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Development of Gas Kinetic Theory Learning Devices with 2013 Curriculum-based Orientation for Senior High School

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Abstract. The purpose of this study was to determine the validity and practicality of gas kinetic theory learning devices oriented to 2013 physics curriculum. The place and time of the research was at the Laboratory of Physics Education FKIP University of Riau from June to November 2017. The object of this study was the developed learning devices based on the inquiry approach which includes experimental devices, Learning Plans and Worksheets. This type of research was four D models. Validation was carried out by 3 lecturers of Physics Education Study Program FKIP University of Riau and 2 SMA teachers from Pekanbaru. Limited trial was used to see the practical implementation in class XI IPA 3 of SMAN 4 Pekanbaru. The results of the data analysis obtained that the validity of the gas kinetic theory experimental instrument has very valid category with a logical validation value of 3,47. The validity of the Learning Plan is 3.73 in the very valid category, the validity of the Worksheet is 3.5 whit the very valid category. The practicality of the developed device is 94.1% with a very practical category. The conclusions of the results show that the gas kinetic theory learning devices of High School Oriented Curriculum 2013 were developed valid and high in practicality so that they could be used in physics learning in class XI SMA.

Keyword: *Experiment tool, Gas kinetic theory, Lesson plan, Work sheet*

1. Introduction

Physics is one of the branches of science that underlies the development of advanced technology and the concept of harmonious living with nature (Prayekti, 2010). Physics according to Serway etc. (2009) is based on experimental observations and quantitative measurements. The main purpose of physics is to look for a number of basic laws that govern various

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natural phenomena and use them to develop theories that can predict the results of subsequent experiments.

Physics learning in school is more focused on the concepts contained in the book and delivered by the teacher with the dominance of lecture methods, so that students become not interested in learning physics. Islami (2018) said that learning science in school, especially physics, often creates a less attractive impression for students. Because the teacher's presentation in the class is more focused on achieving curriculum targets so that the classroom atmosphere becomes less enthusiastic, therefore students only master the subject matter in the short term without being able to associate the knowledge they get in the classroom with the reality around them. The success of science learning achievements of a student is influenced by many factors. One of the factors that influence is, the lack of experimental learning or the introduction of tools about the material presented (Susda et al., 2018). This is in accordance with the results of research by Bambang et al. (2010) carry out physics experiments in learning because of the limitations of tools, including the kinetic theory of gas. High School Physics Material about Gas Kinetic Theory according to 2013 Curriculum demands real experience from students in accordance with the four pillars of education from UNESCO namely learn to know, learn to do, learn to be, and learn to life together.

One of the facilities and infrastructures that have an important role in creating a conducive and effective learning atmosphere, especially during the teaching and learning process of physics subject matter The Kinetic Gas Theory takes place is the availability of Gas Kinetic Theory experimental tools and other supporting learning devices. Practical activities are a forum to be able to provide certainty or strengthen information, determine causal relationships, show symptoms, verify (concepts, theories, laws, formulas), develop process skills, help students to use scientific methods in solving problems and to carry out research on material Gas Kinetic Theory (Sutrisno, 2010).

The learning process of the kinetic theory of gas in high school that corresponds to its nature as a process, laboratory facilities must also be supported by adequate experimental devices and can be used as a good learning media. However, experimental equipment for kinetic gas theory can be used to construct concepts or theories as they should be still very limited (Putri, 2012). This is in accordance with the results of research by Jamaluddin (2015) and Suarman et al. (2018) which revealed that one of the factors causing a lack of practicum intensity was that the experimental devices in school laboratories were still inadequate very limited, including the material on the Kinetic Gas Theory. This was stated also by Mohamad et al., (2011) ang Nasir, et al. (2018) that most teachers in the field did not plan to conduct thermodynamic experiments (kinetic theory of gas) due to

lack of tools (50%), lack of experimental materials (21.43%), lack of funds (16, 67%), and lack of school management support (11.90%).

The lack of experimental equipment in schools is not a secret anymore. The limited funds channeled by the government to buy KIT Physics have caused physics teachers to teach as they are from the available facilities. As a result, the teacher tends to present the Gas Kinetic Theory material with traditional patterns (teacher- centered) by telling the teacher as the only source of information, this is considered by the teacher lack of time efficiency and the learning process is also less meaningful (meaningful learning). While the demands of learning, according to the 2013 curriculum are emphasizing learning approaches that are more innovative and student-centered. Physics learning emphasizes learning experiences for students which include both material and process so that there is a balance between conceptual and procedural abilities. Learning that is relevant to the signs as above is categorized in learning activities with an inquiry approach and should be carried out in scientific inquiry (scientific inquiry) to develop the ability to think, work and be scientific and communicate as an important aspect of life skills.

It is necessary to realize that the price of a set of thermodynamic practicum tools (in which there is also a Gas Kinetic Theory practicum) is quite expensive, which is Rp 2,925,000.00 (Phyedumedia, 2016). Therefore, researchers are interested in conducting research on the development of the Gas Kinetic Theory experimental device which can actually be developed at a relatively inexpensive cost because it can utilize used materials in the surrounding environment. However, in this paper, the objective of this study is to develop the Gas Kinetic Material High School Physics Theory learning device (experimental tool, RPP, LKPD) which is oriented towards a valid and practical Curriculum 2013.

2. Methodology

This research was conducted at PMIPA Physics Education Laboratory FKIP Universitas Riau starting from May 2017 to October 2017. The type of this research was development research, namely developing a learning device for the Physics Gas Kinetic Theory of High School Material consisting of Gas Kinetic Theory experiment tools, Learning Implementation Plans, 2013 curriculum oriented curriculum.

To achieve the objectives of the development research above, in this study, primary types of data were obtained directly. The primary data obtained are:

a. The data of logic validity from the SMA Physics Material Gas Kinetic Theory learning device based on the inquiry approach

oriented to the 2013 curriculum (Gas Kinetic Theory Experiment Tool, Learning Implementation Plan, and Student Worksheet) was developed. The instruments of logical validity were questionnaires and the parameters were a). Identity, b) Format of the matrix, c). Development Principle, d). Substance Component which was assessed by experts in the fields of material, pedagogics, learning media, and high school Physics learning (teacher) practitioners.

b. Empirical validity data was obtained of the 2013 curriculum-oriented high school physics gas kinetic theory learning device (Experimental Tool, RPP, LKPD). The instrument of empirical validity was the experimental tool of kinetic gas theory and its indications were the suitability of experimental results with theory.

c. Practicality data of the 2013 curriculum-oriented learning materials for the High School Kinetic Theory of Gas Physics (Gas Kinetic Theory Experiment Tool, Learning Implementation Plans, Student Worksheets) were developed from student questionnaires through the implementation of the Gas Kinetic Theory learning tool (Gas Kinetic Theory Experiment Tool, Learning Implementation Plan, Student Worksheet). The indicator is 1). Practical Tool for the Kinetic Theory of Gas based on the Inquiry approach. 2). Practical Practice of the Kinetic Gas Theory based on the Inquiry approach. 3) How teachers teach the Theory of Gas Kinetic based on the Inquiry approach. 4). Student Worksheet.

The process of developing the kinetic theory of gas learning materials for high school physics material on the 2013 curriculum-based inquiry approach consists of four stages, namely: 1) defining, at this stage the steps taken were the 2013 physics study curriculum analysis, front, and back-end analysis, analysis of students, assignments, concepts, and formulation of learning indicators. 2) designing, the steps taken were the compilation of tools, selection of media and initial design of learning devices (experimental tools, RPP, LKPD), 3) develop (develop) including device validation. Revision of draft I, simulation, revision of draft II, limited trial, analysis of trial results and 4) deployment (disseminate). However, the research can only be done in three stages (Zulirfan et al., 2018). Because the distribution phase requires a long time and a large number of sample schools.

The data needed in this study were collected by questionnaire techniques, experimental techniques and interview techniques. The questionnaire technique was used to capture the device validation data, practicality through student responses using the questionnaire. The experimental technique was used to determine the validity of empirical experiments. Interviews were used to strengthen the opinion of the validator regarding the devices developed (Ridzuan et al., 2017).

The obtained data were analyzed descriptively using statistic method. The decision-making criteria used the following provisions (Table 1):

Table 1. Criteria for Validity of Gas Kinetic Theory Learning Devices

No.	Validation Value Interval	Category validity
1	$1 \leq Va < 1{,}75$	Very invalid
2	$1{,}75 \leq Va < 2{,}5\ 3$	Invalid
3	$2{,}5 \leq Va < 3{,}25$	Valid
4	$3{,}25 \leq Va \leq 4$	Very valid

The criteria stated that the learning device has good criteria of validity if the minimum level of validity achieved is in a valid level. Especially for the Gas Kinetic Theory experimental tool, besides being validated by experts and users, empirical validity was also carried out by conducting experiments with tools developed and adapted to the physics concept. The criteria are shown in Table 2:

Table 2. Criteria Validity of the Gas Kinetic Theory Experiment Tool

No.	Validation Value Interval (%)	Category validity
1	$0{,}0 \leq Va < 25$	Very low
2	$25 \leq Va < 50$	Low
3	$50 \leq Va < 75$	High
4	$75 \leq Va \leq 100$	Very high

Determination of practicality was obtained from the responses of students after the implementation of classroom learning. The determination of the practicality level (P) of the Kinetic Theory Gas learning device for high school Physics material was used the equation of percentage of score obtained divided with maximum of score, and the criteria are given in the Table 3.

Table 3. Practical Criteria for the Kinetic Gas Theory Learning Tool

No.	Practicality Value Interval (%)	Practicality category
1	$0{,}00 \leq Va < 25$	Very Not Practical
2	$25 \leq Va < 50$	Not Practical
3	$50 \leq Va < 75$	Practical
4	$75 \leq Va \leq 100$	Very Practical

The criterion states that learning devices have a good degree of practicality if the minimum level achieved is practical.

3. Results and Discussion

The validity of the Gas Kinetic Theory Experiment Tool

Logical validity is done through content validity and constructs of the developed Gas Kinetic Theory experimental tool. It was validated by 3 physics education experts and 2 high school physics teachers as users. For empirical validity was done by taking the experimental data about the basic laws of thermodynamics that can be obtained through these tools (Boyle's Law, Gay Lussac's Law, Charles's Law, and Boyle Gay Lussac's Law). The results of logic and empirical validation can be seen in Table 4 and Table 5.
Table 4. Results of Logic Validation Experiment of Gas Kinetic Theory

Table 4. Results of Logic Validation Experiment of Gas Kinetic Theory

No	Type of Experiment	Validator					Average	Category
		I	II	III	IV	V		
1	Boyle's Law	3,40	3,40	3,50	3,60	3,50	3,47	Very Valid
2	Gay Lussac's	3,40	3,40	3,70	3,60	3,40	3,50	Very Valid
3	Charles's Law	3,40	3,40	3,70	3,60	3,40	3,50	Very Valid
4	Boyle Gay	3,33	3,33	3.60	3.30	3,20	3,40	Very Valid
	Average	3,38	3,38	3,63	3.53	3,38	3,47	Very Valid
	Category	S V	S V	SV	SV	SV		

The data obtained from Table 4. shows that the Gas Kinetic Theory experimental tool gave the results that this tool has validity in very valid categories. Logical validation is done only once because the results of validation I of all validators have given a valid and very valid score. To reassure the validity of the developed Gas Kinetic Theory experimental tool, empirical tests for each of the basic laws of the Kinetic Gas Theory, repetition of each experiment was carried out 3 times and data was obtained as shown in the Table 5:

Table 5. Empirical test results for Gas Kinetic Theory Experiments

No.	Type of Experiment	Average Trust Rate Test Results (%)	Average
1	Boyle's Law	98,76	Very valid
2	Gay Lussac's Law	98,76	Very valid
3.	Charles's Law	98,25	Very valid
4.	Boyle-Gay Lussac's Law	97,71	Very valid
	Average (%)	98,37	Very valid

Based on the results of empirical tests, it has an average of 98.37% including in a very valid category. Based on the two methods above both logical and empirical validity, it can be stated that the Gas Kinetic Theory developed experimental tools have valid validity categories.

The validity of the Learning Implementation Plan (RPP)

The results of the validation analysis can be seen in Table 6

Table 6. RPP validity result of the Gas Kinetic Theory

No	Assessment Aspect	Validator					Average	Category
		I	II	III	IV	V		
1	RPP identity	4	4	4	4	4	4	Very Valid
2	RPP Component Matrix	4	4	4	4	4	4	Very Valid
3	Inquiry Approach	3,67	3,67	4	3,5	3,33	3,63	Very Valid
4	Principles of RPP Development	3,67	3,33	3	3,67	3	3,33	Very Valid
5	Substance of RPP Components	3,8	4	3,6	4	3	3,68	Very Valid
	Average	3,83	3,8	3,72	3,83	3,47	3,73	Very Valid

The data in Table 6 shows that the Kinetic Theory RPP Gas High School Physics material based on inquiry-oriented approaches 2013 Curriculum was developed with very valid both by experts and practitioners. This means that the RPP developed is suitable for the use by teachers in learning of high school physics.

Validity of Student Worksheet (LKPD) with Inquiry Approach base

The results of the LKPD analysis can be seen in Table 7:

Table 7. Validity of LKPD Gas Kinetic Theory with Inquiry Approach base

No.	Aspek Penilaian	Validator					Average	Category
		I	II	III	IV	V		
1	LKPD I	3,3	3,1	3,1	3,6	3,4	3,3	Very valid
2	LKPD II	3,4	3,4	3,5	3,6	3,4	3,5	Very valid
3	LKPD III	3,5	3,6	3,6	3,6	3,4	3,5	Very valid
4	LKPD IV	3,6	3,6	3,6	3,6	3,4	3,6	Very valid
5	LKPD V	3,7	3,8	3,3	3,6	3,4	3,6	Very valid
	Average	3,5	3,5	3,4	3,6	3,4	3,5	Very valid

Based on the data analysis shown in Table 7, it shows that the Student Workload that was developed provides an average index of 3.5 in the validity category. The lowest validity is in the Student Workload one, namely the span of Boyle's Law.

The practicality of the Kinetic Gas Theory Learning Tool Based

Determination of the practicality of Learning Devices was conducted by distributing questionnaires to students who were the subjects in this study, (class XI IPA3 SMAN 4 Pekanbaru) by asking for their responses about learning tools that had been developed after learning using a device these includes a) Gas Kinetic Theory practicum tool based on inquiry approach, b) Student Worksheet, c) Gas Kinetic Theory practicum activity based on

inquiry approach, and d) How teachers teach Gas Kinetic Theory practice based on inquiry approach. The results of student responses can be seen in Table 8.

Table 8 Practicalities of Gas Kinetic Theory Learning Devices

No	Assessment Aspect	Practicality Score (%)			Average (%)	Category
		Happy	New	Good		
1	Practical Tool for the Kinetic Gas Theory	100	67	83	83,3	Very Practical
2	LKPD	100	90	100	96,6	Very Practical
3	Practical Activities on the Kinetic Gas Theory	100	93	100	97,6	Very Practical
4	How Teachers Teach the Kinetic Theory of Gas	100	72	100	90,6	Very Practical
	Average	100	80,5	95,8	94,1	Very Practical

From the data analysis of the practicalities of the Gas Kinetic Theory learning tool based on the inquiry-oriented high school curriculum in 2013, the results were 94.1% with very practical categories. This means that the device developed is practically used in high school Physics learning based on the 2013 curriculum on the kinetic theory of gas.

The results of the validity analysis obtained from the Gas Kinetic Theory Experiment developed is in a very valid category, meaning that this tool can be used as an experimental tool for material about Boyle's Law, Gay Lussac's Law, Charles's Law and Boyle's Law - Gay Lussac. The advantages of the experimental tools for the Kinetic Gas Theory developed are:

1. The tool has been established to be used as a practical tool because the validity level is very valid.
2. The tool can show variables significantly in each change that occurs.
3. The design of the tool is good and easy to understand.

The suggestion was given for repairing the tools before being tested to school is as follows:

1. Add a lock to hold the pump so that it is not held down manually by avoiding inaccurate data.
2. Static should be elevated a little bit to make it easier when pouring or removing water from the vessel.
3. Add a cold water box to lower the Erlenmeyer tube.
4. Need to be careful of the piston (pump) to avoid leakage because it should be made as effective as possible.
5. The connecting hose is more suitable for its size so that there is no gas leak.

Before going down to the field to do a trial in learning, all of the suggestions given by the validator have been improved. So, the observation data is more accurate and has a high precision.

The learning implementation plan developed has an average validity in a very valid category. This means that the implementation plan of learning developed is very feasible to be used by the teacher in physics learning for the material of the Kinetic Gas Theory (Zulhelmi et al., 2017). The suggestions given by the validator for the perfection of the learning implementation plan are:

1. Determining the formulation of the problem there are several that need to be detailed.
2. Clarify the form of science and technology that can be integrated in this Learning Implementation Plan.
3. Describe the assessment score.
4. Clarify the form of remedial activity.
5. Learning activities are developed to be more evenly distributed throughout the students
6. Give additional information about the symbol of physical formulas that exist in the subject matter for example p for pressure, V for volume and others.

Student Worksheets developed in this study were 5 pieces. The validation results of the Student Worksheet on average are 3.5 in a very valid category. This shows that the Student Worksheets developed are suitable for the use in physics learning in the material of Gas Kinetic Theory based on the Inquiry approach. The input from the validator for the perfection of the Student Worksheet are:

1. It should be avoided to make reference to the Student Worksheet using the words 'above', 'below' etc., but directly drawings ... or Tables ...
2. Images in Student Worksheet 01 for the formulation of the problem are corrected because it is not right and causes students to be difficult to form a hypothesis.
3. Give direction to the problem in the Student Worksheet 04 so that students easily formulate problems.

The results of data analysis on practicality based on the responses of students after carrying out the learning material on the Gas Kinetic Theory based on the 2013 high school curriculum oriented inquiry approach were 94.1% in the very practical category. This shows that the learning carried out using the tools developed was felt by the students to be fun, new, both the guidance and direction given were clear and 100% of the students stated that there were benefits. The responses given by students are:

1. Save time understanding and mastering the material being studied.
2. The lesson is very clear and interested in learning it.

3. Student Worksheets are good and have additional knowledge.
4. Learning with the inquiry approach is very good
5. Know more about applying the kinetic theory of gas in everyday life.

The response given by students to the learning of Gas Kinetic Theory based on inquiry approach should need to provide a theoretical explanation before carrying out the practicum, and it should be ensured that all tools can function properly, because at the time of practicing there was one tool that was not good in the previous can function well and so is the availability of ice must be guaranteed enough. Students also want that during the whole lab they can try to retrieve the experimental data, because in the group there are some students who like to dominate the practicum. For this reason, supervision from the teacher during practicum guidance is more on tightening again. Students also expect to have time to clean up both the concept and the count questions.

Based on interviews conducted with high school Physics teachers who acted as validators regarding the devices developed, responses were obtained:

1. The learning device developed (Gas Kinetic Theory Experiment Tool, Learning Implementation Plan, Student Worksheet) can be used in learning Physics on the kinetic theory of gas.
2. The Kinetic Gas Theory experiment tool has been able to show results for the basic laws of the Kinetic Gas Theory according to the inquiry approach.
3. The kinetic theory of gas learning tool has the potential to improve understanding, reasoning, activity, creativity and learning motivation of students.

4. Conclusion

The Validity of Learning devices in Gas Kinetic Theory of High School Physics Materials based on inquiry approaches oriented 2013 curriculum has a validity level in very valid categories. While, the practicality of the devices has a practical level in a very practical category. Based on the conclusions, it can be stated that the devices are worthy of being used in physics learning in high school. The results of this study illustrate that a teacher should have high creativity, activity and dedication so that the class learning is more meaningful.

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