Development of Dynamic Fluid props with ADDIE design at SMA

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Abstract. This study aims to develop physical teaching aids on dynamic fluid material. This research is a research development (Research & Development) using the ADDIE design with the stages of analysis (analysis), design (design), development (development), and evaluation (evaluation). This research was conducted at MAS Darul Qur'an with sample of 37 students. The development stage was carried out with a validation test with four expert validators, which were divided into two expert validators and two material expert validators. The results of the validation of the props are based on the validation of material experts with a percentage of 97.5% and the percentage of validation of media experts is 87.5% with the very feasible category. The effectiveness of the developed teaching aids in understanding dynamic fluid material based on the results of the teacher's assessment of the effectiveness test of dynamic fluid teaching aids, it was found that the teaching aids developed were effective for use in classroom learning activities with a total percentage of 90% in very good categories. The practicality of the props developed in understanding dynamic fluid material is 93.80% in the very practical category.

1. Introduction
Physics is a part of science, learning physics cannot be separated from practicum activities. Practicum is a series of activities to prove the theory and development of the concepts that have been studied [1]. Physics is a science that develops rapidly along with the development of science and technology [2]. Physics learning rests on the specific embodiment of physics itself which starts from efforts to obtain cultured truth, namely systematic thinking through physics that does not forget the nuances of humanity [3]. Advances in technology facilitate the formation of creative and innovative elements in physics learning.

The expected physics learning is that students not only master the theoretical concepts of physics but must also be able to use scientific methods to prove the physics concepts obtained from the theory [4]. Learning media is an important component in planning, implementing and evaluating learning. Media is a tool that has the function of conveying messages [5]. The word media comes from the Latin medium which literally means ‘middle’, ‘intermediary’, or ‘introduction’. Gerlach & Ely stated that the media when understood in broad terms is humans, material, or events that build conditions that enable students to acquire knowledge skills and attitudes [6-8].

Teaching aids are teaching media that contain or convey the characteristics of the concepts being learned. Science teaching aids are a set of concrete objects that are designed, created, collected...
or deliberately arranged to help instill or develop concepts or principles in science. With visual aids, abstract things can be presented in the form of concrete objects that can be seen, held, turned around so that they are easier to understand [9]. Props are anything that can be used to express messages, stimulate students' thoughts, feelings and attention, as well as students' abilities so that they can encourage the learning process [10].

The visual aid developed in this research is a dynamic fluid, which is able to compare the flow of water with the electric power produced through the visual aid. This dynamic fluid props is one of the tools that can be used in learning to support physics learning activities, especially on the subject matter of dynamic fluids. The reason for choosing this media is because there are no props used to support or increase students' knowledge on the subject matter of dynamic fluids at MAS Ponpes Darul Qur'an.

2. Method
The research and development concept used is the ADDIE design by Robert Maribe Branch, but this research is limited to the development stage. The stages in this research are:

2.1. Analyze
The analysis stage has 5 stages, namely: Learning Analysis, where researchers analyze school learning to find out and clarify whether the learning problems faced require a solution in the form of implementing product development. The analysis of instructional objectives, namely to analyze whether the tools developed were needed by class XI students at MAS Ponpes Darul Qur'an and whether the objectives of developing the tools carried out could be accepted by students? If the results of data analysis have been collected leading to product development as a solution to the learning problem at hand, the product designer then performs a needs analysis. Student analysis, namely analyzing student characteristics with developmental research criteria. Analyzing the available resources, namely recommending existing and easy-to-find resources for making props.

2.2. Design
Design (planning) includes developing objectives, developing products, describing initial behavior and determining the structure and sequence of learning. The aim of the design phase is to verify the desired learning and appropriate testing methods.

2.3. Development
The phase develop is the realization of a product design that has been made in the design phase which is still in a conceptual framework. This conceptual framework is realized into a product that is ready to be implemented. The purpose of the development stage is to produce a product and validate the tools that have been developed.

2.4. Implementation
The implementation phase includes implementing the learning management plan and conducting learning / training (Sani, et al. 2018). In this phase, the researcher applies or implements the use of dynamic fluid props. During implementation, the design of the teaching aid that has been developed is applied to the actual conditions. An initial evaluation was carried out to provide feedback on the application of the teaching aids that were developed next. The feedback given was obtained from the magnitude of the responses by students and the implementation of learning which applied two aspects that affected the practicality of the developed teaching aids.

2.5. Evaluation
The evaluation phase includes internal evaluation activities, external evaluation, and revision of the system being developed (Sani, et al. 2018). The general procedure of the evaluation phase is to determine evaluation criteria, choose the appropriate evaluation tool, and conduct an evaluation.
3. Results and Discussion

Research on the development of dynamic fluid teaching aids in SMA has gone through several stages. The stages of this development research are carried out based on the ADDIE design stages which include analyze, design, development, implementation and evaluation. However, this research is limited to the stage development. Explanation of the stages of research and development of dynamic fluid props are as follows:

3.1. Analyze

In this research, the analysis stage has 5 stages, namely: Learning Analysis, the results of the learning analysis are based on the results of interviews with the physics teacher at the Darul Qur'an Islamic Boarding School, that teachers still use the lecture method when delivering dynamic fluid material, the rarely use of props by the teacher to explain a physics material, especially on dynamic fluid material, the teacher never uses teaching aids. This reason causes students to find it difficult to learn physics because the physics material is too much mathematical formulation. The second stage is determining instructional objectives. This research can be carried out because the results of the analysis of instructional objectives based on a needs questionnaire show that 100% of students or all students in class XI MIA 2 MAS Ponpes Darul Qur'an are happy to learn using media and all students state that they want to exist teaching aids in dynamic fluid learning. The third stage, analysis of students. Based on the results of observations to students of the MAS Ponpes Darul Qur'an, it was found that:

a. The characteristics of students who take part in the teaching aids development program are class XI MIA 2 students who have followed dynamic fluid learning on the material of discharge, the principle of continuity, and fluid power.

b. Knowledge and skills possessed by students, namely students have understood the concept of discharge, the principle of continuity, and power in fluids and their application in life. Knowing the flow meter and how to measure the discharge manually.

c. The ability or competence possessed, students have understood the concept of dynamic fluids, especially discharge, the principle of continuity and power in fluids.

d. The indicator used to determine that students have achieved the predetermined competence after learning is 85% of students in one class reach a minimum score of 80.

e. The conditions required by students when conducting experiments with calm, responsibility and discipline.

The fourth stage, analyzing the available resources. Analyze the resources available in the development of teaching aids, including the estimated cost of manufacture. The tools and materials used in this study are easy to find in everyday life and easy to assemble.

The fifth stage, the product management stage must prepare the tools and materials needed and estimate the time to complete the project to be developed. In this analysis stage, the researcher collected information using observational studies, interviews and questionnaires to determine the need for teaching aids to be developed.

3.2. Design

The purpose of the design stage is to verify the desired learning and testing methods are appropriate. The use of dynamic fluid teaching aids can help students observe directly the application of dynamic fluid material in life. Students can calculate the discharge manually and digitally using water flow and compare the percent error. Students are also able to calculate the amount of electric current, and the power in the fluid that causes the LED light to light.

The design of the props made is also equipped with the student worksheet used by the students. The design of the props can be seen in Figure 1.
3.3. Development (development)
Development in the ADDIE model contains product design realization activities. Researchers realize dynamic fluid props according to the design that has been made. The general procedures associated with the dynamic fluid trainer development phase are as follows:

1. Produce Content / Products
Research on the development of dynamic fluid props produces products with tools and materials as in table 1.

Table 1. Tools and Materials for the Development of Dynamic Fluid Teaching Aids

| Number | Name of equipment and material   | Amount |
|--------|---------------------------------|--------|
| 1      | Aquarium                        | 1 piece|
| 2      | Pin                             | 1 piece|
| 3      | Water flow ½ inch               | 1 piece|
| 4      | Water flow ¾ inch               | 1 piece|
| 5      | Water pump                      | 1 piece|
| 6      | LED Light                       | 1 piece|
| 7      | Arduino uno                     | 1 piece|
| 8      | Arduino uno cable               | 1 piece|
| 9      | PVC pipe                        | 1 piece|
| 10     | Project Board                   | 1 piece|

2. Developing student worksheet
The dynamic fluid used is equipped with student worksheets.

3. Developing Guidance for Teachers
Researchers guided 2 physics teachers on how to use the dynamic fluid props developed.

4. Perform Formative Revisions
Products that have been developed are validated by material experts and media (product) experts as validators. The developed teaching aids have been validated by the validator and tested for their feasibility. The results of the assessment in the form of a questionnaire analyzed are as follows:

1) Results of the Material Expert's assessment
Assessment of dynamic fluid props by a team of material experts, namely two physics lecturers at the State University of Medan. The results of the validation data analysis of each material expert can be seen in table 2:
Table 2. Results of Material Expert Validation Recapituation

| Assessment Aspect | Indicator                                                                 | Scale | ∑Indicator | ∑Aspect | Percentage (%) | Criteria       |
|-------------------|---------------------------------------------------------------------------|-------|------------|---------|----------------|----------------|
|                   | V1                          | V2    |            |         |                |                |
| Content Feasibility| 1. Suitability of the exercise equipment to indicators                     | 4     | 5          | 9       | 19             | 95             | Very feasible |
|                   | 2. Suitability of the props to the material                               | 5     | 5          | 10      |                |                |                |
| Conformity concepts| 1. Fluid discharge                                                       | 5     | 5          | 10      | 30             | 100            | Very feasible |
|                   | 2. The principle of continuity                                             | 5     | 5          | 10      |                |                |                |
|                   | 3. Fluid power                                                            | 5     | 5          | 10      |                |                |                |
| Total             |                                                                           | 24    | 25         | 49      | 97.5           |                | Very feasible |

The assessment carried out by material expert validators on dynamic fluid props is shown in table 4.1 with a percentage obtained of 97.5% with a very feasible category. The graph of the percentage acquisition of the assessment of material expert aspects can be seen in Figure 2:

![Figure 2](image)

**Figure 2.** Graph of the percentage of aspects of the material expert validation assessment

Material experts assess that the dynamic fluid props developed are suitable for use as learning media in schools with revisions according to suggestions. Advice given by material experts, namely:

- The material on the trainer is focused only on dynamic fluids
- The material shown on the media should show the ratio of discharge to fluid power not to electric power
- Adjusting the use of teaching aids with learning indicators

2) Results of the Media Expert’s assessment (product)

Assessment of dynamic fluid props by a team of media (product) experts, namely two physics lecturers at the State University of Medan. The results of the validation data analysis of each media expert can be seen in table 3:

Table 3. Results of Media Expert Validation Recapituation

| Assessment Aspect | Indicator                                               | Scale | ∑Indicator | ∑Aspect | Percentage (%) | Criteria       |
|-------------------|---------------------------------------------------------|-------|------------|---------|----------------|----------------|
|                   | V1                          | V2    |            |         |                |                |
| Product design    | 1. Have a proportional shape                            | 5     | 4          | 9       | 46             | 92             | Very feasible |
|                   | 2. Interesting display props                            | 4     | 5          | 9       |                |                |                |
|                   | 3. The accuracy of the installation of each component on the measuring instrument | 5     | 5          | 10      |                |                |                |
4. Security props
5. The ability to add insight to students

| Present          | 1. LKPD presentation systematics | 2. Feasibility of the props to be tested | 3. The effectiveness of the media for teaching |
|------------------|---------------------------------|----------------------------------------|----------------------------------------------|
|                  | 4                               | 4                                      | 4                                            |
|                  | 4                               | 5                                      | 4                                            |
|                  | 4                               | 4                                      | 8                                            |
|                  | 8                               | 9                                      |                                               |
|                  | 25                              | 83                                     |                                               |
|                  | total                           | 35                                     | 36                                           |
|                  | 71                              | 87.5                                   |                                               |
|                  | very feasible                   | very feasible                          |                                               |

The assessment made by the media expert (product) validator on dynamic fluid props is shown in table 4.2 with the percentage of the assessment of the product design aspects obtained by 92% with the very feasible category and the presentation aspect percentage of 83% with the very feasible category. The graph of the percentage acquisition of the media expert’s aspect assessment (product) can be seen in Figure 3:

![Figure 3. Graph of the percentage of the Assessment Aspect of media experts](image)

3.4. Implementation

The implementation phase or application of the researcher applies or implements the use of dynamic fluid props. The design of teaching aids that have been developed and validated by experts is applied to the actual conditions for students. The trial phase carried out was small group trials and field trials.

1. Small Group Trial

Small group trials were carried out on 10 students who did a dynamic fluid practicum based on LKPD guidelines. The results of the small group assessment with the total value of the overall aspects were 374 and the total percentage was 93.5% in the feasible category. In the four aspects assessed, the highest score in the learning aspect was 96%, with the very good category. The lowest score for effectiveness and efficiency was 89% with very good categories, while the implementation and material aspects were 94% and 95% respectively with very good categories.

2. Field Trial

Field trials were conducted on 37 students in class XI MIA 2 MAS Ponpes Darul Qur’an. The aspects that were assessed in the field trial were the ability to be implemented, sustainability, suitability with the environment and attractiveness of the props. The results of the overall field test assessment with a total percentage of 93.80% are in the very good category. The percentage order of the highest to lowest assessment aspects, namely: attractiveness aspect 94.86% with very good category, continuity aspect 94.41% with very good category, and aspects of ability to be implemented and aspects of compatibility with the environment obtained the same percentage, namely 92.97% with very good category.
3.5. Evaluation
The evaluation phase includes internal evaluation activities, external evaluation, and revision of the developed system [11]. The general procedure of the evaluation phase is to determine evaluation criteria, choose the appropriate evaluation tool, and conduct an evaluation. The effectiveness test of dynamic fluid teaching aids was carried out by assessing the physics subject teacher. The results of the effectiveness are viewed from the assessment of physics subject teachers. The results of the teacher’s assessment of the effectiveness test of dynamic fluid teaching aids, it was found that the teaching aids developed were very effective for use in classroom learning activities with a total percentage of 90% in very good category. With the indicators studied, namely the achievement of student learning outcomes got a percentage of 80% and for the ease of presenting dynamic fluid phenomena got a percentage of 100%.

4. Conclusion
1) The feasibility of the props developed in understanding dynamic fluid material has been validly used as a learning medium with an average total validity of the material expert validator of 97.5% with a very feasible category and a media expert validator of 87.5% with a very feasible category.
2) The effectiveness of the developed teaching aids in understanding dynamic fluid material based on the results of the teacher's assessment of the effectiveness test of dynamic fluid teaching aids, it was found that the teaching aids developed were effective for use in classroom learning activities with a total percentage of 90% in very good categories.
3) The practicality of the props developed in understanding dynamic fluid material is 93.80% in the very practical category.

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