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Development of Students' Worksheet Through Guided Inquiry Model to Increase Science Process Skills in The Harmonic Vibration Subject

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ABSTRACT

Objective: This study uses guided inquiry models to test the relationship between the Student Worksheets and Science process skills on the Harmonic Vibration subject. **Method**: This research uses an experimental method with subjects on high school students in two State Islamic School 1 Sumenep classes. **Result**: Through comprehensive equipment and questions. This research results in several aspects as follows: (1) the average validity on the Student Worksheet (SW) is 3.58, which is categorized as a very-valid; (2) the exciting aspect of SW is 93% with attractive criteria, the understanding SW is 87% with easy-to-understand criteria, clarity in terms of font size and typeface is 100% with clear criteria, clarity in terms of language aspects is 92% with clear criteria, as well as clarity of description supported by graphic illustrations of 87% with clear criteria; (3) The effectiveness of SW is measured through the pre-test and post-test which depicts that there is an increase in students' science process skills after the using learning tools and guided inquiry learning models. **Novelty**: This research contributes to the development of indicators in student's worksheets relating to science process skills, including formulating a problem, making a hypothesis, determining the experimental variable, defining operational definitions of variable, creating a data table, creating a finding and analysis, and making a conclusion.

INTRODUCTION

The curriculum is one of the educational programs provided for students learning. Curriculum 2013 contains the improvement and balance between soft and hard skills, including behaviors, abilities, and knowledge (Fadlillah, 2014). Likewise, The regulation of the Minister of Education and Culture No. 54 of the Year 2013 stated that Curriculum 2013 covers students' spiritual and social behavior, knowledge, and skills. Therefore, the curriculum 2013 is relevant to develop process and scientific skills of students in physics (Akib et al., 2020; Maryanti et al., 2021, 2021; Munastiwi & Marfuah, 2019; Salimi et al., 2021).

One of the competencies in Physics in Curriculum 2013 is to design a problem associated with object physics, make a hypothesis, design an experiment, do an exact measurement, note taking and deliver a result and discussion through graphs and charts, make a conclusion, and presenting the result (The regulation of Minister of education and culture No. 64 the Year 2013). In studying physics, students are required to give practical experience. Science process skill is the thinking ability to develop knowledge, solve the problem, and produce a finding result (Haryadi & Pujiastuti, 2020; Kurniawan et al., 2019; Nasir et al., 2019; U. Sari et al., 2020).

Science process skill is a scientific method that includes finding something through tests and experiments. However, process skill involves intellectual, manual, and social abilities. It can be seen in how students utilize tools and instruments and use their minds to interact with others. Based on these theories, science process skill is a thinking ability to develop knowledge in problem-solving through observation and experiments by involving intellectual, manual, and social abilities (Darmaji et al., 2019; Duda et al., 2019; Ekici & Erdem, 2020; Irwanto et al., 2019).

Process skills are into two levels, including basic science process skills and integrated process skills. Basic process skills include observation, classification, communication, measurement, prediction, and inference. Meanwhile, integrated process skills include determining variables, processing data, analyzing investigations, developing hypotheses, determining variables operationally, planning investigations, and conducting experiments. Science process skills are divided into two groups, namely basic science process skills, which include: observing, classifying, measuring, and predicting (Martiningsih et al., 2019; Subali et al., 2019; Tanti et al. et al., 2020; Winarti et al., 2019). At the same time, integrated science process skills include: identifying and defining variables, collecting and processing data, creating tables and graphs, describing relationships between variables, interpreting data, manipulating materials, recording data, formulating hypotheses, designing investigations, drawing conclusions, and generalizations.

Furthermore, science process skill is necessary to be implemented and tested by students through national exam test. Most of these exams have yet to represent students' science process skills. Skill should be developed through study cases in Islamic Senior High School in Mojokerto. This research yields that the difficulty level of science process skill is 59.00%, categorized as low-level. The level of science process skills among high school students must improve to get optimum results. Therefore, developing a learning model and proper worksheet must be developed to address it. In favoring the regulation of educational and cultural minister No. 22 the Year 2016, discovered/inquiry learning is beneficial to strengthen the scientific approach in classroom practice. The inquiry learning model will stimulate students' ability to find and figure out critically, systematically, and logically so they can get their experimental discovery full of confidence. Implementing the inquiry model can also improve students' science process skills. Likewise, Hidayatulloh & Madlazim (2015) find that the achievement of science process skills after being intervened by the inquiry model is 91.07%.

Inquiry is a learning strategy that teaches, stimulates, and invites students to think analytically, critically, and systematically to find answers to various independently expressed problems. Inquiry learning is a strategy that requires students to find something and know how to solve problems in scientific research (Ngalimun, 2017). Guided inquiry is an inquiry that the teacher interferes with a lot, where in this case, the teacher directs more by providing instructions with complete procedures and guiding questions so that the conclusions obtained will always be correct according to the teacher's wishes. Inquiry-based learning consists of several steps, namely observing or observing, formulating problems, submitting hypotheses, collecting data, testing hypotheses, and formulating conclusions. Furthermore, guided inquiry learning is a learning activity that emphasizes the process of thinking analytically and critically to seek and find answers to a problem in question (Husnaini & Chen, 2019; Kwangmuang et al., 2021; Palupi et al., 2020; Rodriguez et al., 2020). The teacher directs by giving instructions through procedures and guiding questions during the inquiry process. The teacher gives problems, and students solve these problems with procedures directed by the teacher.

One of the efforts to practice science process skills is developing the prototype of a learning model which can support classroom activities. The learning model could be qualified only if valid, feasible, and practical (Plomp & Nieveen, 2013). In addition to the learning model, one of the learning resources (students' worksheet) also influences the results of students' science process skills. A student worksheet is a sheet containing assignments addressed to students that are tailored to the essential competencies and learning objectives to be achieved (Nurdin & Andriantoni, 2016). In fact, the students' worksheet still needs to be utilized by the 2013 curriculum. The students' worksheet that is usually used only contains material and questions, is not oriented towards a particular learning model, and does not train specific skills. The ideal students' worksheet should refer to international standards such as those in the Glencoe student book published by McGraw-Hill. Students' worksheets can be used in a process skills approach, where students practice science process skills and collect as many concepts as possible about the material to be studied through SW and then discuss to obtain conclusions about the definitions and characteristics of the material being studied.

Students' science process skills are one of the implementations of Strengthening Character Education (SCE) in the learning process. This is per the objectives of SCE in Presidential Regulation no. 87 Article 2 of 2017, namely revitalizing and strengthening the potential and competence of educators, education staff, students, the community, and the family environment in implementing SCE. In other words, science process skills not only drive students to mastery of the material but also provide students the flexibility to develop physical and mental skills so that learning activity becomes more meaningful for students (Atun & Latupeirisa, 2021; Kriswantoro et al., 2021; Li et al., 2021; Suhendi et al., 2021; Tabiin, 2020; Yuliansyah & Ayu, 2021). SCE will eventually shape an attitude that is by the demands of student life and can internalize the life values for themselves and their circumstances.

The students' worksheet that the researcher will develop is different from the latest students' worksheet since it only contains brief descriptions and questions and has no specific orientation toward learning models and objectives, and there are no experiments. Researchers will develop students' worksheets by taking into account the eligibility criteria. The eligibility criteria are the suitability of the content, the suitability of the presentation, the suitability of the science process skills component, and the suitability of the used model. Therefore, this current research will be entitled "Development of Student Worksheets (SW) Using the Guided Inquiry Model to Train Students' Science Process Skills on Harmonic Vibration Material."

This student's worksheet improves the previous one, which only briefly describes materials and exercises. Besides, the prior worksheet has no purpose for specific learning models or particular skills and no experimental learning. Therefore, this research contributes to advancing the student's worksheet by considering the feasibility criterion. Those aspects encompass the suitability of the content, delivery, science process components, and learning models. There are some essential indicators in the student's worksheet that the researcher develops, i.e., formulating a problem, making a hypothesis, finding an experimental variable, determining the operational definition of a variable, making a data table, analyzing the data and discussion, and building a conclusion (Hasanah & Shimizu, 2020; Kurniawan et al., 2020; Sari et al., 2023; Wulandari et al., 2020).

RESEARCH METHOD

General Background

The research method is an experimental study that tests Student Worksheets using the guided inquiry model. The selection of this type of research is adjusted to the research objectives, namely to develop SW using the guided inquiry model to increase students' science process skills.

Sample

The subject of this research is divided into two groups, 15 students for the experimental group and 15 students for the control group. To reduce the bias, these two groups are from two different classes in 1st-grade science class at Islamic State School in Sumenep. These total students participated in five times of meetings during the odd semester in 2018-2019. The first meeting is to conduct a pre-test for both groups. The second to fourth meetings is a learning activity for the experimental group only with the learning instrument that the researcher has prepared. The final meeting is a post-test for both groups to test whether the guided inquiry model in harmonic vibration subject has a relationship or not to enhance science process skills.

Instrument and Procedures

Plomp & Nieveen (2007) point out that the characteristics of high-quality interventions are relevance, consistency, practicality, and effectiveness. Thus, the instruments developed to collect data in this research include validity instruments of learning devices, practical instruments of learning devices, and instruments for the effectiveness of learning devices. This research was conducted through two stages: Phase 1 was the development of learning tools (Trial 1). The researcher began developing learning tools, including syllabi, lesson plans, worksheets, student textbooks, and assessment sheets. Learning tools developed using a 4-D model; this phase aims to see how far learning tools' validity, practicality, and effectiveness have developed in classroom learning. Experiment 1 in this study can be carried out with the following conditions.

1. The developed learning tools meet the valid criteria and have been revised the learning tools based on the validator's suggestions and input.
2. Experimental device 1 is a syllabus, learning implementation plan, student worksheets, student textbooks, learning outcomes assessment sheets, and research instruments declared valid by the validator and approved by the supervisor.

Data Analysis

1. Analysis of the Validity of Learning Devices.
   The validity of learning tools includes syllabi, lesson plans, student books, worksheets, and Assessment Sheets. The data obtained was analyzed descriptively qualitatively, utilizing an average score for each aspect likely in Table 1.

Table 1. The scoring results of the validity

Average Interval Score	Categories	Explanation
$1.00 \leq SV \leq 1.69$	Invalid	Not feasible, cannot be used, and still requires consultation
$1.70 \leq SV \leq 2.59$	Slightly valid	Less decent, usable with multiple revisions
$2.60 \leq SV \leq 3.59$	Valid	Decent, usable with minor revisions
$3.60 \leq SV \leq 4.00$	Very valid	Very decent, usable without revision

Slightly revised category if the newly revised learning implementation plan sub-components are at most 25.00% of the total number of learning device sub-components. Many revisions of the learning device sub-components that must be revised are more than 25.00% of the total number of learning device sub-components.

2. Analysis of Learning Practicality
   a. Analysis of learning implementation
   Two observers analyzed the implementation of learning; then, the data were processed using descriptive statistics. The observer's assessment of the implementation of learning includes the introduction, core activities, closing, processing time, and observing the classroom atmosphere.
   b. Readability Analysis of Student Textbooks and SW
   This instrument is used to measure the readability percentage of Student Textbooks and SW, which includes students' responses to the contents of the book and SW with the Readability Instrument of Student Textbooks and SW, which is carried out in a qualitative descriptive manner. The results of the student corrections were then percentage based on the student's positive and negative responses in filling out the Student Textbook and SW readability questionnaires.
   c. Learning Constraints Note Sheet
   Obstacles during the implementation of learning were analyzed using descriptive qualitative, namely observers and researchers provided notes about obstacles or obstacles that occurred during the implementation of guided inquiry learning models.
3. Analysis of Learning Devices Effectiveness
   a. Effective Assessment Analysis
   The practical assessment was analyzed using a qualitative descriptive analysis.
   b. Analysis of Cognitive Skill Process
   Cognitive process test data (science process skills) and students' product cognitive were analyzed using qualitative descriptive analysis.
4. Analysis of Psychomotor Assessment
   The psychomotor assessment was analyzed using a qualitative descriptive analysis. The formula obtains the psychomotor value of students:

$$P = \frac{\sum K}{\sum N} \ x \ 100\%$$

   Notes:
   P = Performance percentage
   $\sum K$ = number of aspects implemented
   $\sum N$ = Sum of all aspects experienced
5. Students' Response
   Data on student responses were obtained from questionnaires on student responses to learning activities and then analyzed using descriptive qualitative, namely calculating the percentage of the given statement. The guided inquiry model uses the response data obtained to follow up on learning activities.

RESULTS AND DISCUSSION

Result

Validity

Students' worksheet that has already been developed is eventually validated by two physics lecturers and a teacher in the targeted school. The result of validity can be viewed in Figure 1.

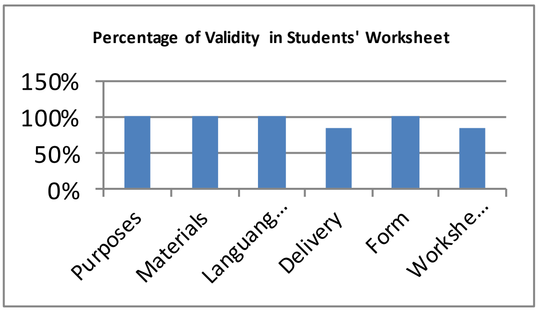

Figure 1. Percentage of validity.

The lowest percentage is the aspect of presenting and the model of students' worksheets supporting innovation and improving the quality of teaching and learning activities, obtained by 83.30%. This is due to the need for more motivation and curiosity. In addition, the low percentage is caused by students' low level of thinking and reading ability at school. The aspect of the student's worksheet model also has a low percentage of 83.30%.

Practicality

The lesson plan scenario was implemented by two observers who are physics teachers from different schools. The results of observations are included in the observation sheet of learning implementation. The following results of learning implementation using the guided inquiry learning model are presented to increase science process skills in Table 2.

Table 2. Science process skills practice.

Phases	Meeting			Average
	2	3	4	
Phase 1: Identifying the problem	3.63	3.75	3.63	3.67
Phase 2: Formulating the hypothesis	3.50	3.50	3.50	3.50
Phase 3: Identifying variables	3.75	3.88	3.88	3.84
Phase 4: Doing an experiment	4.00	3.50	4.00	3.83
Phase 5: Collecting and Analyzing the data	3.50	3.75	3.75	3.67
Phase 6: Conveying the result	3.75	3.75	3.75	3.75
Phase 7: Making a conclusion	4.00	3.50	3.67	3.72
Average	3.73	3.66	3.74	

Based on Table 1, the implementation of the learning process in the first phase of the lesson plan scenario on meeting 2, meeting 3, and meeting four has gained above 3.5, with the categories well-implemented and very well-implemented. In the first phase, the teacher encourages students by giving attention through observations or activities related to harmonious vibrations and conveying to achieve the learning objectives. Such strong motivation can allow students to deepen more curiosity regarding the material of harmonious vibrations so that they have a solid intention to participate in learning activities. Due to the short time available at the third meeting, the average coefficient is only 3.66.

Furthermore, the readability of students' worksheets describes students' reading to the learning model. The readability of the SW was represented by 15 students who were the subject of the study. In the following the results obtained from each aspect of the readability of the SW are shown in Table 3.

Table 3. The readability of SW.

No	Criteria of Assessment	Criteria
		Interest rate
1.	Is the worksheet interesting?	93.00%
		Understandable
2.	Is the explanation of the worksheet understandable?	87.00%
3.	Is the worksheet straightforward in some aspects:	Clear
	. Font type	100.00%
	·. Font size	100.00%
	. Language	92.00%
		Clear
4.	Are the images able to describe the lesson	87.00%

The readability of students' worksheets is carried out to determine how much students can grasp the experimental student's worksheet. Assessing the readability is conducted by using a questionnaire instrument which contains several aspects of the assessment, including interest in the SW, ease of understanding the contents of the SW, clarity in understanding the SW in terms of the aspect of font size, typeface, and language as well as the clarity of the description supported by illustrated pictures.

Effectiveness

a. The result of product cognitive

The cognitive product assessment sheet consists of 15 multiple-choice questions. Product cognitive learning outcomes can be gained based on students' test scores during the pre-test, the learning activities, and the post-test. The following results of product cognitive learning are revealed in Table 4.

Table 4. Result of product cognitive.

Number	Students	Pre Test		Post Test		N-Gain	Categories
		Score	Accomplished	Score	Accomplished		
1	A	47	TT	87	T	0.75	High
2	B	33	TT	80	T	0,.70	High
3	C	27	TT	80	T	0.73	High
4	D	33	TT	80	T	0.70	High
5	E	33	TT	80	T	0.70	High
6	F	27	TT	93	T	0.90	High
7	G	40	TT	80	T	0.67	Medium
8	H	40	TT	80	T	0.67	Medium
9	I	53	TT	87	T	0.72	High
10	J	27	TT	80	T	0.73	High
11	K	40	TT	93	T	0.88	High
12	L	33	TT	87	T	0.81	High
13	M	47	TT	87	T	0.75	High
14	N	40	TT	93	T	0.88	High
15	O	33	TT	80	T	0.70	High

Table 4 depicts that the average value of the product cognitive pre-test is 36.87, and the product cognitive post-test value is 84.47 with an N-Gain value of 0.75, which is included in the high category. These results indicate an increase in students' understanding of concepts after the learning process given as an effect of using science process skill-based learning models and learning tools that have been developed.

b. The result of science process skills

The science process skill assessment sheet is a description test instrument consisting of seven questions containing indicators of science process skills: formulating problems, formulating hypotheses, identifying variables, identifying variables operationally, making observation tables, communicating graphs, analyzing data, and concluding. This test instrument measures students' science process skills that have been trained during the learning process. The learning outcomes of science process skills can be received according to student test scores during the pre-test, learning activities, and post-test. The result of learning science process skills for each item is shown in Table 5.

Table 5. Result of science process skills.

Number	Students	Pre-Test		Post-Test		N-Gain	Category
		Score	Accomplished	Score	Accomplished		
1	A	20	TT	80	T	0.75	High
2	B	25	TT	75	T	0.67	Medium
3	C	20	TT	85	T	0.81	High
4	D	15	TT	75	T	0.71	High
5	E	15	TT	85	T	0.82	High
6	F	20	TT	75	T	0.69	Medium
7	G	20	TT	75	T	0.69	Medium
8	H	15	TT	75	T	0.71	High
9	I	15	TT	80	T	0.76	High
10	J	10	TT	75	T	0.72	High
11	K	20	TT	75	T	0.69	Medium
12	L	20	TT	80	T	0.75	High
13	M	20	TT	75	T	0.69	Medium
14	N	10	TT	85	T	0.83	High
15	O	25	TT	75	T	0.67	Medium
Average Value		**18**		**78**		**0.73**	

Discussion

Validity

The highest percentage is the aspect of purpose, material, and language because the objectives of the students' worksheets are relevant to the objectives of the lesson plan, syllabus, and assessment sheets. In addition, there are also phenomena in the developed students' worksheets so that students are highly motivated to carry out investigations and further information about the material presented. Exciting pictures and videos in students' worksheets can improve learning motivation and curiosity. Hence, Students' worksheets can significantly influence the learning process (Nurdin & Andriantoni, 2016).

Practicality

Based on Table 2 and Table 3, the percentage of readability in terms of attractive criteria is 93.00%, ease of understanding SW is 87.00%, clarity in terms of font size and type is 100.00%, clarity in terms of language aspects is 92.00%, and clarity of description supported by illustrated images is 87.00%. The results of the experimental student's worksheet have a high level of readability. This can help students understand several indicators of science process skills in SW. The high legibility of students' worksheets also affects students' cognitive learning outcomes.

Effectiveness

One of the aspects supporting improving cognitive learning outcomes is shown in Table 2 regarding the legibility of good student worksheets. It makes it easier for students to understand the material. In addition, the science process skill-based learning model also provides a learning atmosphere that allows students to be actively involved in training their thinking skills and influencing students' conceptual understanding of harmonic vibration subject. Thus, students understanding of concepts can be easily improved through science process skills-based learning.

The results showed that the average pre-test value of science process skills was 18. The low pre-test score of students' science process skills was because, so far, students had not been able to develop science process skills due to the unavailability of supporting tools for implementing the 2013 curriculum that specifically trains science process skills. After applying science process skill-based tools in learning, the average post-test of science process skills is 78 with an N-Gain value of 0.73 which is in the high category. This shows an increase in students' science process skills after the learning process is carried out through learning tools and models based on science process skills.

CONCLUSION

Fundamental Finding: Learning instruments (Syllabus, Lesson Plan, SW, Teaching Materials, and assessment sheets) are well-proven and effective in improving science process skills. **Implication**: Regarding validity, students' worksheets contribute a large portion of the components of purpose, material, and language. At the practical level, those learning tools have also been applied with good results through some practical steps in skill-based learning. In terms of effectiveness, experimental students' worksheet has increased the result of both product cognitive and science process skills, yet the latter is categorized with medium and high results proportionally. **Limitation**: However, this study has a limitation regarding specific subject areas. **Future Research**: Future research beyond harmonic vibration subjects is necessary to increase the reliability of methods in other subjects.

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