in this stage included material, graphics, and language.

Based on the results of the self-evaluation, several weaknesses were found in the language and graphic design of the LKPD. In terms of language, some expressions needed to be revised so that the content would be clearer and easier for students to understand. In terms of graphics, some parts of the visual design were considered less attractive and less effective in supporting students' understanding. Therefore, revisions were made to these aspects before the LKPD was submitted for expert validation so that the product would be more optimal and ready for further evaluation.

Validity Stage (Expert Review)

The subsequent assessment was conducted by experts. The validation of the LKPD was carried out by seven validators. The analysis of the validation sheet used Aiken's V, with the results shown in Appendix 5. The validators assessed the developed LKPD by considering several predetermined aspects.

The results of the validation test data analysis of the LKPD that has been developed can be seen in Table 3.

Table 3. Validity Test Data

Aspects assessed	Assessment	Category
Content Feasibility Aspects	0.86	Valid
Presentation Feasibility Aspects	0.90	Valid
Language Feasibility Aspects	0.88	Valid
Contextual Feasibility Aspects	0.88	Valid
Average	0.88	Valid

The validity test of the developed Science and Technology-Based LKPD on Material and Its Changes covered four aspects, namely content feasibility,

presentation feasibility, language feasibility, and contextual feasibility. The results showed that the content aspect obtained an Aiken's V value of 0.86, the presentation aspect 0.90, the language aspect 0.88, and the contextual aspect 0.88, with an overall average of 0.88. These results indicate that the developed LKPD was categorized as valid and suitable for further testing. The LKPD was considered valid because the material was aligned with the learning objectives and curriculum, the presentation was systematic and attractive, the language was clear and appropriate for students' level of understanding, and the contextual aspect reflected real-life situations related to the topic of material and its changes. Therefore, the quality of the worksheet was not reflected by a single score only, but by the consistency of its validity across content, presentation, language, and contextual aspects. This finding is consistent with international studies showing that context-based and STS-oriented science learning materials are more meaningful when they connect scientific concepts with real-life contexts, support student engagement, and contribute positively to learning quality and outcomes (Acut et al., 2023; King et al., 2008; Ültay et al., 2012). In vocational education settings, meaningful and supportive learning environments have also been shown to strengthen student motivation, which further supports the relevance of the developed LKPD for improving both motivation and learning outcomes (Held et al., 2024; Januarti et al., 2024; Munandar et al., 2024).

Practicality Stage

Teacher Practicality Stage

Based on Table 4, the five assessed aspects obtained an average score of 93%, which falls into the very practical category. This result indicates that the worksheet was considered useful, attractive, clear, and efficient for classroom use.

Table 4. Teacher Practicality Test Data

Aspects assessed	Score (%)	Category
Useful Aspects	95	Very practical
Media Aspects Used	94	Very practical
Attractiveness Aspects	85	Very practical
Clarity Aspect	97	Very practical
Efficiency Aspects	95	Very practical
Average	93	Very practical

Practicality Stage One to One

Based on Table 5, the four assessed aspects obtained an average score of 92%, which was categorized as very practical. This finding indicates that the LKPD was easy to use, interesting, efficient, and beneficial for students in the one-to-one trial.

Table 5. One to One Practicality Test Results

Aspects assessed	Assessment (%)	Category
Ease of Use	83	Very practical
Attraction	90	Very practical
Efficiency	100	Very practical
Benefits	94	Very practical
Average	92	Very practical

Practical Stage (Small group)

Based on Table 6, the four assessed aspects obtained an average score of 94%, which was categorized as very practical. This result indicates that the LKPD remained practical when implemented in a small group setting.

Table 6. Small Group Practicality Test Results

Aspects assessed	Assessment (%)	Category
Ease of Use	93	Very practical
Attraction	92	Very practical
Efficiency	100	Very practical
Benefits	92	Very practical
Average	94	Very practical

Table 7. Overall Results of Student Practicality Tests

Aspects assessed	Assessment	Category
One to one	92%	Very practical
Small group	94%	Very practical
Average	93%	Very practical

Based on Table 7, both student practicality trials, namely the one-to-one and small group trials, showed consistent results with a very high average score of 93%. This finding indicates that the developed LKPD met the overall practicality criteria from the students' perspective. The practicality results for teachers and participants can be seen in Table 8.

Table 8. Overall Results of the Practicality Test for Teachers and Students.

Aspects assessed	Value (%)
Teacher Practicality	93
Practicality of Students	93
Average	93

The practicality of the developed LKPD was assessed through teacher responses and student responses in the one-to-one and small group trials. Teacher responses showed an average practicality score of 93%, which was categorized as very practical. This result indicates that the worksheet was considered useful, clear, attractive, and efficient for classroom implementation because it contained structured learning activities, clear instructions, an appealing design, and learning tasks that could be carried out effectively within the available classroom time. In the one-to-one trial, the average practicality score was 92%, while in the small group trial it increased to 94%, both of

which were categorized as very practical. These results suggest that students found the LKPD easy to use, interesting, efficient, and beneficial in supporting their understanding of the topic. The overall student practicality score was 93%, indicating consistent results with a very high average score. When teacher and student practicality were compared in Table 8, both showed the same average percentage of 93% in the very practical category. These findings suggest that the developed LKPD is feasible and easy to use in the learning process because it is understandable, attractive, time-efficient, and relevant to students' learning needs on the topic of material and its changes.

Asessment Phase
Prerequisite test
Normality test

The method used in this study was the Shapiro-Wilk test, which was chosen because the sample size was less than 50 people. Data processing was performed using SPSS 21.

Table 9. Normality Test Results

Class	Statistic (Shapiro–Wilk)	df	Sig.
Experimental Class	0.921	21	0.092
Control Class	0.885	11	0.119

Based on Table 9, the experimental class obtained a Shapiro–Wilk significance value of 0.092, while the control class obtained 0.119. Since both values were greater than 0.05, the post-test scores in both classes were normally distributed. This indicates that the data did not significantly deviate from a normal distribution, so they met one of the main assumptions required for the use of parametric statistical analysis, particularly the independent samples t-test.

Homogenity Test

This test was conducted on the control class and the experimental class.

Table 10. Homogeneity Test Results

Class	Statistic (Levene)	df	df2	Sig.
Postest Score	1.908	1	30	0.177

Based on Table 10, the significance value obtained from Levene's test was 0.177, which is greater than 0.05. Therefore, the post-test scores of the experimental and control classes were homogeneous. This result indicates that the score variations in both groups were relatively similar, meaning that the two classes were comparable and appropriate for further hypothesis testing using the independent samples t-test.

Hypothesis Test Analysis

In hypothesis testing, the t-test was used to determine whether the post-test scores of students in the experimental class were higher than those in the control class.

Table 11. T-test Results

Class	t	df	Sig
Postest Score	2.678	30	0.012

Based on Table 11, the significance value obtained was 0.012, which is lower than 0.05. This means that the null hypothesis was rejected and the alternative hypothesis was accepted. In other words, the post-test scores of students in the experimental class were significantly higher than those of students in the control class. This finding indicates that the use of the developed STS-based LKPD contributed positively to improving students' learning outcomes. The improvement occurred because the LKPD encouraged students to engage actively in contextual learning activities, helping them understand the concepts of material and its changes more meaningfully than through conventional one-way instruction.

Analysis of Student Learning Motivation

The next test was conducted on the learning motivation of students in both classes, namely the experimental class and the control class. The analysis of data on student learning motivation was obtained from the results of filling out the learning motivation questionnaire.

Table 12. Results of Student Learning Motivation Analysis

Class	Motivation to learn	Category
X TAB 1	92	Very High
X TKJ	80	High

Based on Table 12, the experimental class (X TAB 1) obtained an average learning motivation score of 92%, which was categorized as very high. Meanwhile, the control class (X TKJ) obtained an average score of 80%, which was categorized as high. These findings indicate that the learning motivation of students in the experimental class was higher than that of students in the control class. Because the motivation data were presented descriptively, it is more appropriate to state that the experimental class showed higher motivation rather than claiming a statistically significant difference unless an additional inferential test was conducted for the motivation data. This higher motivation can be explained by the characteristics of the STS-based LKPD, which integrated socio-technological issues, such as rusting iron, into scientific concepts and made learning

less abstract and more relevant to students' daily and vocational experiences.

Based on the above explanation, the improvement in both motivation and learning outcomes occurred because the STS-based LKPD integrated socio-technological issues into scientific concepts, making learning more contextual and meaningful. Unlike the control class, which only received material through one-way instruction, the experimental class was actively involved in the STS stages, namely Initiation, Exploration, Solution, and Application. In the Exploration stage, for example, students were encouraged to investigate real phenomena such as rusting iron in the school environment, which helped them connect theory with direct observation. This active involvement allowed students to build understanding through experience, discussion, and problem-solving, which in turn increased both their motivation and their post-test performance. This is also in line with the principles of the Merdeka Curriculum, which emphasizes meaningful learning and the holistic development of students' competencies.

Conclusion

Based on the results of this study, the Science, Technology, and Society (STS)-based student worksheet on the topic of substances and their changes was shown to be valid, practical, and effective for use in vocational high school learning. The validity of the product was reflected in the expert assessment covering content, presentation, language, and contextual aspects, with an average Aiken's V score of 0.88, indicating that the worksheet met the validity criteria. In addition, the worksheet was categorized as very practical based on teacher and student responses, with an average practicality score of 93%. The effectiveness of the worksheet was demonstrated by the higher learning motivation of students in the experimental class (92%, very high) compared to the control class (80%, high), as well as significantly better learning outcomes, as indicated by the hypothesis test result ($p = 0.012 < 0.05$). This effectiveness was supported by the STS approach, which connected the material to real-life issues relevant to vocational students, making learning more meaningful and engaging. Future research is recommended to implement this worksheet in a wider range of schools and vocational programs to examine its broader applicability and long-term impact on students' motivation and achievement.

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Author Contributions
Siti Nur Wahyuningsih contributed to the preparation of the original draft, the presentation of research results, the discussion, the methodology, and the formulation of the conclusions. Okta Suryani contributed to the research design, supervision of the research implementation, language review, manuscript review, and editing. Kurniawati and Riga contributed by providing suggestions and feedback on the research and manuscript preparation.

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The authors declare that there are no conflicts of interest related to this research.

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