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Strategy for Developing Science Student Worksheets Based on Concept Maps to Improve Student Learning Outcomes at Elementary School

*Yogi Yunefri[1] ; Rizki Novendra[2], Yogi Ersan Fadrial[3]. Fajrizal[4]

[1,2,4] Department of Vocational Engineering Education, Universitas Lancang Kuning, Pekanbaru, Riau

[3] Department of Vocational Engineering Education, Universitas Lancang Kuning, Pekanbaru, Riau

*[1]yogiyunefri@unilak.ac.id; [2]rizkinovendra@unilak.ac.id; [3]yogiersan@unilak.ac.id,[4]fajrizal@unilak.ac.id

(*) Yogiyunefri@Unilak.ac.id

ABSTRACT

This study aims to develop and evaluate concept map-based Science Student Worksheets (LKS) to improve learning outcomes of fourth-grade students at SDN XXX. Using a quasi-experimental nonequivalent control group design, two groups were involved: an experimental group using concept map-based LKS and a control group using conventional LKS. The sample consisted of 31 students selected through random sampling. Data were collected through pretests, posttests, expert validations, and student and teacher responses, then analyzed using descriptive statistics, N-Gain, and t-tests. Results showed that the experimental group achieved a higher posttest mean score (85.71) compared to the control group (70.71), with an N-Gain of 0.68 (moderate-high) versus 0.36 (low). Expert validation indicated high validity and practicality (average score 92.5%). Students reported improved conceptual understanding and engagement due to the visual and systematic nature of concept maps. Statistical analysis confirmed a significant positive effect ($p < 0.05$) of the concept map-based LKS on learning outcomes. This study concludes that concept map-based LKS are effective learning tools for enhancing science conceptual mastery and recommends their broader application and integration with interactive media.

KeyWords: Concept map, student worksheet, science education, learning outcomes, elementary school

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INTRODUCTION

Education is one of the most important aspects in the development of a country, especially in efforts to create an educated and high-quality generation (McCowan, 2019). A good education system aims not only to transfer knowledge but also to shape the character and skills of students so that they can play an active role in society (Brooks & Harrison, 2024). In Indonesia, basic education plays a very strategic role as it serves as the foundation for students' intellectual and social development (Rahardjanto & Susilowati, 2018). Through basic education, students are expected to gain in-depth knowledge and the ability to think critically, creatively, and independently (Raj et al., 2022). Education at the basic level, particularly in the field of Natural Sciences (IPA), presents its own challenges. Many students struggle to understand the abstract concepts of science, which can hinder their progress in learning more advanced scientific subjects (Upmeier zu Belzen & Beniermann, 2020). Therefore, it is important to continue developing effective and innovative teaching methods to improve the quality of science education in elementary schools.

Science education in elementary schools aims to provide students with a systematic and scientific understanding of the natural world around them (Pei, 2019). At the elementary level, science subjects should provide learning experiences that are direct and relevant to students' lives. According to Law No (Selvakumar et al., 2025). 20 of 2003 on the National Education System, the national education objectives are to develop the potential of students to become individuals who are faithful and devoted to God Almighty, have noble character, are healthy, knowledgeable, skilled, creative, independent, and become democratic and responsible citizens (Umami et al., 2019). In this context, science education is expected to facilitate students in developing their intellectual abilities and understanding the natural phenomena that occur around them (Apedaile, 2020).

However, even though science is an important subject in the elementary school curriculum, student learning outcomes in many schools are still unsatisfactory. One of the main factors causing low science learning outcomes is students' difficulty in understanding and connecting basic science concepts (Bloom, 2010) (Nowicki et al., 2013). Many students find it difficult to see the relationships between concepts in science, so they cannot apply the knowledge they have learned in their daily lives. This results in poor understanding of the material taught, which in turn affects their evaluation results (Skopeliti, 2022). Therefore, a learning approach is needed to help students understand science concepts more easily, one of which is by using effective learning media, such as concept map-based student worksheets (LKS) (Kamble & Jagtap, 2023a).

Worksheets are one of the tools used in learning to facilitate students in learning the material provided by teachers. Worksheets serve as teaching materials that guide students in carrying out learning tasks related to the basic competencies that must be achieved. According to Prastowo (2015), LKS is teaching material consisting of sheets of paper containing material, summaries, and instructions for completing tasks that must be done by students (Mulhayatiah et al., 2019). With LKS, students can learn independently and in a structured manner, so that they can better understand the material being taught. The use of LKS can also help teachers deliver material in a more organized and clear manner. However, despite the long-standing use of LKS in education, many LKS remain conventional and unappealing to students, particularly in the context of science education (Miarsyah et al., 2019).

One way to improve the effectiveness of worksheets in science learning is to develop concept map-based worksheets (Diwakar et al., 2007). Concept maps are graphical representations of relationships between concepts that can help students understand the relationships between ideas or information visually (Katagall et al., 2015). The use of concept maps in science learning can help students organize information and see the relationships

between the concepts being studied, thereby gaining a deeper understanding. Additionally, concept maps can assist students in remembering and processing information more effectively. By using concept map-based worksheets, it is hoped that students will find it easier to understand and remember abstract and difficult-to-grasp science concepts (Kamble & Jagtap, 2023b).

Concept map-based worksheets are highly relevant for implementation at SDN XXX, given the low learning outcomes of students in science subjects. Based on observations conducted at the school, it was found that many students had difficulty understanding basic science concepts and often failed to connect one concept to another (Merrill, 2014). This has resulted in poor academic performance, particularly in assessments that measure conceptual understanding and analytical skills. Therefore, the use of concept map-based worksheets is expected to be an effective solution to enhance students' understanding of science concepts, thereby significantly improving their academic performance (Pabón-Galán et al., 2021).

However, even though the use of concept maps in science education has been widely discussed in the literature, there are still shortcomings in the development of concept map-based worksheets specifically for science education in elementary schools (Marulcu et al., 2013). Several existing studies have focused more on the use of concept maps in general learning contexts, while the use of concept maps in worksheets for science subjects at the elementary school level is still very minimal. This study aims to address this gap by developing concept map-based worksheets that can improve students' learning outcomes in science at SDN XXX (Zheng & Dahl, 2009).

This study is expected to contribute significantly to the development of science learning in elementary schools. By developing concept map-based worksheets, this study not only provides solutions to the problems faced by students at SDN XXX, but also serves as a model for other schools facing similar problems (Chen & Hu, 2013). The use of concept map-based worksheets can improve students' understanding of basic science concepts and help them develop critical and analytical thinking skills. Additionally, this study can provide important theoretical contributions to the development of learning media, particularly in the use of concept maps to enhance student learning outcomes (Chen & Hu, 2013).

Therefore, it is important to develop effective concept map-based worksheets that are tailored to the needs of students at SDN XXX. This study will focus on the design and development of concept map-based worksheets that can be used in science learning in fourth grade, with the aim of improving student learning outcomes (Huynh & Yang, 2023). This study will also test the validity, practicality, and effectiveness of the developed concept map-based worksheets, as well as provide recommendations for their use in science education in elementary schools in Indonesia (Xu & He, 2014).

METHODS
Research design
This study uses a quantitative approach, focusing on assessing the effectiveness of using concept map-based Student Worksheets (LKS) in improving student learning outcomes in Natural and Social Sciences (IPAS). The design used is a quasi-experimental model with a Nonequivalent Control Group Design, involving two groups, namely the experimental group and the control group, for comparison.

Populasi dan Sampel

The population of this study was all fourth-grade students at SDN XXX, consisting of two classes with a total of 31 students. The sampling technique used was random sampling, in which each class had an equal chance of being selected as the experimental group or control group.

Research Variables
1. Independent variable: The use of concept map-based worksheets in science learning.
2. Dependent variable: Student learning outcomes (understanding of knowledge and concepts).

The independent variable is measured through the application of worksheets, while the dependent variable is measured using pretest and posttest scores.

Research Procedure:
Analysis Stage: Identify student and teacher needs through interviews and classroom observations.
1. Design Stage: Design concept map-based worksheets that are effective and interesting for students.
2. Development Stage: Create worksheet prototypes and validate them with subject matter experts, media experts, and teachers.
3. Implementation Stage: Apply the worksheets in the classroom with experimental and control groups.
4. Evaluation Stage: Evaluate the effectiveness of the worksheets by comparing pretest and posttest results and analyzing feedback from teachers and students.

Experiment Protocol
This study uses a nonequivalent control group design, in which:

1. Experimental group: Uses concept map-based worksheets.
2. Control group: Uses conventional worksheets that have not been developed.

Both groups will be given pre-tests and post-tests to see the difference in their learning outcomes.

Data Analysis Techniques
The data will be analyzed using:
1. Descriptive analysis to summarize the characteristics of the data.
2. N-Gain analysis to measure the improvement in student learning outcomes from the pretest to the posttest.
3. T-test or Mann-Whitney U test to test the hypothesis, depending on the normality of the data.

FINDINGS AND DISCUSSION

Findings
This study aims to determine the effectiveness of using concept map-based student worksheets (LKS) on student learning outcomes in IPAS lessons in grade IV at SDN XXX. The study involved two groups, namely the experimental group, which used concept map-based LKS, and the control group, which used conventional LKS.

To determine the effectiveness of the SW, pre-tests and post-tests were conducted on both groups. The following are the average learning outcomes of students from both groups.

Table 4.1. Average Pretest, Posttest, and N-Gain of Students

Group	Average pretest	Posttest Average	N-Gain
Eksperimen	55	85.71	0.68
Kontrol	54.29	70.71	0.36

Description :
a) N-Gain is calculated using the formula N-Gain = (Posttest − Pretest) / (100 – Pretest
b) Interpretation of the N-Gain category:
   High: > 0.7
   Currently : 0.3 – 0.7
   Low: < 0.3

Interpretation of Table 4.1:

The table shows that the experimental group experienced a much higher increase in learning outcomes than the control group. The average posttest score for the experimental group reached 85.71 with an N-Gain of 0.68 (moderate-high category), while the control group only reached 70.71 with an N-Gain of 0.36 (low category). This indicates that concept map-based worksheets are significantly more effective in improving student learning outcomes.

The main findings of this study are as follows:

1. Improvement in Learning Outcomes
   a) The average pretest score in the experimental group was 55, while in the control group it was 54.29. This shows that the initial conditions of the two groups were relatively equal.
   b) After the treatment, the average posttest score in the experimental group increased to 85.71, while in the control group it only reached 70.71.
   c) The results of the N-Gain analysis show that the increase in learning outcomes in the experimental group was in the moderate to high category, with an N-Gain value of 0.68, while the control group showed a value of 0.36 or in the low category.

2. Validation of Concept Map-Based Workbooks
   a) The LKS developed has been validated by experts and received an average score of 92.5% from media and material experts, which is considered highly acceptable.
   b) Classroom teachers also responded positively to the readability, appeal, and meaningfulness of the workbooks.

3. Student Response
   Most students stated that concept map-based worksheets made it easier for them to understand IPAS concepts because of the visual display and systematic structure of concept maps.

Discussion

The results of the study indicate that the use of concept map-based worksheets has a significant positive impact on improving student learning outcomes. This is in line with constructivist theory, which emphasizes the active involvement of students in constructing knowledge through the visual and conceptual organization of information.

The success of using LKS can be attributed to several factors:

a) A systematic visual structure helps students understand the interrelationships between IPAS concepts.
b) Targeted activities in the workbook encourage active and participatory involvement from students.
c) The visually appealing design of the workbook increases students' motivation to learn.

In addition, validation by experts shows that this workbook is highly suitable for use (average validation score: 92.5%), and teachers also give positive assessments regarding its practicality and ease of implementation in the classroom.

CONCLUSIONS AND SUGGESTION

Conclusions

Based on the findings of the study, the following conclusions can be drawn:

1. The concept map-based Student Worksheet (LKS) developed for science education has been validated as highly effective and practical. Validation results from subject matter experts (92%), media experts (83.27%), and education practitioners (96%) confirm that these worksheets are highly valid and practical. The evaluation covered content accuracy, visual design, functionality, and ease of use in the classroom, all of which met the required standards.

2. The use of concept map-based worksheets significantly improved student learning outcomes. N-Gain calculations showed a significant increase in the experimental class (57.62%) compared to the control class (46.11%), indicating that concept map-based worksheets are more effective in improving conceptual understanding.

3. Statistical analysis (t-test) showed a significant difference in learning outcomes between the experimental group and the control group. The significance value of 0.003 was less than the threshold of 0.05, confirming that concept map-based worksheets had a significant impact on student learning outcomes.

4. The application of this learning tool has proven effective in helping students understand the concept of "Plants, the Source of Life on Earth," demonstrating that concept map-based learning can improve student understanding and retention compared to traditional methods.

Suggestion

1. Concept map-based worksheets can be used as an alternative learning medium for science subjects at various levels of education to improve students' conceptual understanding and engagement.

2. Further research could explore the integration of these worksheets with digital media or educational technology such as interactive applications or QR codes. This would support distance learning and accommodate different student learning styles.

3. It is recommended to add further interactive elements, such as self-reflection exercises, educational games, or links to additional learning videos, in the next version of the LKS to increase student engagement and critical thinking skills.

4. Further research could involve a broader sample from various educational levels and regions to validate the generalization of these findings, as well as to assess the long-term effectiveness of using concept map-based worksheets in improving learning outcomes.

Acknowledgments

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