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HATRAVY: a virtual laboratory of heat transfer concept in microscopic form

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Abstract. This study aims to analyze the feasibility of HATRAVY learning media for heat transfer material. The method used in this study is ADDIE developed by Robert Marie Branch. The stages are Analysis (Analysis), Design (Design), Development (Development), Implementation (Implementation), and Evaluation (Evaluation). The steps of this research are: 1) Curriculum analysis, analysis of the results of interviews and questionnaires of students, as well as analysis of literature studies, 2) Designing HATRAVY learning media, 3) Realizing HATRAVY practicum tools 4) Conducting expert validation tests 5) Product revision. The results of the study obtained the validity value of the tool by 90.47% with a feasible category. This study concludes that HARTAVY is suitable to be used as a learning medium in heat transfer material.

1. Introduction
Creating an attractive and pleasant atmosphere in the classroom is one of the tasks of the teacher [1]. This is in accordance with Law Number 20 of 2003 article 40 paragraph (2), namely: "Educators and education personnel are obliged to: (a) Create an educational atmosphere that is meaningful, fun, creative, dynamic, and dialogical, (b) Having a professional commitment to improve the quality of education, and (c) Give an example and maintain the good name of the institution, profession, and position in accordance with the trust given to him ". A meaningful and enjoyable learning process can be handled using learning media [2]. Learning media have a big influence on the success of the learning process [3], making students become positively active when the learning process takes place.

Interesting and fun media is expected to facilitate students in understanding the subject matter and be able to visualize abstract concepts [4].

One concept that is abstract or its quantity cannot be observed directly is the material of heat transfer, whereas the material of heat transfer is basically closely related to everyday life, [5], causing these concepts to be quite difficult to understand [6]. As a result, students eventually understand the concept based on phenomena that can be seen directly [7].
Based on the results of a literature review and preliminary study, information was obtained that students experienced some misconceptions related to heat transfer material [8], [9], [10], following the presentation of their misconceptions:

- The concept of conduction (in the thermos only utilizes the working principle of conduction because the outside is made of plastic; heat flow is caused by molecules of substances that move)
- The concept of convection (heat transfer of convection is accompanied by the collision process between molecules; assuming that water is a good conductor like metal; the rate of convection becomes fast when the water boils)
- The concept of radiation (radiant heat power is proportional to the final temperature; color is the single most important factor in the process of heat transfer by radiation; objects that absorb radiation heat more quickly will emit radiant heat more slowly)

Another problem was found that there was no practical tool on heat transfer material, so the concept of heat transfer could not be delivered optimally.

According to the explanation above, it is necessary to develop learning media in the form of virtual laboratories in heat transfer material. Virtual laboratories can visualize phenomena that are abstract or complicated experiments carried out in real laboratories, so as to enhance learning activities in an effort to develop skills needed in problem solving [11]. Therefore, researchers developed a virtual laboratory called HATRAVY. HATRAVY is a development tool from tools that have been made by [12].

2. Methods

The research method used is development research. Research and development serves to validate and develop products [13]. The models used in this study are ADDIE (Analysis, Design, Development, Implementation, Evaluation). According to Robert Maribe Branch ADDIE is used as a way of looking at developing a learning design [14], this statement is a strong reason for researchers to use the ADDIE model. More detailed stages of the ADDIE model development in this study are presented in the form of tables as below:

| ADDIE Stage | Detail of stage |
|-------------|-----------------|
| **Analysis** | Conduct literacy studies on heat transfer material. Analyzing the need for the development of learning media, and analyzing the feasibility of the media in accordance with the needs of students based on the results of teacher interviews and questionnaires of students and analyzing learning media in accordance with the applicable curriculum |
| **Design** | Make learning media designs based on the results of the analysis phase |
| **Development** | Realizing the design that has been made in stages: |
| | a. Make HATRAVY media using Adobe flash software |
| | b. Media validation by some experts. This stage is done so that the media can be accounted for, because a good learning tool must be validated and verified properly [15] |
| | c. Product revision based on validation results by a team of experts |
| **Implementation** | The developed media is then applied in actual learning |
| **Evaluation** | Overall evaluation of HATRAVY products |

The sample of this study were several schools in Bandung Regency. Research data sources include questionnaires, interviews, questions about concepts about heat transfer. Data analysis techniques for interviews are qualitative explanations and then concluded and analyzed. Questionnaire is processed using an average percentage of Likert scale. Whereas the concept of the concept to find out the misconceptions experienced by students.
3. Result and Discussion

3.1. Result
The results of research on the development of HATRAVY learning media through the ADDIE model can be described as follows:

3.1.1 Analysis stage. The analysis in this study begins with curriculum analysis. The curriculum used in schools is using the national curriculum. The basic competency in heat transfer material is 3.6 analyzing the effect of heat and heat transfer in various real cases and 4.6 Conducting experiments to investigate the thermal characteristics of a material, especially heat capacity and conductivity. Analysis of the results of interviews with physics subject teachers found that the learning media that is often used in schools is PowerPoint and there is no special practicum tool for heat transfer material. The results of the analysis of the questionnaire distribution to students, the students stated agreed that to visualize the concept must use learning media. Finally, the results of the analysis of the literature study were obtained from examining several researchers who developed virtual laboratories on the concept of heat transfer [16] [17]. The renewal of the learning media developed by researchers is a heat transfer process that is presented microscopically and practicum simulations like actual lab work.

3.1.2 Design stage. At this stage explaining the HATRAVY design that was developed, the design made must be in accordance with the results of the analysis phase. The design consists of 3 parts of the concept, namely conduction, convection, and radiation. The following below is one of the HATRAVY design drawings:

![HATRAVY Design Drawings](image)

Figure 1. HATRAVY in Convection Concept

The design drawings above show that HATRAVY not only simulates heat transfer microscopically, but students are given the opportunity to carry out practicum simulations such as in real conditions.
3.1.3 Development stage. The development phase is the realization phase of the tool to be developed. At this stage the tool is made and tested by experts. Here's the HATRAVY development stage:

- The making phase of HATRAVY

This virtual laboratory is created using the Adobe Flash CS3 application and practicum component images are created using the Corel Draw application. Following below is the display of the HATRAVY manufacturing process:

**Figure 2.** HATRAVY main menu display

**Figure 3.** HATRAVY in Conduction Concept
Validation phase by Expert

Validation test aims to determine the accuracy of HATRAVY according to experts. The first validator as a media expert, based on the assessment sheet obtained a value of 95.83%. The second validator is material expert. The assessment given on the tool validation sheet is 90.52% so that the HATRAVY
practicum tool can be categorized as feasible to be used as a learning medium. The following is the average data of the two validator results:

**Table 2. Average Result of Validation**

| No. | Validation Aspect | Number of Validator Values | Average Indicator Value | Average (%) | Index (%) | Category |
|-----|-------------------|---------------------------|-------------------------|-------------|-----------|----------|
| 1   | Content           | 33                        | 11                      | 3.67        | 91.67     | feasible |
| 2   | Illustration/Display | 24                   | 8                       | 4           | 100       | feasible |
| 3   | Operationality    | 23                        | 7.67                    | 3.83        | 95.83     | feasible |
| 4   | Suitability       | 23                        | 7.67                    | 3.83        | 95.83     | feasible |
|     | Total             | 103                       | 34.34                   | 3.7         | 95.83     | feasible |

3.1.4 Implementation stage. The implementation phase is the HATRAVY trial phase for students. The trial was carried out in several districts of Bandung. The students who conducted the HATRAVY trial were 260 people. At this stage students are also given a test of the concept of heat transfer. The concept test includes questions about heat transfer as many as 20 questions in the form of reasoned PG. The material includes the concepts of conduction, convection, and radiation.

3.1.5 Evaluation stage. In the evaluation stage is the overall assessment process from each phase of ADDIE. The first evaluation is done by processing the students' concept test results and questionnaires distributed to students regarding the use of HATRAVY. Recapitulation of students' concept test results can be seen in the bar diagram below:

![Figure 6. Score of Heat Transfer Concept Test.](image)

Based on the diagram above shows that the percentage of the PK category is higher than the other categories. These results indicate that after being given the HATRAVY media the understanding of students' concepts related to the concept of heat transfer increases. Students then fill out a response questionnaire on the use of HATRAVY learning media. There are three categories of questions submitted in the questionnaire, namely regarding the ease of implementation, sustainability, and acceptance and attractiveness. Students stated that the implementation of practicum using HATRAVY can help improve understanding of the concept of heat transfer and apply the concept and improve
generalization skills. In addition, the simulations and animations shown can increase their motivation in learning physics and be able to understand abstract concepts. This is in accordance with what was stated by [18], learning that is accompanied by the right media in addition to making it easier to experience, understand, and do also creates strong motivation compared to only using abstract words. Then based on the results of validation tests, field tests, and student questionnaires it can be concluded that the HATRAVY practicum tool is suitable to be used as a learning medium in heat transfer material.

4. Conclusion

The results of this study state that the feasibility of HATRAVY can be categorized as feasible as a learning medium in heat transfer material based on the average value obtained from the two validators that is equal to 95.83% with valid / feasible categories according to the relationship with teaching materials, the value of education, resilience, accuracy, efficiency, safety for students and aesthetic tools. Plus HATRAVY can remediate the misconception of the concept of heat transfer experienced by students.

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