The Development of student worksheets based on a scientific approach in the dynamic fluid concepts

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Abstract. This study aims to develop student worksheets (SW) based on the Scientific Approach on the concept of dynamic fluids. Another objective is to determine the level of validity and response of students. The design of this study uses the R&D (Research and Development) method with the ADDIE model including the stages of analysis, design, development, implementation and evaluation. This research was conducted at the Public Middle School, Prisai Kutacane district, Southeast Aceh in class XI IPA 1, which numbered 36 people. The data collected comes from validity tests by experts, reliability, pilot tests and student responses. The data collection instruments that used were tests, questionnaires and observation sheets. The results showed that the SW validity level tested by experts was in the very good category. Based on the results of this study, it can be concluded that by applying the SW-based scientific approach, learning the dynamic fluid concept becomes more effective.

1. Introduction

Understanding of science concepts (especially physics concepts) is still very low, this is shown by the 2015 TIMM and PISA research reports. In the last TIMMS report, it was stated that the ability of Indonesian students to master science concepts was 66th with a total score of 383 or below the average score. -International mean 463 or OECD version mean score of 501 [1]. The TIMMS and PISA reports are a trigger or a whip for all individuals or groups involved in the world of primary and secondary education to identify and correct weaknesses that have been carried out so far. Teachers and students have carried out many activities to improve the quality of education, including using methods, reading materials, implementing practicum and problem solving exercises. Several research results have been reported related to the development of media and practicum tools, including the development of student worksheets based on a scientific approach [2, 3, 4], development of SW through a guided inquiry approach [5]. Beside that show that development of a PhET-based multi representative practicum module [6, 7, 8], EduPlasa media development [9], use of smartphones as learning media [10], use of LED media [11], use of PhET simulation media [12, 13], SW development based on science process skills [14, 15], and problem solving based SW development [16]. Understanding of science concepts (especially physics concepts) is still very low, this is shown by the 2015 TIMM and PISA research reports. In the last TIMMS report, it was stated that the ability of Indonesian students to master science concepts was 66th with a total score of 383 or below the average score -International mean 463 or OECD
version mean score of 501 [1]. The TIMMS and PISA reports are a trigger or a whip for all individuals or groups involved in the world of primary and secondary education to identify and correct weaknesses that have been carried out so far.

Teachers and students have carried out many activities to improve the quality of education, including using methods, reading materials, implementing practicum and problem solving exercises. Based on the results of observations at school, researchers see and observe how the teachers in the school teach, and what media the teachers use in the school. Most of the teachers in these schools still teach using the lecture method so that what happens is the teacher centre, so students are less enthusiastic in participating in learning. In these schools, there are also Student Worksheets (SW) tools, but teachers rarely use them. The results of an interview with one of the students at the school were about the reasons that the SW was rarely used, because the language in the writing of the SW was too difficult for them to understand, there were many questions, were not interesting, were not coloured, and were too thick like a textbook. This is also, in accordance with what the researchers felt after seeing one of the SWs used in the school. Another finding was the cause of not or rarely used SW, because the teacher's ability to formulate questions was very limited [17].

Some SW based on scientific approaches that have been developed have received good responses from teachers and students. Among them is SW based on the scientific approach to the concept of reaction rate with a percentage of the content suitability aspect of 94.54%, readability of 93.33%, and attractiveness of 96.00%, all of which are included in the very high category. Student responses to the developed scientific approach-based SW were very good with an average percentage of the readability aspect of 84.87%, and attractiveness of 86.90%, all of which were in the very high category [18]. Based on the findings of previous researchers, the current condition of the target school, and the benefits of the types of tools developed in this study, it is time for the research target schools to develop SW based on a scientific approach to the concept of dynamic fluids. The purpose of this study was to obtain a valid and reliable form of SW based on a positive approach for use in the target school. Another goal, so that the teacher makes it easier to convey the concept of dynamic fluids and students can understand the concept with a sense of fun and not boring.

2. Research Methods

2.1. Research design

This research uses a mixed approach, namely quantitative and qualitative research and the type of research used is research and development or R&D with reference to the ADDIE learning device development model (Analysis, Design, Development, Implementation, and Evaluation) [19]. The mixed approach means data in the early stages (analysis and design) in a qualitative form, while data for the later stages (development and evaluation) is in a quantitative form. The design of the model is shown in Figure 1. The ADDIE model begins with an initial analysis or survey and ends with an evaluation of product implementation.

![ADDIE model design](image-url)
2.2. Population and sample
The main respondents in development research are experts or validators of learning tools, content validators, and product users, namely teachers and students. A total of two validators for devices or media and two validators for content validation (physics field). For the limited pilot test, 36 students from class XI IPA 1 Public High School in Perisai Kutacane, Aceh Tenggara were used. Therefore, in this study there is no sample selection as is usually done in quantitative research.

2.3. Data collection
There are two types of data collected in this study, firstly qualitative data (analysis and design stages) and secondly quantitative data (development, implementation and evaluation or pilot test stages). Qualitative data uses observation and interview sheets, while quantitative data uses questionnaires for experts, teachers and students. Indicators for the development of observation sheet instruments, interview manuscripts, questionnaires for experts, teachers and students were adopted from the work of previous researchers with adjustments to several question items [6, 20, 21, 22, 27].

Table 1. Research instrument.

| No | Names | Types | Data | Subject |
|----|-------|-------|------|---------|
| 1  | Sheet of SW validation Approach Based Specific on Fluid Matter Dynamic | Non-test | Qualitative | Validators Team |
| 2  | SW quality sheets Approach Based Specifics of Fluid Matter Dynamic | Non-test | Qualitative | Physics Teacher |
| 3  | Student response questionnaire. | Non-test | Qualitative | Learners |

2.4. Research Implementation
The research implementation begins with a reference analysis of the results of previous research and the conditions of the school being the research target. After analyzing the data from the initial stage, it was continued with the design of Student Worksheet (SW) in draft form and the results were given to media and content experts to get initial input data. Based on the second stage of data, the SW development stage continues by referring to expert input (this stage can be done several times) to get the right form of SW. After completing the development, it continues with the implementation of SW on a limited sample and simultaneously evaluates. The results of using the SW by 36 students (per group of 5 students) were analyzed and assessed the feasibility of the SW by the researcher. Finally, a questionnaire was given to teachers and students to get information or responses related to the use of SW.

2.5. Data Analysis
Qualitative data analysis used Miles and Huberman's model as suggested by Sigioyono in his book [23]. The model begins with data collection, reduces the amount of data, displays the data in a table form and draws conclusions from the data. While the quantitative data from the results of expert validation and SW pilot tests use descriptive statistics or use the percentage formula as suggested by Halim et.al in his article. [24, 25].

Figure 2. Qualitative data analysis by Miles and Huberman's model [23].
3. Result and Discussion

3.1. Analysis stage
The activity in the analysis stage is to collect all information from articles and from the target school where the SW is being tested. One of the information obtained in the sample schools is the form of the old SW as shown in Figure 3. The SW already has stages of use, but it is not clear, the design is less attractive, has no pictures, is colorless and does not reflect the scientific approach. The SW in Figure 3 is used as the basis for the design of the SW based on the scientific approach.

![Figure 3. Old SWs obtained in target schools.](image)

3.2. Design stage
SW based on a scientific approach is designed based on the 2013 Curriculum, which guides students to find concepts. SW design uses scientific steps, and the writing is adjusted to the indicators. The indicators used by the author in designing this type of SW are indicators in the sub-concept of Debit, Bernauli Principles, and Torricelli’s Theorem.

![Figure 4 (a) SW cover initial design and (b) SW cover product design.](image)

3.3. Development Stage
The development stage is more focused on the content or subtopic of the Bernoulli Principle. The development results are shown in Figure 5 (a) as a result of developing pages 1, 5 (b) as a result of development for pages 2, and 5 (c) as a result of development for SW page 3 on the Bernoulli Principle subtopic. At this stage, the complete development results from page skin to page 8 for the subtopic Debit, Bernoulli Principle, and Toricelli’s Theorem are given to the expert to be validated. The results of validation from the viewpoint or format of the SW based on the scientific approach are shown in Table 2.

![Figure 5. The results of the development of the content of the SW on the Bernoulli’s subtopic.](image)

**Table 2.** Table of validation results of SW display format by media experts.

| No | Assessment criteria                              | Score 1 | Score 2 | Score 3 | Score 4 | Score 5 | sum  | Percentage (%) | categories |
|----|--------------------------------------------------|---------|---------|---------|---------|---------|------|----------------|------------|
| 1  | Clarity of writing with the appropriate type and size | 1       | 4       | 80      |         |         |      | B              |            |
| 2  | The suitability of using images with content     |         |         |         | 80      |         | 80   | B              |            |
| 3  | Appropriate image size and clarity               |         |         |         |         | 100     | 100  | SB             |            |
| 4  | Presentation can attract attention               |         |         |         |         | 1       | 5    | SB             |            |
| 5  | Proportional paper size                          |         |         |         | 80      |         | 80   | B              |            |
| 6  | The paper thickness is suitable                   |         |         |         |         | 1       | 4    | B              |            |
| 7  | Suitability of the colors used in SW             |         |         |         |         | 1       | 4    | B              |            |
| 8  | The right page design                            |         |         |         |         | 1       | 4    | B              |            |
| 9  | Attractive cover selection                       |         |         |         |         | 1       | 4    | B              |            |

The average feasibility of the SW format uses a scientific approach 38 84.44 SB

The validation of the SW display format was carried out against nine assessment criteria. Based on the results of the SW performance format validation that has been done, the average percentage shows a high number with a very good category. However, two assessment criteria score very well. These criteria are the suitability of the size and use of images, as well as the presentation of the SW to attract attention. This assessment is good, because SWs that did not include pictures on the front page before validation and the size of the pictures was still not suitable. When viewed as a whole, the percentage of
the SW assessment shows a value of 84.44% in the very feasible category. The content validation in the SW is intended to be able to see the appropriateness of the content in the SW being developed. In this SW, the content section does not present the content directly, but requires students to think about the concept. The results of content validation in SW using an inquiry model on the dynamic fluid concept can be seen in Table 3. SW content validation based on five assessment criteria. Based on the results of the SW content validation, it was found that the average percentage showed a high number with a very good category. In these assessment criteria, there are three criteria with good categories and two criteria with very good ratings. When viewed as a whole, the percentage of the SW assessment shows a value of 88% in the very good category. This shows that the content in this SW is very suitable for use in learning.

Table 3. Results of content validation in SW based on a scientific approach by content experts.

| No | Assessment criteria                                                                 | Score | sum | Percentage (%) | Categories |
|----|-------------------------------------------------------------------------------------|-------|-----|----------------|------------|
| 1  | Clarity of KD, indicators and objectives                                           | 1 5   | 100 | SB             |
| 2  | Learning                                                                           | 1 5   | 100 | SB             |
| 3  | The accuracy of the questions with KD and the learning indicators that have been formulated | 1 4   | 80  | B              |
| 4  | Easy to digest concept presentation                                                 | 1 4   | 80  | B              |
| 5  | The suitability of the contents of the important components of the development of SW based on a scientific approach (SW title, student identity, basic competencies, learning objectives and SW content) | 1 4   | 80  | B              |

Average feasibility of content in scientific based SW 22 88 SB

3.4. Implementation Stage
After validation by media and content experts, it was continued with pilot tests on a limited sample, namely 36 students of class XI High School Kutacane Aceh Tenggara. SW was distributed to five groups of students and carried out three times according to each subtopic, namely the Debit subtopic (SW-1), Bernoulli Principle (SW-2), and Torricelli’s Theorem (SW-3). After students use SW-1 or complete all group assignments in the SW, then they collect their work. The data on their work is analyzed for every aspect in the SW. In the first pilot test, students had the opportunity to explore Debit content through the application of SW-1 with their respective group members. The results of student responses show that data collection activities, data analysis and concluding the results have the highest average percentage of all aspects with scores of 20, 19, and 19 or 100%, 95%, and 95%. Meanwhile, activities to formulate problems and hypotheses have a high average. The overall average rating of media and content experts is 92% in the very good category, meaning that it is very feasible to use.

Table 4. Data from SW-1 test results Debit content based on student work.

| No | Assessment Aspects      | Sum of Score | Total of Score | Percentage (%) |
|----|--------------------------|--------------|----------------|----------------|
| 1  | Formulate problems       | 3 1 1        | 17             | 85             |
| 2  | Formulating Hypotheses  | 2 3          | 17             | 85             |
| 3  | Collecting data          | 5            | 20             | 100            |
| 4  | Analyze Data             | 4 1          | 19             | 95             |
| 5  | Conclude                 | 4 1          | 19             | 95             |

Percentage average 92
Table 5. SW-2 trial data for the Bernoulli Principle content based on student work.

| No. | Assessment Aspects      | Sum of Score | Total of Score | Percentage (%) |
|-----|-------------------------|--------------|----------------|----------------|
| 1   | Formulate problems      | 3 2          | 18             | 90             |
| 2   | Formulating Hypotheses  | 2 3          | 17             | 85             |
| 3   | Collecting data         | 2 2 1        | 16             | 80             |
| 4   | Analyze Data            | 3 1 1        | 17             | 85             |
| 5   | Conclude                | 3 2          | 18             | 90             |

Percentage average 86

In the first pilot test, students had the opportunity to explore the content of the Bernoulli Principle through the application of SW-2 with their respective group members. The results of student responses show that the activity of formulating problems and concluding the results has the highest average percentage of all aspects with a value of 18 and 18 or 90%, and 90%. Meanwhile, the activities of making hypotheses, collecting data, and analysing data have a high average. The overall average rating of media and content experts is 86% in the good category, meaning it is feasible to use.

Table 6. Test data for SW-3 Torricelli Theorem content is based on student work.

| No. | Assessment Aspects      | Sum of Score | Total of Score | Percentage (%) |
|-----|-------------------------|--------------|----------------|----------------|
| 1   | Formulate problems      | 3 1 1        | 17             | 85             |
| 2   | Formulating Hypotheses  | 2 3          | 17             | 85             |
| 3   | Collecting data         | 5            | 20             | 100            |
| 4   | Analyze Data            | 4 1          | 19             | 95             |
| 5   | Conclude                | 4 1          | 19             | 95             |

Percentage average 92

In the first pilot test, students had the opportunity to explore the content of Torricelli’s Theorem through the application of SW-3 with their respective group members. The results of student responses show that data collection activities, analysing data and concluding the results have the highest average percentage of all aspects with scores of 20, 19, and 19 or 100%, 95%, and 95%. Meanwhile, activities to formulate problems and hypotheses have a high average. The overall average rating of media and content experts is 92% in the very good category, meaning that it is very feasible to use. Based on the results of the validation of content experts and media experts as well as the results of pilot tests that have been carried out on a limited sample, it shows that SW based on a scientific approach is good and suitable for use in High School Kutacane Aceh Tenggara students. The findings in this study are supported by several relevant previous research results, including the work of Hasja et.al [7], which shows that SW based on a scientific approach, is feasible and very effective to use for learning physics. Another finding by Arifullah et.al [9] shows that SW based on PhET simulation is very effective to be used to improve students' science process skills. Another support was reported by Afrida et.al [24] that guided inquiry-based SW was effectively used to improve the science process skills and interest of Banda Aceh high school students. Likewise, the findings of Rahamatilla et.al [25] that SW based on science process skills are suitable for use in high school students with positive teacher responses or about 89.8% and student responses are positive and feasible or 92.6%. Besides that, there are also SW, which are very effectively used to train students' problem-solving skills in learning physics [26].

4. Conclusion

Therefore, it is recommended to physics teachers in particular and science teachers in general for High School in Kutacane district, Aceh Tenggara to use the SW in implementing learning. For the perfection of the development of SW based on a scientific approach it is recommended that further research be
carried out through pilot tests on expanded samples and used in real time to obtain information on the effectiveness of the SW.

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Acknowledgments

To all parties who have helped this research activity, we would like to thank and give our highest appreciation. This study is funded by the NAS and USAID under the USAID Prime Award Number AID-OAA-A-11-00012, and that any opinions, findings, conclusion, or recommendations stated in the article are from the author only, and do not always reflect the view of USAID or NAS. In addition, the author also expresses his gratitude to all colleagues at the Syiah Kuala University who gave ideas and thoughts for the perfection of this paper.