

Development of Thermal Radiation Experiments Kit Based on Data Logger for Physics Learning Media

H Permana^{1,*}, B H Iswanto²

¹Physics Education Study Program, Faculty of Mathematic and Natural Sciences, Universitas Negeri Jakarta, Jl. Rawamangun Muka Jakarta Timur 13220, Indonesia

²Physics Study Program, Faculty of Mathematic and Natural Sciences, Universitas Negeri Jakarta, Jl. Rawamangun Muka Jakarta Timur 13220, Indonesia

*handjoko@unj.ac.id

Abstract. Thermal Radiation Experiments Kit (TREK) based on data logger for physics learning media was developed. TREK will be used as a learning medium on the subject of Temperature and Heat to explain the concept of emissivity of a material in grade XI so that it can add variations of experiments which are commonly done such as thermal expansion, transfer of thermal energy (conduction, convection, and radiation), and specific heat capacity. DHT11 sensor is used to measure temperature and microcontroller Arduino-uno used as data logger. The object tested are in the form of coated glass thin films and aluminum with different colors. TREK comes with a user manual and student worksheet (LKS) to make it easier for teachers and students to use. TREK was developed using the ADDIE Development Model (Analyze, Design, Development, Implementation, and Evaluation). And validated by experts, physics teachers, and students. Validation instrument is a questionnaire with a five-item Likert response scale with reviewed aspect coverage: appropriate content and concepts, design, and user friendly. The results showed that TREK was excellent (experts 88.13%, science teachers 95.68%, and students 85.77%).

1. Introduction

Permendikbud no.65/2013 explains that the learning process in the 2013 curriculum is emphasized using a student-centered learning approach that emphasizes the scientific approach including observing, asking, trying, processing, presenting, summarizing and creating [1]. Experiments in lab are activities that make learners active and loaded with a scientific approach. The series of lab activities begins by installing equipment, observing, measuring, retrieving data to draw conclusions [2]. Experiment activities are very effective for achieving three domains, namely: (1) High cognitive skills by practicing in order to understand the theory, integrate different theoretical aspects, and apply theory to real problems. (2) Affective skills by learning to plan activities independently, working together, communicating information about the field, and appreciating the field; (3) Psychomotor skills by learning to install the equipments so that it really works [3].

However, there are some obstacles faced by students in doing experiment activities such as the limited time of learning so it makes it difficult for students to do repetition data retrieval and the accuracy of data taken / measured. Data retrieval is a boring activity in the lab. All these constraints can be overcome by using an experiment kit equipped with data logger equipment [4]. Data logger is an apparatus for data recording with sensors and probes with a certain precision. The data logger will be the main equipment in secondary science classroom technology as becomes more widespread and in common use. The use of the computer and data logger can be of enormous benefit for



improvements in time efficiency, clear presentation of data to allow easier analysis and interpretation, data rapidly displayed clear visual interpretation of relationship between variables [5]. The Table 1 shows the comparison between conventional / manual experiments and using data loggers.

Table 1. Comparison between Conventional/manual Experiments and using Data Loggers.

	Conventional	Data Logger
Implementation	<ul style="list-style-type: none"> • Manual • Need more time 	<ul style="list-style-type: none"> • Automatic • More faster
Data Accuracy	<ul style="list-style-type: none"> • Quite accurate • Observations should be done thoroughly 	<ul style="list-style-type: none"> • Very accurate • Data is recorded automatically and in real time
Result of experiment	<ul style="list-style-type: none"> • Results in the form of numbers 	<ul style="list-style-type: none"> • Results in the form of numbers, graph, diagram or table

Expected competences in subject Temperature and Heat grade XI (Kurikulum 2013 Revisi) are that students are able to analyze the heat transfer, thermal characteristics of a material and able to experiment on the thermal characteristics of a material. Based on the data presented by Viajayani (2013), found that 82% of students expressed difficulty in imagining physical processes on the subject of temperature and heat, especially in understanding heating curve when the temperature of the object increased [6]. Experimental activities are needed to address this.

From the preliminary needs-analysis it is known that common topics that frequently demonstrated are thermal expansion, transfer of thermal energy (conduction, convection, and radiation), and specific heat capacity. Other topics which are not less interesting are heating curve characteristic at phase transition, characteristic of thermal radiation, and characteristic of thermal emissivity. But there is no experiment kit to show that.

Purpose

The purpose of this study was to develop a Thermal Radiation Experiments Kit (TREK) for senior high school (SMA) students. This TREK is comprised of microcontroller arduino-uno, heat sensor (DHT11), and a modified Leslie’s cube. The TREK is expected to be an alternative kit that can be used in learning physics. The study investigated the level of respondent’ agreement using Likert-type scale about the TREK in terms of learning content, learning concept, design, and interaction. It also investigated the perceptions of the participants towards using the TREK. Respondents are made up of experts, science teachers, and students.

2. Methods

The method used in this study was the method of research & development. The research model used is the ADDIE's Model (Analyze-Design-Develop-Implement-Evaluate) as shown in Figure 1 [7].

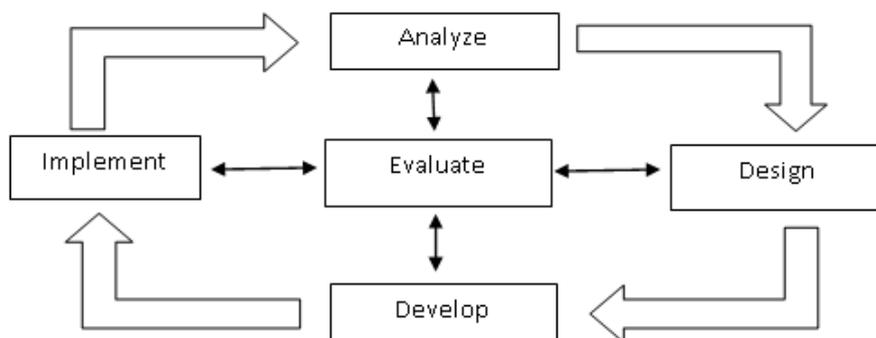


Figure 1. The development model of ADDIE

The study was conducted on March – July 2017 at laboratory of Instructional Research and Development, Faculty of Mathematics and Science, Universitas Negeri Jakarta. A small-group trial was conducted at “SMAN-99 & SMAN-105” senior high school, Jakarta.

Analysis phase (Analyze) begins with preliminary needs-analysis of the high school physics teachers, basic competences literature studies (KD 2013 curriculum) relating thermal radiation materials, preliminary study of tools and materials required.

- Design phase : makes product design TREK, students worksheet and manual book, collecting materials and tools to operate arduino and data logger.
- Development phase: realize the design of the previous phase,
- Implementation phase : doing test of the TREK, preparing validation instruments, collecting feedback from respondents (experts and science teachers)
- Evaluate phase: evaluation and revision of the TREK, redesign based on the feedback from respondents (experts and science teachers)

Data Analysis Technique

Likert scale is a scale used to measure attitudes, opinions, and perceptions of a person or a group of social phenomenon. The calculation is as below :

$$P_{(K)} = \frac{S}{N} \times 100\% \tag{1}$$

where,

- P_(K) = the percentage of component
- S = total score of components research
- N = the amount of the maximum score

Then the data were interpreted using the score table as shown in Table 2.

Table 2. Likert-scale interpretation [8]

No.	Percentage(%)	Interpretation
1	<= 20 %	Very poor
2	20% – 40%	Poor
3	40% – 60%	Average
4	60% – 80%	Good
5	80% – 100%	Very good

Instruments and Participants

There were 2 types of questionnaires used in this study. Preliminary needs-analysis questionnaires were distributed to science teachers and students. Validation instruments were questionnaires with a five-item Likert response scale with scope of reviewed aspects: appropriate content and concept, design, and user friendly. Table 3 shows number of participants.

Table 3. Number of participants

No.	Reviewed Aspects	Number of Participants		
		Expert	Science Teacher	Student
1	Appropriate Content	1	4	-
2	Appropriate Concept	1	4	-
3	Design	1	4	36
4	User friendly	1	4	36

3. Results and Discussion

The results of preliminary need-analysis of 8 physics teachers at SMA Negeri 99 Jakarta and SMA Negeri 105 Jakarta are as below:

- 87.5% of teachers use powerpoint slide as learning media for temperature and heat materials.
- 62,5% of teachers use students worksheet,
- 75% of teachers use laboratory activities,
- 100% of teachers said there was no thermal radiation experiment kits' available.

So it can be concluded that there was a need to develop a thermal radiation experiment kit that can perform measurements of temperature on the material in real time at a certain time interval.

The development of thermal radiation experiment kit (TREK) was developed based on the concept of radiation on the Leslie cube and some relevant research results. The TREK uses a DHT11 temperature sensor to measure the radiation absorbed by the material from the heat source (heater) over a specified time interval measured using the data logger. The measurement results are then displayed in the form of data and graphs.

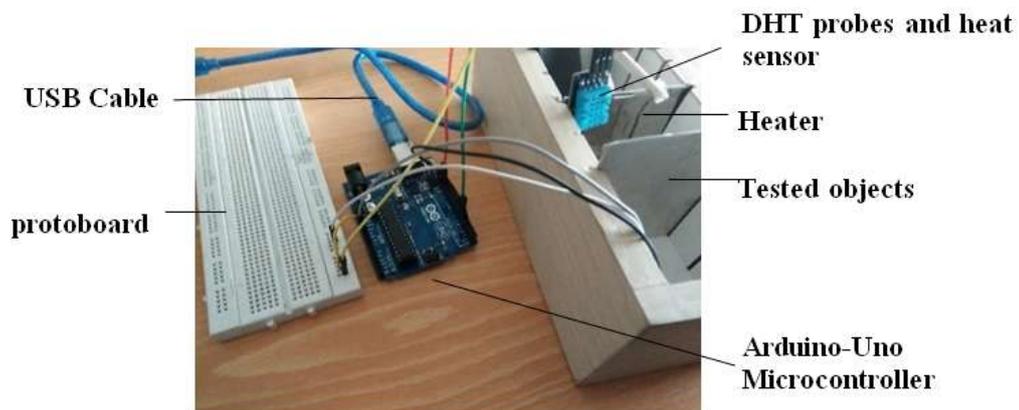


Figure 2. Thermal Radiation Experiment Kit

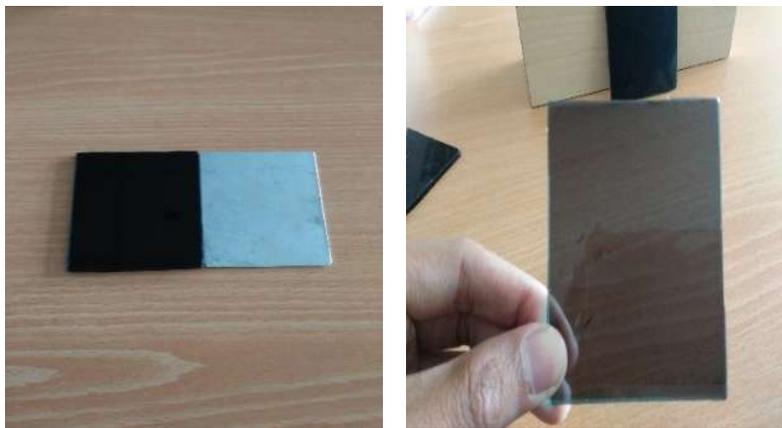


Figure 3. Tested Object (painted alumina and thin coated glass)

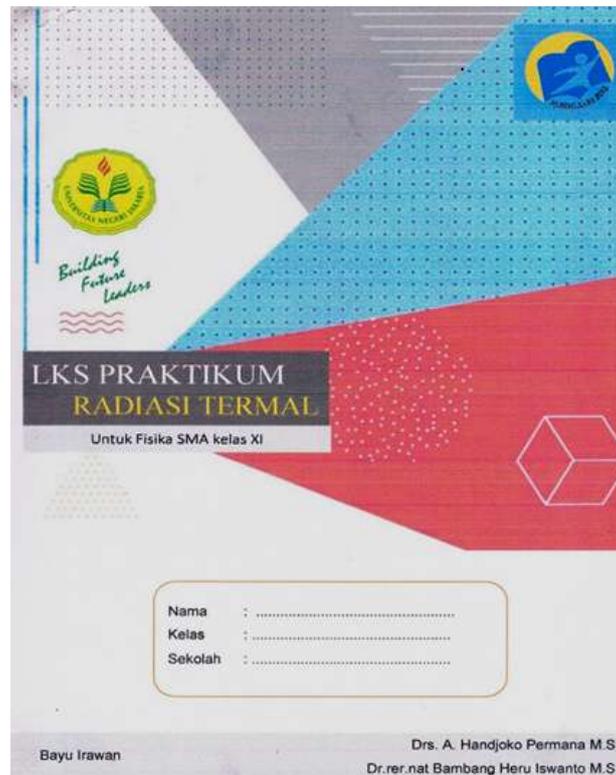


Figure 4. Students' Work-Sheet

How does the TREK work ?

- Thermometer digital + data logger (microcontroller arduino uno + 2 units thermal sensor DHT11).
Thermal sensors (DHT11) get temperature data in real time and record in CSV format. We have prepared an interface application using python that can issue table data and temperature-time curve.
- Modified Leslie's Cube:
Leslie's cube is a device used in the measurement or demonstration of the variations in thermal radiation emitted from different surfaces at the same temperature (BBC GCSE 2016). We used a heating element as a heater. The two sensors are used to record data temperature from inside the cube, and from the front of the two-sides of the cube.

The TREK's test results are shown in Figure 5.

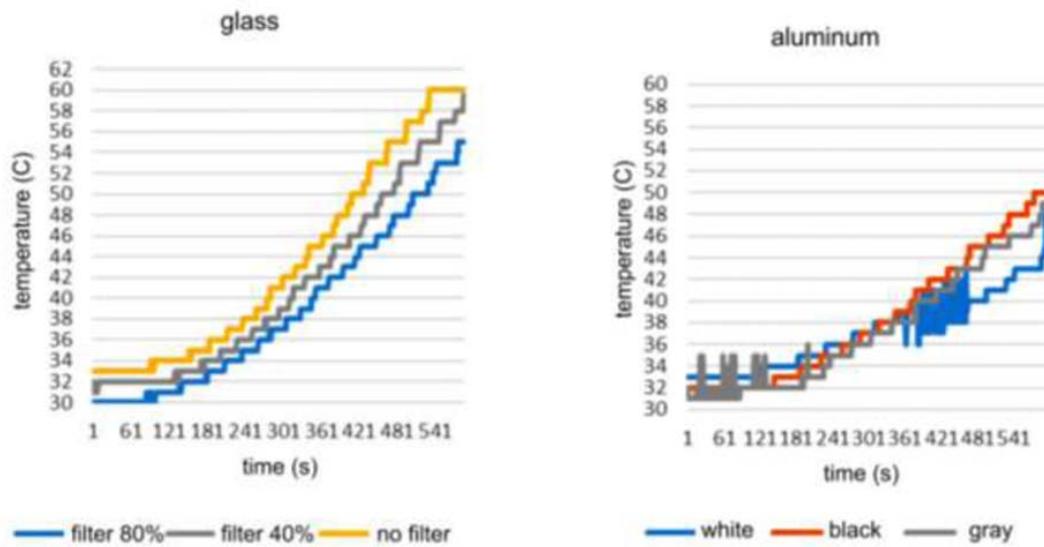


Figure 5. Test-Result of TREK



Figure 6. Small-group Trial

Validation results

The validation results by the experts, the science teachers and a small group of trial by students are shown in Table 4, 5, 6.

Table 4. Validation result by experts.

No.	Aspects	Average score	Remarks
1	Appropriate content	85.71%	Very good
2	Appropriate concept	81.54%	Very good
3	Design	97.14%	Very good
Total Average score		88.13%	Very good

Table 5. Validation results by science teachers.

No.	Aspects	Average score	Remarks
1	Appropriate content	98.58%	Very good
2	Appropriate concept	97.14%	Very good
3	Design	94.0%	Very good
4	User friendly	93.0%	Very good
Total Average score		95.68%	Very good

Table 6. Validation results by students.

No.	Aspects	Average score	Remarks
1	Design	85.24%	Very good
2	User friendly	86.30%	Very good
Total Average score		85.77%	Very good

4. Conclusion

The developed Thermal Radiation Experiment Kit is viable and valid to be used as an instructional media. Conduct a field test in schools. In the further research the study the effect of using this TREK will be investigated.

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