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Developing Computer Program as a Learning Resource on Gas Law Topics for High School Students

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The research aims to: (1) produce a computer program as a learning resource on gas law topics; (2) determine the appropriateness and quality of the computer program; and (3) describe the effectiveness of the computer program to help students in learning the concept of gas law. We employed 4D (define, design, develop, disseminate) models in this research. The computer program is validated by physics expert, learning media expert, and physics teachers. The appropriateness and quality of the computer program were analyzed descriptively. The field testing involved a small group consists of 4 students and a larger group consists of 61 students. The effectiveness of the computer program in improving students' learning achievement was investigated through one group pretest and posttest design. The results of this study showed that the computer program is feasible for high school physics learning. Based on the assessment by physics experts, learning media experts and high school physics teachers, the quality of computer program can be categorized as very good. Normalized gains from the conducted pretest and posttest to small and larger group are found as 0.68 and 0.55, respectively. It indicates that there is medium improvement of students' learning achievement after using the computer program as a learning resource.

Keywords: computer-based learning resource, gas law, high school physics, learning resource, developing computer program

INTRODUCTION

In some occasions carrying experiment or practical work in science course is difficult. It is due to complexity of instruments, limited time that teachers have, difficulty of class

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management during the experiment etc. On the other hand, practical work is important in science course (Barrie et al., 2015). High-quality laboratory develops many skills such as data processing, and analysis, observation, interpretation, problem solving, critical thinking skills, scientific reasoning, communication, presentation, ethical and professional behavior, and teamwork (Schmid & Read, 2010). Laboratory work also has goas such as to encourage accurate observation and description, to make scientific phenomena more real, to enhance understanding of scientific ideas, to arouse and maintain interest, to promote a scientific method of thought (Hofstein, 2017). Although in some cases, carrying real experiment activity in the classroom is difficult, adapting experiment activity in the computer program is possible (Rutten, Van Joolingen, & Van Der Veen, 2012; Supurwoko et al., 2017).

The impressive development of computer technology gives rise to the use of computer in learning process (De Witte, Haelermans, & Rogge, 2015; Kleij, Feskens, & Eggen, 2015; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Computer assisted learning in science education have also been studied widely (Rutten, Veen, & Joolingen, 2015; Smetana & Bell, 2012; Tsai & Chou, 2002). Some researches indicate that students' achievement increases with the use of computer in science education (Erdoğan & Dede, 2015; Powell, Aeby, & Carpenter-Aeby, 2003). Moreover, the use of computer in learning science may support abstract reasoning abilities (Chang, Chen, Lin, & Sung, 2008).

Enormous number of physics education software arises, such as: tools for the acquisition and manipulation of data, multimedia software, micro worlds and simulation, modeling tools, telematics and internet tools. Simulations are programs that contain models of physical process and display visualization of them. Simulations can encourage students to explore the physical system, set physical parameter, manipulate physical quantity and observe the result of the manipulation. Simulations provide students with opportunity to develop their understanding about the physical phenomena and laws through the hypothesis making and idea testing. Simulations also allow students to manipulate parameters and investigate the phenomena that would not be possible to experience in a classroom or even in laboratory (Rutten et al., 2012).

Experiment to investigate gas law is not easy to be carried in the classroom. It is still possible to be conducted through lab activities. However, not every school has apparatus to conduct this experiment. Moreover, gas law is related to the concept of kinetic theory of gas. In kinetic theory of gas, there are many concepts about microscopic things which are difficult to be observed directly (Niaz, 2000). In this case, computer-based media can provide experimental simulation and microscopic visualization of gas which may become an alternative way to do virtual experiment. Computer based media may help students in understanding the concepts of gas law and theory of kinetic gas.

In addition, sometimes students need to do individual learning activity outside the class. For some students, the regular class time may be not enough to deeply understand the physical concepts. Some students probably miss some concepts in the class so they need self-recitation. Therefore, students also need a learning resource that can accommodate them to do individual learning activity by themselves.

In Indonesia, computer has been integrated in science learning. Researchers and science teachers have tried to use computer assisted learning in science class. Some of them used the existed program such as PhET (Saputra, Nur, & Purnomo, 2016; Wartono & Batlolona, 2018), some of them have tried to develop their own program (Gunawan, Harjono, & Sutrio, 2015; Wulandari, Dewi, & Akhlis, 2013). Related to the topics of gas law, there is computer program developed such as virtual reality modelling language (VRML) in kinetic theory of gas (Wartono & Batlolona, 2018). The computer program has been validated and tested to students, however the field testing did not evaluate the impact of those programs on learning process. Moreover, the programs are not specifically designed for individual learning purpose on gas law topics.

This study aims to develop a computer program as a learning resource on gas law topics that can be used as both a learning media support in class and individual learning resource outside the class. Even though there are existing learning resources to support students in learning gas law in Indonesia, so far, we could not find comprehensive learning resource that provide complete features which are appropriate for individual learning purpose. Our developed computer programs are accompanied by simulation, concepts explanation and application with video and animation, problem exercise, and quiz. Other than that, the computer program was developed in bilingual i.e. Indonesian and English to support bilingual learning for students who need it. To face the global era, promoting bilingual study in Indonesia is also necessary, but the number of learning resources to support it is still limited. In this research, the appropriateness and quality of the computer program were determined. The effectiveness of the computer program to help students in learning the concept of gas law was also investigated through field testing.

METHOD

Research Design

In this study, we adapted research and development method within 4D models (Thiagarajan, Sammel, & Melvyn, 1974). The 4D model consists of 4 main stages, i.e. define, design, develop, and disseminate. In the define stage, we did need analysis, task and concept analysis. The need analysis is done by observation in class and interview with several physics teachers. The task and concept analysis were done by matching the material with the physics curricula in Indonesia. Based on some analysis in the define stage, we designed the computer program with Adobe Flash CS4 software (Adobe, 2009). The design stage results the prototype of computer program that is ready for develop stage through several evaluation and testing.

The develop stage is initiated by experts' appraisal. An expert in physics (thermodynamic and statistical mechanics) and an expert in computer-based learning media evaluated the computer program. Evaluation was also done by three high school physics teachers. The evaluation result from experts and high school physics teachers became consideration for computer program revision.

After experts' appraisal and evaluation from physics teachers, the computer media was tested by high school students. The preliminary testing was done to a smaller group consisting of 4 students. The students' response in the preliminary testing was used as a consideration for the improvement of computer program. After several revisions, the computer program was tested to a larger group consist of 64 high school students. We used one group pretest and posttest design in the field testing. Finally, from the field testing in the larger group of students, students gave response to the computer program that they used. The responses were used as consideration for the final revision. The final version of computer program was distributed in some schools.

Research Instrument

The quality of the computer program was determined through experts' appraisal, teachers' evaluation and students' response. The instruments used for gathering experts' appraisal, teachers' evaluation and students' response were questionnaires. The questionnaire was developed using Likert scale (1-5). The questionnaires for evaluation by material experts cover three aspects, i.e. instructional, context (material), and languages. The questionnaires for evaluation by learning media experts cover two aspects, i.e. layout and accessibility. The questionnaire for evaluation by physics teachers cover four aspects, i.e. instructional, context/material, language, accessibility, and layout.

The students' responses were gathered through "yes" or "no" checklist. The checklist contains several statements which actually gathered the students' response about fitness for individual learning purpose, usefulness, layout, language, and accessibility.

The effectiveness of the computer program to help students in learning the concept of gas law was determined by comparing the pretest and posttest result. The students were given a pretest before they used the computer program as a learning resource. After they studied using the computer program, they were given posttest. The pretest and posttest consist of 15 items to assess the students' conceptual understanding on gas law topics. The items were contextually and constructively validated by our colleagues who are expert in thermodynamics and in physics education.

Technique of Data Analysis

In this study, we used descriptive technique in the data analysis. The evaluation scores of computer program quality given by the experts and physics teachers through questionnaires were averaged. The average scores of each aspect were classified into appropriateness level based on the criteria in Table 1. Eko Putro Widoyoko makes a classification with comparison to the ideal average score (X_i) and the ideal standard deviation score (SDi) as basis. The qualification level is divided into five categories with criteria as in Table 1 (Eko Putro Widoyoko, 2016).

Table 1
Conversion of Actual Average Score to Qualitative Criteria (5 Scale)

No	Score	Score Interval	Criteria
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	Very Good
2	$\overline{X}_i + 0.6SDi < \overline{X} \leq \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \leq 4.2$	Good
3	$\overline{X}_i - 0.6SDi < \overline{X} \leq \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \leq 3.4$	Fair
4	$\overline{X}_i - 1.8SDi < \overline{X} \leq \overline{X}_i - 0.6SDi$	$1.8 < \overline{X} \leq 2.6$	Poor
5	$\overline{X} \leq \overline{X}_i - 1.8SDi$	$\overline{X} \leq 1.8$	Very Poor

$\overline{X}$: average score of each aspect
$\overline{X}_i$: 1/2 (maximum ideal score + minimum ideal score)
SDi = 1/6 (maximum ideal score - minimum ideal score)

The students' response to computer program was gathered through "yes" or "no" checklist (dichotomous scale). The "yes" or "no" answer were converted into numerical data; the conversion is given in Table 2. After conversion, the numerical data were averaged and interpreted according the criteria in Table 3.

Table 2
Conversion of Students' Answer into Numerical Data

Answer	Score for Positive Statement	Score for Negative Statement
Yes	1	0
No	0	1

Table 3
Conversion of Actual Average Score to Qualitative Criteria (dichotomous scale)

No	Score	Score Interval	Criteria
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	Very Good
2	$\overline{X}_i + 0.6SDi < \overline{X} \leq \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \leq 4.2$	Good
3	$\overline{X}_i - 0.6SDi < \overline{X} \leq \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \leq 3.4$	Fair
4	$\overline{X}_i - 1.8SDi < \overline{X} \leq \overline{X}_i - 0.6SDi$	$1.8 < \overline{X} \leq 2.6$	Poor
5	$\overline{X} \leq \overline{X}_i - 1.8SDi$	$\overline{X} \leq 1.8$	Very Poor

$\overline{X}$: average score of each aspect

The effectiveness of the computer program to help students in learning the concept of gas law were investigated. Pre-test and post-test were conducted before and after students used the learning resource for individual learning activity. We used one group pre-test and post-test design in this research and then analyze the normalized gain score using equation (1). In formula (1), %post-test score denotes the score of post-test in percent, %pre-test score denotes the score of pre-test in percent, while g is the normalized gain score (Hake, 1998). The gain score indicates how significant the improvement of the students' conceptual understanding is. The criteria are given in Table 4.

$$g = \frac{\%posttest\ score - \%pretest\ score}{100 - \%pretest\ score} \quad (1)$$

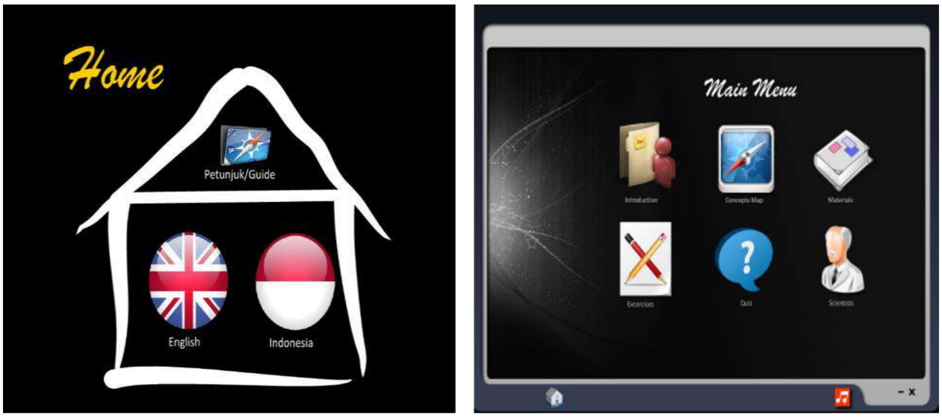
Table 4
The Criteria of Gain Score (*g*) (Hake, 1998)

g	Criteria
$g > 0,7$	High
$0,3 < g \leq 0,7$	Medium
$g \leq 0,3$	Low

FINDINGS

The Feature of the Learning Resource

The learning resource consists of some features such as material, simulation of experiments, exercise, quiz, and scientists' biography. The features contained in this learning resource are presented in the home page of the computer program, as shown in Figure 1. Material contains introduction to physical concepts, concepts' explanation, basic mathematical derivation, and some examples of related physical phenomena. The material is accompanied by videos and animation.



(a) (b)

Figure 1
The layout of (a) home page and (b) main menu. This learning resource is available in both English and Indonesian.

This learning resource also includes simulation of ideal gas experiments. As the experiments are not always easy to be carried out in the physics class, we developed some simulations that may become an alternative to substitute hands-on experiments.

Students are guided to find the relationship between pressure and temperature (*P-T*), volume and temperature (*V-T*), and pressure and volume (*P-V*) in ideal gas system through the simulation. Students have to present their result in a graph form and interpret the result. The activity in the simulation can be used in both ordinary class and individual learning activity outside ordinary class. In an ordinary traditional class, teacher will be the facilitator who guides students to gather data, analyze, and present the result. However, the learning resource still can be used in individual learning activity where there is no instructor because the learning resource provides detail guides from taking the data to interpreting the data (see Figure 2).

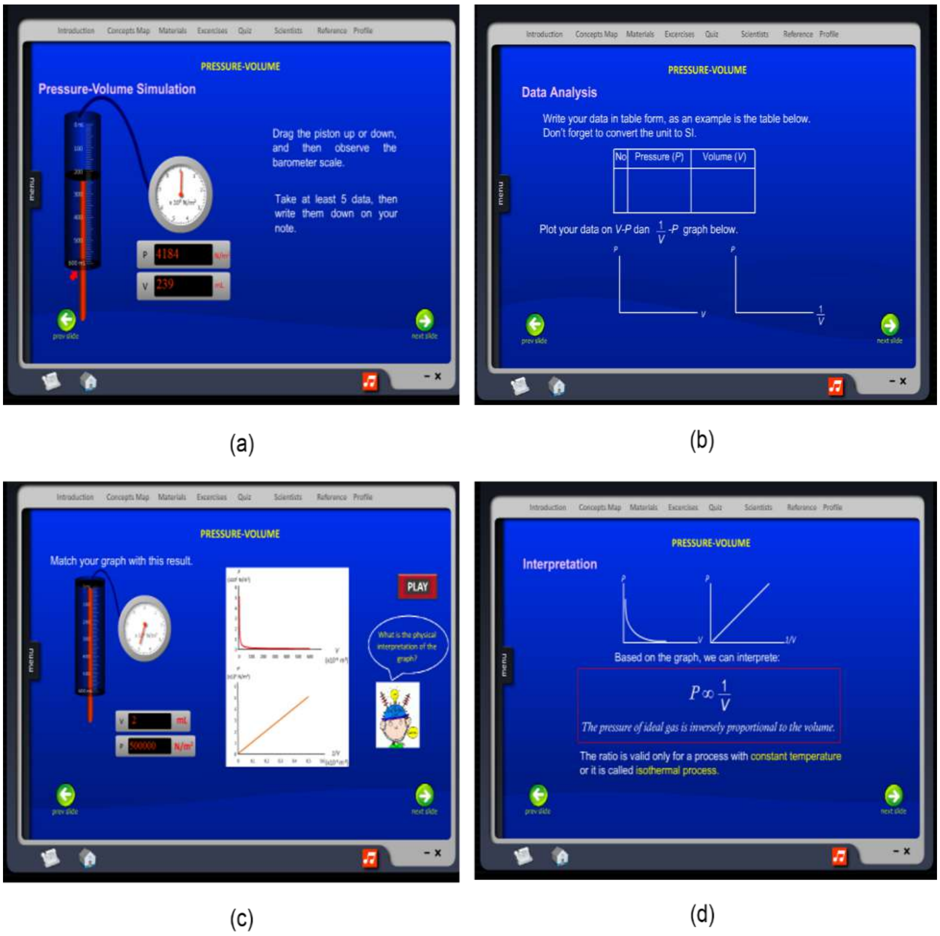
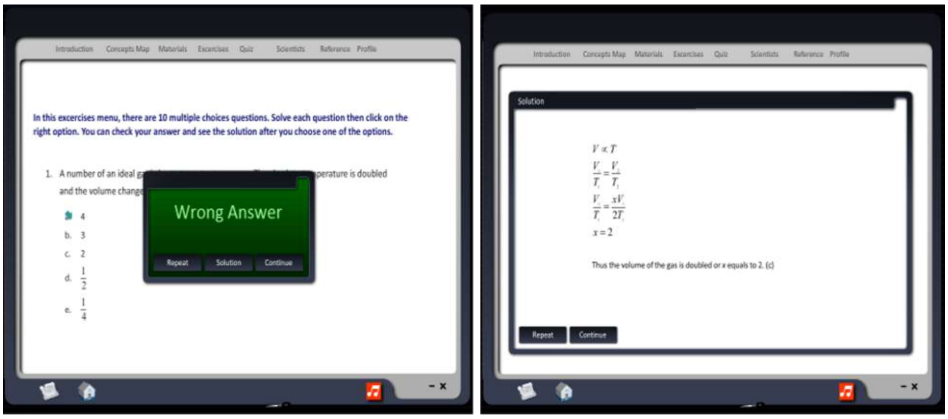


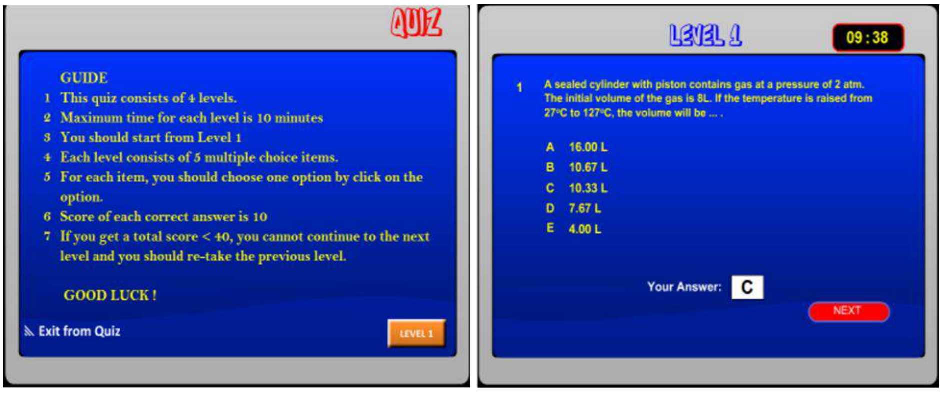
Figure 2
Simulation of *P-V* relationship. The simulation contains some activities such as (a) data collecting, (b) data analysis, (c) confirmation of result through automatic simulation, and (d) interpretation of result.

Besides *P-V-T* relationship in ideal gas, simulation of root-mean-squared (rms) speed of gas molecules is also provided. The simulation shows the relation between temperature, relative mass, and rms speed of gas molecules, the simulation is adopted from PhET (PhET, 2018). The relationship between some quantities in kinetic theory of gas is derived mathematically with a simple assumption. This explanation aims to give the students a comprehensive understanding from theoretical point of view and experimental result.



(a) (b)

Figure 3
The layout of Exercises Menu. (a) Problem given in the Exercises. (b) The problem solutions.



(a) (b)

Figure 4
The layout of Quiz Menu. (a) The Guidelines. (b) Problem displayed in Quiz, there are 5 randomly displayed questions in each level and students must answer them within 10 minutes.

Exercise allows students to apply some concepts that have been studied in the material to solve some problems. In the exercise, the solutions of each problem are provided; one of examples is given in Figure 3. Move up to the next level, students can do Quiz, as shown in Figure 4, to evaluate their study by themselves. The Quiz is constructed from 4 levels with different difficulties of problems. Students have to pass ≥80% score if they want to go the next level. The questions of each level are always randomly changed if students restart the quiz.

Figure 5 shows the last feature of this learning resource, scientists' biography. The biography of some physicists who worked on the experimental and theoretical studies related to ideal gas and kinetic theory of gas is presented. This feature aims to motivate students for further studies.

Figure 5
Short biography of scientist who worked on gas law and theory kinetic gas is also included.

Developmental Testing of the Learning Resource

The learning resource has been validated through expert appraisal and tested to senior high school students. We also asked some teachers to use this learning resource and fill a questionnaire to evaluate the computer program. Overall, teachers agreed that this computer program is potentially can be used by students as their individual learning resources on ideal gas and theory of kinetic gas material. The learning resource was revised based on some advices from experts and physics teachers before being directly tested to students.

We did initial field testing to a small group consists of 4 students. To measure students' initial knowledge of gas law, a pre-test was given to students. After that, students learnt the material by themselves using the learning resource that we have developed. A post-test was given to them to measure their final understanding on the material after they used the learning resource. Using equation (1), the results of pre- and post-test were analyzed to yield the normalized gain-score. The average gain score from the first field testing was 0.68, which is categorized as medium gain (Hake, 1998). At the end of the session they also filled the checklist about their opinion of the quality and usability of the learning resource.

We received some advices from this initial field testing and thus we did a minor revision on the learning resource. We did the second field testing to a bigger group of students. On this field testing, there were 61 students from two schools. Similarly, we conducted pre- and post-test to students before and after they used the learning resource to study the material by themselves. The average gain score from the second field testing was found as 0.55, which is categorized as medium gain (Hake, 1998). Table 3 shows the average of pre- and post-test score and gain score.

Table 3
The Comparison of Pre- and Post-Test Score and the Gain

Group	Average pre-test score (out of 100)	Average post-test score (out of 100)	Average gain score (g_{av}) *	Criteria
Smaller group (4 students)	38.33	80.00	0.68	Medium
Bigger group (61 students)	41.99	73.87	0.55	Medium

*Average gain score is calculated by averaging each individual gain scores in the group.

After each field testing, we gave students some checklist to know their opinions about the quality and usability of the learning resource. The final results are summarized in Table 4. Overall, most of students from the initial field testing (smaller group) and second field testing (bigger group) agreed that the fitness of learning resource for individual learning activity, the usefulness of the learning resource to learn ideal gas and theory kinetic gas, layout quality, language quality, and accessibility of the learning resource are very good.

Table 4
Students' Response on Checklist about the Quality and Usability of the Learning Resource

Aspects	Smaller Group		Bigger Group	
	Average Score	Criteria	Average Score	Criteria
The fitness for individual learning purpose	0.94	Very Good	0.86	Very Good
The usefulness of to learn ideal gas and theory kinetic gas	0.94	Very Good	0.90	Very Good
Layout quality	0.81	Very Good	0.88	Very Good
Language quality	0.94	Very Good	0.85	Very Good
Accessibility	0.94	Very Good	0.86	Very Good

We found there is significant improvement of students' cognitive achievement after students learned individually using the developed computer program. Both preliminary field testing and main field testing showed medium gain score of pre- and post-test result. Our developed computer program mainly consists of simulation of experiment and concept explanation which accompanied with video and animation to engage students and show the example of concept application in daily life. Our finding is consistent with previous studies which showed that physics simulation based learning give good impact on learning results (Jimoyiannis & Komis, 2001; Srisawasdi & Panjaburee, 2015; Syaifulloh & Jatmiko, 2014).

Simulation of experiment and concept animation helps students to learn abstract concept such as kinetic theory of gas which included in the gas law topics. Other than that, guided simulation of experiments developed in our program has the potential to improve students' ability on data processing and graph interpretation. If we looked at the details, we found that in the post-test, the number of students who gave correct answer about problems related to data processing and graph interpretation is higher than in the pre-test.

In this study we have investigated the impact of using the developed computer program in the students' learning results in gas law topics. However, this study is limited to the investigation on cognitive learning result only. We believe that more comprehensive investigation on other domains such as affective domain is also required.

CONCLUSION

A study has been conducted to develop computer based individual learning resources on the material of gas law. The learning resource has been tested to groups of students. Based on the gain score analysis, the learning resource is potentially can be used to improve students' understanding on gas law effectively. Students' response on the usability and quality of the learning resource in overall can be categorized as very good. Still, the study still has limitation since we only evaluated the learning result on cognitive domain. For further study, comprehensive investigation on other domains such as affective domain is also required.

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Submit Article	
First name	Elisabeth
Last name	Pratidhina
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Your email:	elisa.founda@ukwms.ac.id
Scope of the Article:	educational technology
Article subject	physics education
Add article (doc, docx)	20181018151431_Pratidhina_et_al_Developing_Computer_Program_as_Learning_Resource_on_Gas_Law_Topics_for_High_School_Students_IJI.doc

Elisabeth Founda <elisa.founda@gmail.com> Wed, Oct 24, 2018 at 9:34 AM
To: iji@ogu.edu.tr

Dear IJI Editor,

Thank you for your consideration to accept our paper for further evaluation processes.

Regarding the publication fee. We agree to pay the publication fee if our paper is accepted for publication.

With sincere regards,

Elisabeth Pratidhina

[Quoted text hidden]
--
With sincere regards,

Elisabeth Pratidhina Founda Noviani

---

iji@ogu.edu.tr <iji@ogu.edu.tr> Sun, Oct 28, 2018 at 6:24 AM
To: Elisabeth Founda <elisa.founda@gmail.com>, elisa.founda@ukwms.ac.id

Dear author

We revised your article and sent it to reviewers. Thank you very much for your interest in IJI.

Sincerely yours,
Editorial
International Journal of Instruction

From: "Elisabeth Founda" <elisa.founda@gmail.com>
To: "iji" <iji@ogu.edu.tr>
Sent: Wednesday, October 24, 2018 5:34:48 AM
Subject: Re: your article
[Quoted text hidden]

Elisabeth Founda <elisa.founda@gmail.com>
To: iji@ogu.edu.tr

Mon, Nov 26, 2018 at 10:28 AM

Dear IJI editorial team,

I would like to ask how long the reviewing process will take?

Have the decision for my paper come out yet?

Thank you

[Quoted text hidden]

Gmail **Elisabeth Founda <elisa.founda@gmail.com>**

Amendments

3 messages

iji@ogu.edu.tr <iji@ogu.edu.tr> Wed, Nov 28, 2018 at 5:24 AM
To: elisa.founda@gmail.com, elisa.founda@ukwms.ac.id

Dear author

You have amendments from reviewers. Could you please amend **on attached file "Article 391018_for revision"** and send back your revised article and the list of explanations of the revisions done via e-mail (iji@ogu.edu.tr) as an attached file as soon as possible?

Note: Could you please confirm the receipt of this e-mail?

Sincerely yours,
Editorial
International Journal of Instruction

International Journal of Instruction
http://www.e-iji.net
-

5 attachments

IJI Article Evaluation Form 391018c.pdf
148K

IJI Article Evaluation Form 391018b.pdf
140K

IJI Article Evaluation Form 391018a.pdf
150K

Article 391018_a.doc
1943K

Article 391018_for revision.doc
1934K

Elisabeth Founda <elisa.founda@gmail.com> Wed, Nov 28, 2018 at 5:42 AM
To: iji@ogu.edu.tr

Dear Editors,

Thank fou for sending the review result. We will revise it and send it back to you as soon as possible.

[Quoted text hidden]

Elisabeth Founda <elisa.founda@gmail.com> Wed, Dec 12, 2018 at 1:51 PM
To: iji@ogu.edu.tr

Dear IJI Editor,

We have carefully read the reviewers' comments on our manuscript.
Here, we send the reply letter and revised manuscript.

We look forward the feedback from reviewers and editors to our revised manuscript.

Thank you
[Quoted text hidden]
--
With sincere regards,

Elisabeth Pratidhina Founda Noviani

---

2 attachments

REPPLY LETTER.docx
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Article 391018_for revision.doc
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International Journal of Instruction Article Evaluation Form

Mr. /Mrs.

It is to acknowledge you that the Executive Committee of *International Journal of Instruction* has decided that the article mentioned below would be reviewed by you. Thank you very much for your contributions.

October 27, 2018
Asım ARI
Editor in Chief

Name of the article: Developing Computer Program as Learning Resource on Gas Law Topics for High School Students

After reviewing the attached article, please read each item carefully and select the response that best reflects your opinion. To register your response, please **mark** or **type in** the appropriate block.

	Yes	Partially	No
Do you think the title is appropriate?	☐	☒	☐
Does the abstract summarize the article clearly and effectively?	☐	☒	☐
Are the objectives set clearly?	☒	☐	☐
Is the issue stated clearly?	☒	☐	☐
Is the literature review adequate?	☐	☐	☒
Is the design of the research appropriate, and the exemplary, if any, suitable?	☒	☐	☐
Is the methodology consistent with the practice?	☒	☐	☐
Are the findings expressed clearly?	☒	☐	☐
Is the presentation of the findings adequate and consistent?	☒	☐	☐
Are the tables, if any, arranged well?	☒	☐	☐
Are the conclusions and generalizations based on the findings?	☒	☐	☐
Are the suggestions meaningful, valid, and based on the findings?	☐	☒	☐
Are the references adequate?	☐	☒	☐
Is the language clear and understandable?	☐	☒	☐
Is cohesion achieved throughout the article?	☒	☐	☐
Is the work contributing to the field?	☒	☐	☐

Evaluation:

☐ The article can be published as it is.
☒ The article can be published after some revision.
☐ The article must undergo a major revision before it can be resubmitted to the journal.
☐ The article cannot be published.

Would you like to see the revised article if you have suggested any revisions? ☒ Yes ☐ No

Please write your report either on the this paper or on a spare paper.

REPORT

The abstract be revised regarding the content and language. The table very detailed.

International Journal of Instruction Article Evaluation Form

Mr. /Mrs.

It is to acknowledge you that the Executive Committee of *International Journal of Instruction* has decided that the article mentioned below would be reviewed by you. Thank you very much for your contributions.

October 27, 2018
Asım ARI
Editor in Chief

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After reviewing the attached article, please read each item carefully and select the response that best reflects your opinion. To register your response, please **mark** or **type in** the appropriate block.

	Yes	Partially	No
Do you think the title is appropriate?	☒	☐	☐
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Is the issue stated clearly?	☐	☒	☐
Is the literature review adequate?	☐	☐	☒
Is the design of the research appropriate, and the exemplary, if any, suitable?	☐	☒	☐
Is the methodology consistent with the practice?	☐	☒	☐
Are the findings expressed clearly?	☒	☐	☐
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Are the tables, if any, arranged well?	☒	☐	☐
Are the conclusions and generalizations based on the findings?	☒	☐	☐
Are the suggestions meaningful, valid, and based on the findings?	☐	☐	☒
Are the references adequate?	☐	☐	☒
Is the language clear and understandable?	☒	☐	☐
Is cohesion achieved throughout the article?	☒	☐	☐
Is the work contributing to the field?	☒	☐	☐

Evaluation:

☐ The article can be published as it is.
☒ The article can be published after some revision.
☐ The article must undergo a major revision before it can be resubmitted to the journal.
☐ The article cannot be published.

Would you like to see the revised article if you have suggested any revisions? ☒ Yes ☐ No

Please write your report either on the this paper or on a spare paper.

REPORT

Abstract: The description of the problem should be summarized into a comprehensive paragraph. Abstract must also contain Research Objectives, Methods (development models used, validators, instruments, data analysis) Research Results, and concise conclusions. Keywords must be in alphabetical order (A to Z).

INTRODUCTION:
1. There are still many references that are not up to date. Supposedly, use the last 10 years reference and use primary reference (80%).
2.The introduction has not shown the state of the art prior research (previous literature

overview or theoretical concepts or various studies in related fields / themes in Indonesia), gap analysis statements, and research objectives statement. Author / s must convince readers that this is necessary.

METHODES:
Methods must be written in detail and appropriate / appropriate.
Is the model developed not validated by experts? How many people validate? how is the assessment, and who does it refer to? for qualitative data/information, how to analyze it? the information does not appear in the method.

If the model is tested on students, how many students are used? Where is the validation done?
4D model is not only developed by one person. Please read the source carefully.

FINDINGS AND DISCUSSION:
The discussion needs to be added with aspects: 1) the relationship between the results obtained and the basic concepts, 2) the suitability or contradiction with the results of other studies, 3) the direction of further research in this study (based on these results), and 4) the implications of both theoretical and application.

There should be 1-2 paragraphs that review interesting findings in this study and if possible novelty, which shows the contribution of this research to the development of science and technology, especially in learning / education.

CONCLUSION: It is very good if the author conveys the limitations in this study, which might affect the results and they cannot be met. This was then conveyed to the next researcher to be a consideration and concern.

REFERENCES: The reference used is appropriate, but there are still many references that are not up to date.

International Journal of Instruction Article Evaluation Form

Mr. /Mrs.

It is to acknowledge you that the Executive Committee of *International Journal of Instruction* has decided that the article mentioned below would be reviewed by you. Thank you very much for your contributions.

October 27, 2018
Asım ARI
Editor in Chief

Name of the article: Developing Computer Program as Learning Resource on Gas Law Topics for High School Students

After reviewing the attached article, please read each item carefully and select the response that best reflects your opinion. To register your response, please **mark** or **type in** the appropriate block.

	Yes	Partially	No
Do you think the title is appropriate?	☒	☐	☐
Does the abstract summarize the article clearly and effectively?	☐	☒	☐
Are the objectives set clearly?	☐	☒	☐
Is the issue stated clearly?	☐	☒	☐
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Is the methodology consistent with the practice?	☐	☐	☒
Are the findings expressed clearly?	☐	☒	☐
Is the presentation of the findings adequate and consistent?	☐	☐	☒
Are the tables, if any, arranged well?	☒	☐	☐
Are the conclusions and generalizations based on the findings?	☐	☒	☐
Are the suggestions meaningful, valid, and based on the findings?	☐	☒	☐
Are the references adequate?	☐	☐	☒
Is the language clear and understandable?	☐	☒	☐
Is cohesion achieved throughout the article?	☒	☐	☐
Is the work contributing to the field?	☐	☒	☐

Evaluation:
☐ The article can be published as it is.
☐ The article can be published after some revision.
☐ The article must undergo a major revision before it can be resubmitted to the journal.
☒ The article cannot be published.

Would you like to see the revised article if you have suggested any revisions? ☒ Yes ☐ No

Please write your report either on the this paper or on a spare paper.

REPORT

Unfortunately, this paper is not robust and should be rejected.
1.The gap of the study has not been well –presented. The authors need to show the focus of previous studies and highlight the major contribution to literature. They need to show how this program is different from the previous ones (if there are any) or if the program addresses the shortcomings of available programs.
2.There is no theory or framework in the study.
3.The methodology is not well- presented. This section is neither comprehensive nor well organized enough (research design, participants and sampling technique, data collection tools, their reliability and validity should be explained in detail).

4.The text is readable but needs proofreading in terms of language use, grammar, punctuation, and spelling.
5.The study needs to detail different implications of the developed program for teachers and policymakers and students. (For example, education investors who want to develop the learner autonomy of students, keep the low proficient students at school).

Reply to Reviewer #1 (391018a)

1. **Abstract**

Comment)

The description of the problem should be summarized into a comprehensive paragraph. Abstract must also contain Research Objectives, Methods (development models used, validators, instruments, data analysis) Research Results, and concise conclusions. Keywords must be in alphabetical order (A to Z).

Author Reply)

To address this issue, we have revised our abstract by including research objective, method, result and conclusion. The keywords were revised so that they are arranged in alphabetical order. The revised abstract become:

The research aims to: (1) produce a computer program as learning resource on gas law topics; (2) determine the appropriateness and quality of the computer program; and (3) describe the effectiveness of the computer program to help students in learning the concept of gas law. We employed 4D (define, design, develop, disseminate) models in this research. The computer program is validated by physics expert, learning media expert, and physics teachers. The appropriateness and quality of the computer program were analyzed descriptively. The field testing involved a small group consists of 4 students and a larger group consists of 61 students. The effectiveness of computer program in improving students' learning achievement was investigated through one group pretest and posttest design. The results of this study showed that the computer program is feasible for high school physics learning. Based on the assessment by physics experts, learning media experts and high school physics teachers, the quality of computer program can be categorized as very good. Normalized gain from the conducted pretest and posttest to small and larger group are 0.68 and 0.55, respectively. It indicates that there is medium improvement of students' learning achievement after using the computer program as learning resource.

Keywords: computer-based learning resource, gas law, high school physics

2. **INTRODUCTION**

Comment)

There are still many references that are not up to date. Supposedly, use the last 10 years reference and use primary reference (80%). The introduction has not shown the state of the art prior research (previous literature), overview or theoretical concepts or various studies in related fields / themes in Indonesia), gap analysis statements, and research objectives statement. Author / s must convince readers that this is necessary

Author Reply)

Regarding to the references, we have updated the references which we cite in the introduction. We also add previous study in Indonesia related to our result. We wrote the research objective in our original manuscript, but seems it was not clear. Thus, we have written a clear statement about the research objective and tried to convince readers that this study is necessary. To address the issue, in the manuscript we added sentences such as:

In Indonesia, computer has been integrated in science learning. Researchers and science teachers have tried to use computer assisted learning in science class. Some of them used the existed program such as PhET (Saputra, Nur, & Purnomo, 2016; Wartono & Batlolona, 2018), some of them have tried to develop their own program (Gunawan, Harjono, & Sutrio, 2015; Wulandari, Dewi, & Akhlis, 2013). Related to the topics of gas law, there is computer program developed such as virtual reality modelling language (VRML) in kinetic theory of gas (Wartono & Batlolona, 2018). The computer program has been validated and tested to students, however the field testing did not evaluate the impact of those programs on learning process. Moreover, the programs are not specifically designed for individual learning purpose on gas law topics.

This study aims to develop a computer program as learning resource on gas law topics that can be used as both support learning media in class and individual learning resource outside the class. Even though there are existing learning resources to support students in learning gas law in Indonesia, so far we could not find comprehensive learning resource that provide complete features which appropriate for individual learning purpose. Our developed computer programs are accompanied by simulation, concepts explanation and application with video and animation, problem exercise, and quiz. Other than that, the computer program was developed in bilingual i.e. Indonesian and English to support bilingual learning for students who need it. To face the global era, promoting bilingual study in Indonesia is also necessary, but the number of learning resources to support it is still limited. In this research, the appropriateness and quality of the computer program were determined. The effectiveness of the computer program to help students in learning the concept of gas law was also investigated through field testing.

3. METHOD

Comment)

Is the model developed not validated by experts? How many people validate? how is the assessment, and who does it refer to? for qualitative data/information, how to analyze it? the information does not appear in the method. If the model is tested on students, how many students are used? Where is the validation done? 4D model is not only developed by one person. Please read the source carefully

Author reply)

We revised the Method section to respond the reviewer comments about the model, validation, field testing, experts who validate the computer program, students who participate in the field testing process, instrument, and data analysis. The method section in the manuscript became:

In this study, we adapted research and development method within 4D models (Thiagarajan, Sammel, & Melvyn, 1974). The 4D model consists of 4 main stages, i.e. define, design, develop, and disseminate. In the define stage, we did need analysis, task and concept analysis. The need analysis is done by observation in class and interview with several physics teachers. The task and concept analysis were done by matching the material with the physics curricula in Indonesia. Based on some analysis in the define stage, we designed the computer program with Adobe Flash CS4 software (Adobe, 2009). The design stage results the prototype of computer program that is ready for developed through several evaluation and testing.

The develop stage is initiated by experts' appraisal. An expert in physics (thermodynamic and statistical mechanics) and an expert in computer-based learning media evaluated the computer program. Evaluation was also done by three high school physics teachers. The evaluation result from experts and high school physics teachers became consideration for computer program revision.

After experts' appraisal and evaluation from physics teachers, the computer media was tested to high school students. The preliminary testing was done to a smaller group consisting of 4 students. the students' response in the preliminary testing was used as a consideration for the improvement of computer program. after several revisions, the computer program was tested to a larger group consist of 64 high school students. We used one group pretest and posttest design in the field testing. Finally, from the field testing in the larger group of students, students give response to the computer program that they used. The response was used as consideration for the final revision. The final version of computer program was distributed in some schools.

Research Instrument

The quality of the computer program is determined through experts' appraisal, teachers' evaluation and students' response. The instruments used for gathering experts' appraisal, teachers' evaluation and students' response are questionnaires. the questionnaire was developed using Likert scale (1-5). The questionnaires for evaluation by material experts cover three aspects, i.e. instructional, context (material), and languages. The questionnaires for evaluation by learning media experts cover two aspects, i.e. layout and accessibility. The questionnaire for evaluation by physics teachers cover four aspects, i.e. instructional, context/material, language, accessibility, and layout.

The students' response is gathered through "yes" or "no" checklist. The checklist contains several statements which actually gathered the students' response about fitness for individual learning purpose, usefulness, layout, language, and accessibility.

The effectiveness of the computer program to help students in learning the concept of gas law is determined by comparing the pretest and posttest result. The students were given a pretest before they used the computer program as learning resource. After they studied using the computer program, they are given posttest. The pretest and posttest consist of 15 items to assess the students' conceptual understanding on gas law topics. The items were contextually and constructively validated by our colleagues who are expert in thermodynamics and in physics education.

Technique of Data Analysis

In this study, we used descriptive technique in the data analysis. The evaluation scores of computer program quality given by the experts and physics teachers through questionnaires were averaged. The average scores of each aspect were classified into appropriateness level based on the criteria in Table. Widoyoko (2011) makes a classification with comparison to the ideal average score (X_i) and the ideal standard deviation score (SDi) as basis. The qualification level is divided into five categories with criteria as in Table 1.

Table 1.

Conversion of Actual Average Score to Qualitative Criteria (5 Scale)

No	*Score*	*Score Interval*	*Criteria*
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	*Very Good*
2	$\overline{X}_i + 0.6SDi < \overline{X} \le \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \le 4.2$	*Good*
3	$\overline{X}_i - 0.6SDi < \overline{X} \le \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \le 3.4$	*Fair*

4	$\overline{X}_i - 1.8SDi < \overline{X} \le \overline{X}_i - 0.6SDi$	$1.8 < \overline{X} \le 2.6$	Poor
5	$\overline{X} \le \overline{X}_i - 1.8SDi$	$\overline{X} \le 1.8$	Very Poor

$\overline{X}$: *average score of each aspect*

The students' response to computer program is gathered through "yes" or "no" checklist (dichotomous scale). The "yes" or "no" answer were converted into numerical data; the conversion is given in Table 2. After conversion, the numerical data of were averaged and interpreted according the criteria in Table 3.

Table 2.

Conversion of students' answer into numerical data

Answer	Score for Positive Statement	Score for Negative Statement
Yes	1	0
No	0	1

Table 3.

Conversion of Actual Average Score to Qualitative Criteria (dichotomous scale)

No	Score	Score Interval	Criteria
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	Very Good
2	$\overline{X}_i + 0.6SDi < \overline{X} \le \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \le 4.2$	Good
3	$\overline{X}_i - 0.6SDi < \overline{X} \le \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \le 3.4$	Fair
4	$\overline{X}_i - 1.8SDi < \overline{X} \le \overline{X}_i - 0.6SDi$	$1.8 < \overline{X} \le 2.6$	Poor
5	$\overline{X} \le \overline{X}_i - 1.8SDi$	$\overline{X} \le 1.8$	Very Poor

$\overline{X}$: *average score of each aspect*

The effectiveness of the computer program to help students in learning the concept of gas law were investigated. Pre-test and post-test were conducted before and after students use the learning resource for individual learning activity. We used one group pretest and posttest design in this research and then analyze the normalized gain score using equation (1). In formula (1), %posttest score denotes the score of posttest in percent, %pretest score denotes the score of pretest in percent, while g is the normalized gain score (Hake, 1998). The gain score indicates how significant is the improvement of the students' conceptual understanding. The criteria are given in Table 4.

$$g = \frac{\%posttest\ score - \%pretest\ score}{100 - \%pretest\ score} \qquad (1)$$

Table 4

The Criteria of Gain Score (g) (Hake, 1998)

g	*Criteria*
g > 0,7	*High*
0,3 < g ≤ 0,7	*Medium*
g ≤ 0,3	*Low*

4. FINDINGS AND DISCUSSION:

Comment)

The discussion needs to be added with aspects: 1) the relationship between the results obtained and the basic concepts, 2) the suitability or contradiction with the results of other studies, 3) the direction of further research in this study (based on these results), and 4) the implications of both theoretical and application.
There should be 1-2 paragraphs that review interesting findings in this study and if possible novelty, which shows the contribution of this research to the development of science and technology, especially in learning / education.

Author Reply)

To address those issues, we added sentences in the manuscript such as:

We found there is significant improvement of students' cognitive achievement after students learned individually using the developed computer program. Both preliminary field testing and main field testing showed medium gain score of pre- and post-test result. Our developed computer program mainly consists of simulation of experiment and concept explanation which accompanied with video and animation to engage students and show the example of concept application in daily life. Our finding is consistent with previous studies which showed that physics simulation based learning give good impact on learning results (Jimoyiannis & Komis, 2001; Srisawasdi & Panjaburee, 2015; Syaifulloh & Jatmiko, 2014).

Simulation of experiment and concept animation helps students to learn abstract concept such as kinetic theory of gas which included in the gas law topics. Other than that, guided simulation of experiments developed in our program is potential to improve students' ability on data processing and graph interpretation. If we looked at the details, we found that in the post-test, the number of students who gave correct answer about problems related to data processing and graph interpretation is higher than in the pre-test.

In this studies we have investigated the impact of using the developed computer program in the students' learning results in gas law topics. However, this study is limited to the investigation on cognitive learning result only. We believe that more comprehensive investigation on other domain such as affective domain is also required.

5. CONCLUSION

Comment)

It is very good if the author conveys the limitations in this study, which might affect the results and they cannot be met. This was then conveyed to the next researcher to be a consideration and concern.

Author Reply)

To address those issues, we added sentences in the manuscript such as:

Still, the study still has limitation since we only evaluated the learning result on cognitive domain. For further study, comprehensive investigation on other domain such as affective domain is also required.

Reply to Reviewer #2 (391018b)

Comment)

The abstract be revised regarding the content and language. The table very detailed.

Author Reply)

To address this issue, we have revised our abstract by including research objective, method, result and conclusion. The keywords were revised so that they are arranged in alphabetical order. The revised abstract become:

The research aims to: (1) produce a computer program as learning resource on gas law topics; (2) determine the appropriateness and quality of the computer program; and (3) describe the effectiveness of the computer program to help students in learning the concept of gas law. We employed 4D (define, design, develop, disseminate) models in this research. The computer program is validated by physics expert, learning media expert, and physics teachers. The appropriateness and quality of the computer program were analyzed descriptively. The field testing involved a small group consists of 4 students and a larger group consists of 61 students. The effectiveness of computer program in improving students' learning achievement was investigated through one group pretest and posttest design. The results of this study showed that the computer program is feasible for high school physics learning. Based on the assessment by physics experts, learning media experts and high school physics teachers, the quality of computer program can be categorized as very good. Normalized gain from the conducted pretest and posttest to small and larger group are 0.68 and 0.55, respectively. It indicates that there is medium improvement of students' learning achievement after using the computer program as learning resource.

Keywords: computer-based learning resource, gas law, high school physics

Reply to Reviewer #3 (391018c)

Comment)

The gap of the study has not been well –presented. The authors need to show the focus of previous studies and highlight the major contribution to literature. They need to show how this program is different from the previous ones (if there are any) or if the program addresses the shortcomings of available programs.

Author reply)

To address the issue, in the introduction we added paragraph such as:

In Indonesia, computer has been integrated in science learning. Researchers and science teachers have tried to use computer assisted learning in science class. Some of them used the existed program such as PhET (Saputra, Nur, & Purnomo, 2016; Wartono & Batlolona, 2018), some of them have tried to develop their own program (Gunawan, Harjono, & Sutrio, 2015; Wulandari, Dewi, & Akhlis, 2013). Related to the topics of gas law, there is computer program developed such as virtual reality modelling language (VRML) in kinetic theory of gas (Wartono & Batlolona, 2018). The computer program has been validated and tested to students, however the field testing did not evaluate the impact of those programs on learning process. Moreover, the programs are not specifically designed for individual learning purpose on gas law topics.

This study aims to develop a computer program as learning resource on gas law topics that can be used as both support learning media in class and individual learning resource outside the class. Even though there are existing learning resources to support students in learning gas law in Indonesia, so far we could not find comprehensive learning resource that provide complete features which appropriate for individual learning purpose. Our developed computer programs are accompanied by simulation, concepts explanation and application with video and animation, problem exercise, and quiz. Other than that, the computer program was developed in bilingual i.e. Indonesian and English to support bilingual learning for students who need it. To face the global era, promoting bilingual study in Indonesia is also necessary, but the number of learning resources to support it is still limited.

Comment)

The methodology is not well- presented. This section is neither comprehensive nor well organized enough (research design, participants and sampling technique, data collection tools, their reliability and validity should be explained in detail).

Author reply)

To address the reviewer concern about the research design, participants and sampling technique, data collection
tools, and validity**, the method section has been revised to:**

In this study, we adapted research and development method within 4D models (Thiagarajan, Sammel, & Melvyn, 1974). The 4D model consists of 4 main stages, i.e. define, design, develop, and disseminate. In the define stage, we did need analysis, task and concept analysis. The need analysis is done by observation in class and interview with several physics teachers. The task and concept analysis were done by matching the material with the physics curricula in Indonesia. Based on some analysis in the define stage, we *designed the computer program with Adobe Flash CS4 software (Adobe, 2009). The design stage results the prototype of computer program that is ready for developed through several evaluation and testing.*

The develop stage is initiated by experts' appraisal. An expert in physics (thermodynamic and statistical mechanics) and an expert in computer-based learning media evaluated the computer program. Evaluation was also done by three high school physics teachers. The evaluation result from experts and high school physics teachers became consideration for computer program revision.

After experts' appraisal and evaluation from physics teachers, the computer media was tested to high school students. The preliminary testing was done to a smaller group consisting of 4 students. the students' response in the preliminary testing was used as a consideration for the improvement of computer program. after several revisions, the computer program was tested to a larger group consist of 64 high school students. We used one group pretest and posttest design in the field testing. Finally, from the field testing in the larger group of students, students give response to the computer program that they used. The response was used as consideration for the final revision. The final version of computer program was distributed in some schools.

Research Instrument

The quality of the computer program is determined through experts' appraisal, teachers' evaluation and students' response. The instruments used for gathering experts' appraisal, teachers' evaluation and students' response are questionnaires. the questionnaire was developed using Likert scale (1-5). The questionnaires for evaluation by material experts cover three aspects, i.e. instructional, context (material), and languages. The questionnaires for evaluation by learning media experts cover two aspects, i.e. layout and accessibility. The questionnaire for evaluation by physics teachers cover four aspects, i.e. instructional, context/material, language, accessibility, and layout.

The students' response is gathered through "yes" or "no" checklist. The checklist contains several statements which actually gathered the students' response about fitness for individual learning purpose, usefulness, layout, language, and accessibility.

The effectiveness of the computer program to help students in learning the concept of gas law is determined by comparing the pretest and posttest result. The students were given a pretest before they used the computer program as learning resource. After they studied using the computer program, they are given posttest. The pretest and posttest consist of 15 items to assess the students' conceptual understanding on gas law topics. The items were contextually and constructively validated by our colleagues who are expert in thermodynamics and in physics education.

Technique of Data Analysis

In this study, we used descriptive technique in the data analysis. The evaluation scores of computer program quality given by the experts and physics teachers through questionnaires were averaged. The average scores of each aspect were classified into appropriateness level based on the criteria in Table. Widoyoko (2011) makes a classification with comparison to the ideal average score (X_i) and the ideal standard deviation score (SDi) as basis. The qualification level is divided into five categories with criteria as in Table 1.

Table 1.

Conversion of Actual Average Score to Qualitative Criteria (5 Scale)

No	*Score*	*Score Interval*	*Criteria*
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	*Very Good*
2	$\overline{X}_i + 0.6SDi < \overline{X} \le \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \le 4.2$	*Good*
3	$\overline{X}_i - 0.6SDi < \overline{X} \le \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \le 3.4$	*Fair*
4	$\overline{X}_i - 1.8SDi < \overline{X} \le \overline{X}_i - 0.6SDi$	$1.8 < \overline{X} \le 2.6$	*Poor*
5	$\overline{X} \le \overline{X}_i - 1.8SDi$	$\overline{X} \le 1.8$	*Very Poor*

$\overline{X}$ *: average score of each aspect*

The students' response to computer program is gathered through "yes" or "no" checklist (dichotomous scale). The "yes" or "no" answer were converted into numerical data; the conversion is given in Table 2. After conversion, the numerical data of were averaged and interpreted according the criteria in Table 3.

Table 2.

Conversion of students' answer into numerical data

Answer	*Score for Positive Statement*	*Score for Negative Statement*
Yes	*1*	*0*
No	*0*	*1*

Table 3.

Conversion of Actual Average Score to Qualitative Criteria (dichotomous scale)

No	*Score*	*Score Interval*	*Criteria*
1	$\overline{X} > \overline{X}_i + 1.8SDi$	$\overline{X} > 4.2$	*Very Good*
2	$\overline{X}_i + 0.6SDi < \overline{X} \le \overline{X}_i + 1.8SDi$	$3.4 < \overline{X} \le 4.2$	*Good*
3	$\overline{X}_i - 0.6SDi < \overline{X} \le \overline{X}_i + 0.6SDi$	$2.6 < \overline{X} \le 3.4$	*Fair*
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5	$\overline{X} \le \overline{X}_i - 1.8SDi$	$\overline{X} \le 1.8$	*Very Poor*

$\overline{X}$ *: average score of each aspect*

The effectiveness of the computer program to help students in learning the concept of gas law were investigated. Pre-test and post-test were conducted before and after students use the learning resource for individual learning activity. We used one group pretest and posttest design in this research and then analyze the normalized gain score using equation (1). In formula (1), %posttest score denotes the score of posttest in percent, %pretest score denotes the score of pretest in percent, while g is the normalized gain score

(Hake, 1998). The gain score indicates how significant is the improvement of the students' conceptual understanding. The criteria are given in Table 4.

$$g = \frac{\%posttest\ score - \%pretest\ score}{100 - \%pretest\ score} \quad (1)$$

Table 4

The Criteria of Gain Score (g) (Hake, 1998)

g	*Criteria*
g > 0,7	*High*
0,3 < g ≤ 0,7	*Medium*
g ≤ 0,3	*Low*

Developing Computer Program as Learning Resource on Gas Law Topics for High School Students

The research aims to: (1) produce a computer program as learning resource on gas law topics; (2) determine the appropriateness and quality of the computer program; and (3) describe the effectiveness of the computer program to help students in learning the concept of gas law. We employed 4D (define, design, develop, disseminate) models in this research. The computer program is validated by physics expert, learning media expert, and physics teachers. The appropriateness and quality of the computer program were analyzed descriptively. The field testing involved a small group consists of 4 students and a larger group consists of 61 students. The effectiveness of computer program in improving students' learning achievement was investigated through one group pretest and posttest design. The results of this study showed that the computer program is feasible for high school physics learning. Based on the assessment by physics experts, learning media experts and high school physics teachers, the quality of computer program can be categorized as very good. Normalized gain from the conducted pretest and posttest to small and larger group are 0.68 and 0.55, respectively. It indicates that there is medium improvement of students' learning achievement after using the computer program as learning resource.

Keywords: computer-based learning resource, gas law, high school physics

INTRODUCTION

In some occasions carrying experiment or practical work in science course is difficult. It is due to complexity of instruments, limited time that teachers have, difficulty of class management during the experiment etc. On the other hand, practical work is important in science course (Barrie et al., 2015). High-quality laboratory develops many skills such as data processing, and analysis, observation, interpretation, problem solving, critical thinking skills, scientific reasoning, communication, presentation, ethical and professional behaviour, and teamwork (Schmid & Read, 2010). Laboratory work also has goas such as to encourage accurate observation and description, to make scientific phenomena more real, to enhance understanding of scientific ideas, to arouse and maintain interest, to promote a scientific method of thought (Hofstein, 2017). Although in some cases, carrying real experiment activity in the classroom is difficult, adapting experiment activity in the computer program is possible (Rutten, Van Joolingen, & Van Der Veen, 2012; Supurwoko et al., 2017).

The impressive development of computer technology gives rise to the use of computer in learning process (De Witte, Haelermans, & Rogge, 2015; Kleij, Feskens, & Eggen, 2015; Merchant, Goetz, Cifuentes, Keeney-Kennicutt, & Davis, 2014). Computer assisted learning in science education have also been studied widely (Rutten, Veen, & Joolingen, 2015; Smetana & Bell, 2012; Tsai & Chou, 2002). Some researches indicate that students' achievement increases with the use of computer in science education (Erdoğan & Dede, 2015; Powell, Aeby, & Carpenter-Aeby, 2003). Moreover, the use of computer in learning science may support abstract reasoning abilities (Chang, Chen, Lin, & Sung, 2008).

Enormous number of physics education software arise, such as: tools for the acquisition and manipulation of data, multimedia software, micro worlds and simulation, modeling tools, telematics and internet tools. Simulations are programs that contain models of physical process and display visualization of them. Simulations can encourage students to explore the physical system, set physical parameter, manipulate physical quantity and observe the result of the manipulation. Simulations provide students with opportunity to develop their understanding about the physical phenomena and laws through the hypothesis making and idea testing. Simulation also allow students to manipulate parameters and investigate phenomena that would not be possible to experience in a classroom or even in laboratory (Rutten et al., 2012).

Experiment to investigate gas law is not easy to be carried in the classroom. It is still possible to be conducted through lab activities. However, not every school have apparatus to conduct this experiment. Moreover, gas law is related to the concept of kinetic theory of gas. In kinetic theory of gas, there are many concepts about microscopic things which difficult to be observed directly (Niaz, 2000). In this case, computer based media can provide experiment simulation and microscopic visualization of gas which may become an alternative way to do virtual experiment. Computer based media may help students in understanding the concepts of gas law and theory kinetic gas.

In addition, sometimes students need to do individual learning activity outside the class. For some students, the regular class time may be not enough to deeply understand the physical concepts. Some students probably miss some concepts in the class so they need self-recitation. Therefore, students also need a learning resource that can accommodate them to do individual learning activity by themselves.

In Indonesia, computer has been integrated in science learning. Researchers and science teachers have tried to use computer assisted learning in science class. Some of them used the existed program such as PhET (Saputra, Nur, & Purnomo, 2016; Wartono & Batlolona, 2018), some of them have tried to develop their own program (Gunawan, Harjono, & Sutrio, 2015; Wulandari, Dewi, & Akhlis, 2013). Related to the topics of gas law, there is computer program developed such as virtual reality modelling language (VRML) in kinetic theory of gas (Wartono & Batlolona, 2018). The computer program has been validated and tested to students, however the field testing did not evaluate the impact of those programs on learning process. Moreover, the programs are not specifically designed for individual learning purpose on gas law topics.

This study aims to develop a computer program as learning resource on gas law topics that can be used as both support learning media in class and individual learning resource outside the class. Even though there are existing learning resources to support students in learning gas law in Indonesia, so far we could not find comprehensive learning resource that provide complete features which appropriate for individual learning purpose. Our developed computer programs are accompanied by simulation, concepts explanation and application with video and animation, problem exercise, and quiz. Other than that, the computer program was developed in bilingual i.e. Indonesian and English to support bilingual learning for students who need it. To face the global era, promoting bilingual study in Indonesia is also necessary, but the number of learning resources to support it is still limited. In this research, the appropriateness and quality of the computer program were determined. The effectiveness of the computer program to help students in learning the concept of gas law was also investigated through field testing.

METHOD

Research Design

In this study, we adapted research and development method within 4D models (Thiagarajan, Sammel, & Melvyn, 1974). The 4D model consists of 4 main stages, i.e. define, design, develop, and disseminate. In the define stage, we did need analysis, task and concept analysis. The need analysis is done by observation in class and interview with several physics teachers. The task and concept analysis were done by matching the material with the physics curricula in Indonesia. Based on some analysis in the define stage, we designed the computer program with Adobe Flash CS4 software (Adobe, 2009). The design stage results the prototype of computer program that is ready for developed through several evaluation and testing.

The develop stage is initiated by experts' appraisal. An expert in physics (thermodynamic and statistical mechanics) and an expert in computer-based learning media evaluated the computer program. Evaluation was also done by three high school physics teachers. The evaluation result from experts and high school physics teachers became consideration for computer program revision.

After experts' appraisal and evaluation from physics teachers, the computer media was tested to high school students. The preliminary testing was done to a smaller group consisting of 4 students. the students' response in the preliminary testing was used as a consideration for the improvement of computer program. after several revisions, the computer program was tested to a larger group consist of 64 high school students. We used one group pretest and posttest design in the field testing. Finally, from the field testing in the larger group of students, students give response to the computer program that they used. The response was used as consideration for the final revision. The final version of computer program was distributed in some schools.

Research Instrument

The quality of the computer program is determined through experts' appraisal, teachers' evaluation and students' response. The instruments used for gathering experts' appraisal, teachers' evaluation and students' response are questionnaires. the questionnaire was developed using Likert scale (1-5). The questionnaires for evaluation by material experts cover three aspects, i.e. instructional, context (material), and languages. The questionnaires for evaluation by learning media experts cover two aspects, i.e. layout and accessibility. The questionnaire for evaluation by physics teachers cover four aspects, i.e. instructional, context/material, language, accessibility, and layout.

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5	$\overline{X} \le \overline{X}_i - 1.8SDi$	$\overline{X} \le 1.8$	Very Poor

$\overline{X}$: average score of each aspect

$\overline{X}_i$: 1/2 (maximum ideal score + minimum ideal score)

SDi = 1/6 (maximum ideal score - minimum ideal score)

The students' response to computer program is gathered through "yes" or "no" checklist (dichotomous scale). The "yes" or "no" answer were converted into numerical data; the conversion is given in Table 2. After conversion, the numerical data of were averaged and interpreted according the criteria in Table 3.

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The effectiveness of the computer program to help students in learning the concept of gas law were investigated. Pre-test and post-test were conducted before and after students use the learning resource for individual learning activity. We used one group pre-test and post-test design in this research and then analyse the normalized gain score using equation (1). In formula (1), %post-test score denotes the score of post-test in percent, %pre-test score denotes the score of pre-test in percent, while *g* is the normalized gain score (Hake, 1998). The gain score indicates how significant is the improvement of the students' conceptual understanding. The criteria are given in Table 4.

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Table 4
The Criteria of Gain Score (*g*) (Hake, 1998)

g	Criteria
g > 0,7	High
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g ≤ 0,3	Low

RESULT AND DISCUSSION

The Feature of the Learning Resource

The learning resource consists of some features such as material, simulation of experiments, exercise, quiz, and scientists' biography. The features contained in this learning resource are presented in the home page of the computer program, such as shown in Figure 1. Material contains introduction to physical concepts, concepts' explanation, basic mathematical derivation, and some examples of related physical phenomena. The material is accompanied by videos and animation.

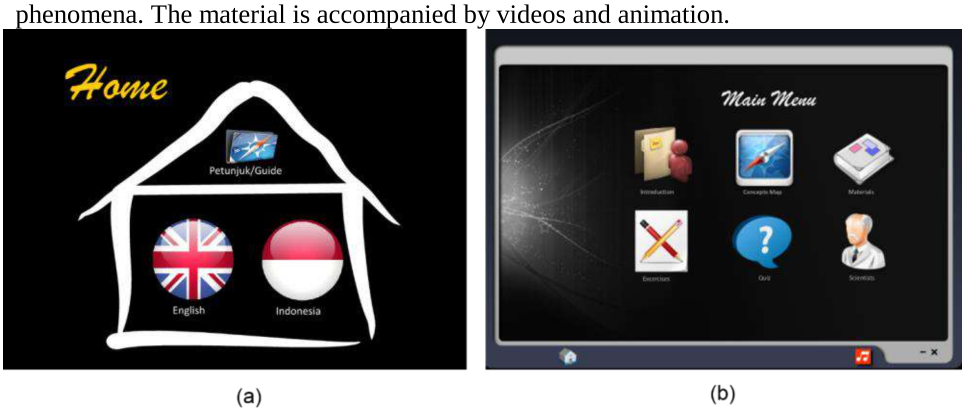


Figure 1
The layout of (a) home page and (b) main menu. This learning resource is available in both English and Indonesian.

This learning resource also includes simulation of ideal gas experiments. As the experiments are not always easy to be carried out in the physics class, we developed some simulations that may become an alternative to substitute hands-on experiments. Students are guided to find the relationship between pressure and temperature (*P*-*T*), volume and temperature (*V*-*T*), and pressure and volume (*P*-*V*) in ideal gas system through the simulation. Students have to present their result in a graph form and interpret the result. The activity in the simulation can be used in both ordinary class and individual learning activity outside ordinary class. In an ordinary traditional class, teacher will be the facilitator who guide students to gather data, analyze, and present the result. However, the learning resource still can be used in individual learning activity where there is no instructor because the learning resource provide detail guides from taking the data to interpreting the data (see Figure 2).

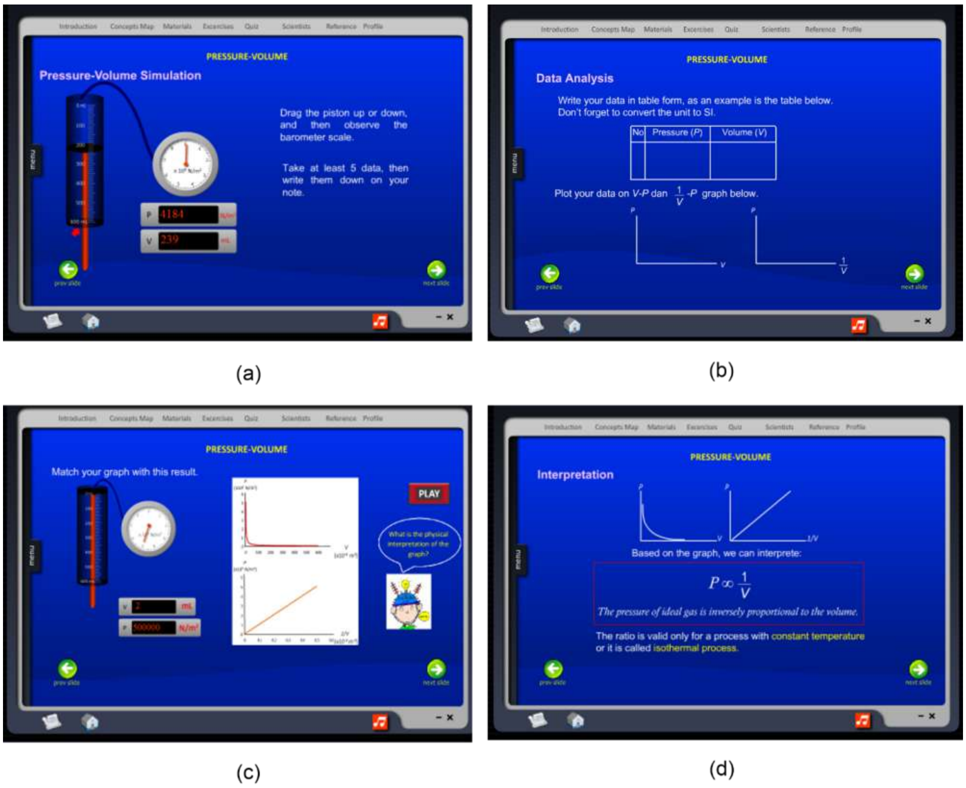
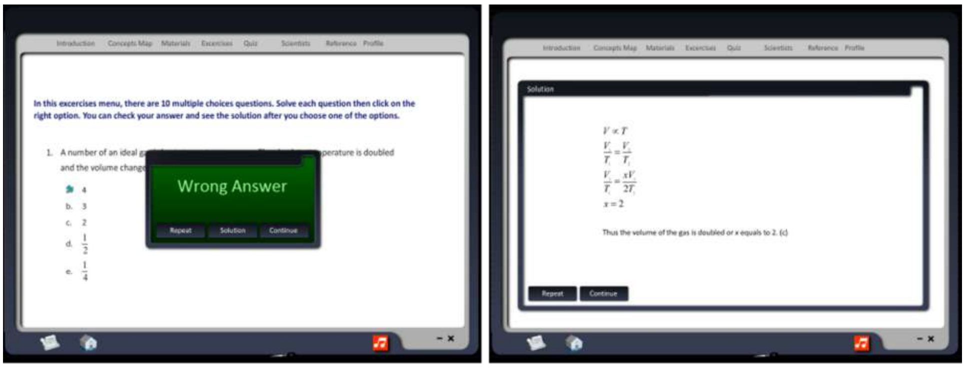


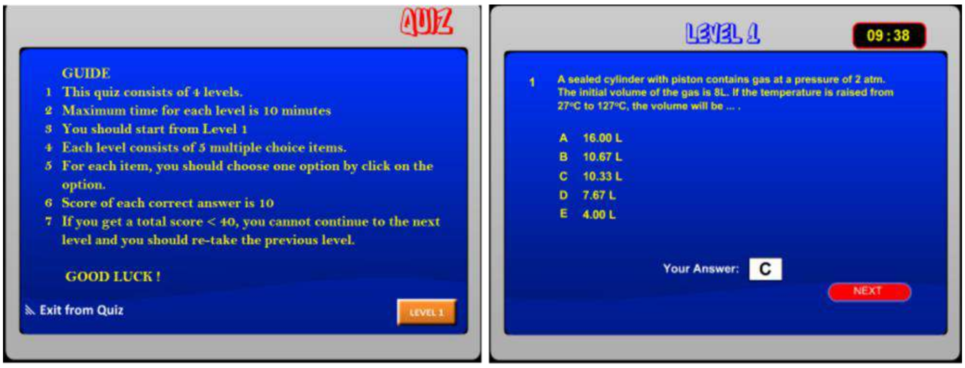
Figure 2
Simulation of *P-V* relationship. The simulation contains some activities such as (a) data collecting, (b) data analysis, (c) confirmation of result through automatic simulation, and (d) interpretation of result.

Besides *P-V-T* relationship in ideal gas, simulation of root-mean-squared (rms) speed of gas molecules is also provided. The simulation shows the relation between temperature, relative mass, and rms speed of gas molecules, the simulation is adopted from PhET (PhET, 2018). The relationship between some quantities in kinetic theory of gas is derived mathematically with a simple assumption. This explanation aims to give the students a comprehensive understanding from theoretical point of view and experimental result.



(a) (b)

Figure 3
The layout of Exercises Menu. (a) Problem given in the Exercises. (b) The problem solutions.



(a) (b)

Figure 4
The layout of Quiz Menu. (a) The Guidelines. (b) Problem displayed in Quiz, there are 5 randomly displayed question in each level and students must answer them within 10 minutes.

Exercise allows students to apply some concepts that have been studied in the material to solve some problems. In the exercise, the solutions of each problem are provided, one of examples is in Figure 3. Move up to the next level, students can do Quiz, such as shown in Figure 4, to evaluate their study by themselves. The Quiz is constructed from 4 levels with different difficulties of problems. Students have to pass ≥80% score if they want to go the next level. The questions of each level are always randomly changed if students restart the quiz.

Figure 5 shows the last feature of this learning resource, scientists' biography. The biography of some physicists who worked on the experimental and theoretical studies related to ideal gas and kinetic theory of gas is presented. This feature aims to motivate students for further studies.

Figure 5
Short biography of scientist who worked on gas law and theory kinetic gas is also included.

Developmental Testing of the Learning Resource

The learning resource has been validated through expert appraisal and tested to senior high school students. We also asked some teachers to use this learning resource and fill a questionnaire to evaluate the computer program. Overall, teachers agreed that this computer program is potentially can be used by students as their individual learning resources on ideal gas and theory of kinetic gas material. The learning resource was revised based on some advices from experts and physics teachers before directly tested to students.

We did initial field testing to a small group consists of 4 students. To measure students' initial knowledge of gas law, a pre-test was given to students. After that, students learnt the material by themselves using the learning resource that we have developed. A post-test was given to them to measure their final understanding on the material after they used the learning resource. Using equation (1), the result of pre- and post-test were analyzed to yield the normalized gain-score. The average gain score from the first field testing is 0.68, which is categorized as medium gain (Hake, 1998). At the end of the session they also filled the checklist about their opinion of the quality and usability of the learning resource.

We received some advices from this initial field testing and thus we did a minor revision on the learning resource. We did the second field testing to a bigger group of students. On this field testing, there are 61 students from two schools were involved. Similarly, we conducted pre- and post-test to students before and after they used the learning resource to study the material by themselves. The average gain score from the second field testing is 0.55, which is categorized as medium gain (Hake, 1998). Table 3 shows the average of pre- and post-test score and gain score.

Table 3
The comparison of pre- and post-test score and the gain.

Group	Average pre-test score (out of 100)	Average post-test score (out of 100)	Average gain score (g_{av}) *	Criteria
Smaller group (4 students)	38.33	80.00	0.68	Medium
Bigger group (61 students)	41.99	73.87	0.55	Medium

*Average gain score is calculated by averaging each individual gain scores in the group.

After each field testing, we gave students some checklist to know their opinions about the quality and usability of the learning resource. The final results are summarized in the Table 4. Overall, most of students from the initial field testing (smaller group) and second field testing (bigger group) agreed that the fitness of learning resource for individual learning activity, the usefulness of the learning resource to learn ideal gas and theory kinetic gas, layout quality, language quality, and accessibility of the learning resource are very good.

Table 4
Students' response on checklist about the quality and usability of the learning resource

Aspects	Smaller Group		Bigger Group	
	Average Score	Criteria	Average Score	Criteria
The fitness for individual learning purpose	0.94	Very Good	0.86	Very Good
The usefulness of to learn ideal gas and theory kinetic gas	0.94	Very Good	0.90	Very Good
Layout quality	0.81	Very Good	0.88	Very Good
Language quality	0.94	Very Good	0.85	Very Good
Accessibility	0.94	Very Good	0.86	Very Good

We found there is significant improvement of students' cognitive achievement after students learned individually using the developed computer program. Both preliminary field testing and main field testing showed medium gain score of pre- and post-test result. Our developed computer program mainly consists of simulation of experiment and concept explanation which accompanied with video and animation to engage students and show the example of concept application in daily life. Our finding is consistent with previous studies which showed that physics simulation based learning give good impact on learning results (Jimoyiannis & Komis, 2001; Srisawasdi & Panjaburee, 2015; Syaifulloh & Jatmiko, 2014).

Simulation of experiment and concept animation helps students to learn abstract concept such as kinetic theory of gas which included in the gas law topics. Other than that, guided simulation of experiments developed in our program is potential to improve students' ability on data processing and graph interpretation. If we looked at the details, we found that in the post-test, the number of students who gave correct answer about problems related to data processing and graph interpretation is higher than in the pre-test.

In this studies we have investigated the impact of using the developed computer program in the students' learning results in gas law topics. However, this study is limited to the investigation on cognitive learning result only. We believe that more comprehensive investigation on other domain such as affective domain is also required.

CONCLUSIONS

A study has been conducted to develop computer based individual learning resources on the material of gas law. The learning resource has been tested to groups of students. Based on the gain score analysis, the learning resource is potentially can be used to improve students' understanding on gas law effectively. Students' response on the usability and quality of the learning resource overall can be categorized as very good. Still, the study still has limitation since we only evaluated the learning result on cognitive domain. For further study, comprehensive investigation on other domain such as affective domain is also required.

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https://www.adobe.com/support/flash/downloads.html#flashCS4

Gmail Elisabeth Founda <elisa.founda@gmail.com>

Amendments

2 messages

iji@ogu.edu.tr <iji@ogu.edu.tr> Thu, Dec 27, 2018 at 12:06 AM
To: elisa.founda@gmail.com, elisa.founda@ukwms.ac.id

Dear author

You have amendments from reviewers. Could you please amend **on attached file "Article 391018_revised_for revision"** and send back your revised article and the list of explanations of the revisions done via e-mail (iji@ogu.edu.tr) as an attached file as soon as possible?

Note: Could you please confirm the receipt of this e-mail?

Sincerely yours,
Editorial
International Journal of Instruction

International Journal of Instruction
http://www.e-iji.net
-

4 attachments

IJI Article Evaluation Form 391018c_2.pdf
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Article 391018_a_2.doc
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Article 391018_revised_for revision.doc
2002K

Elisabeth Founda <elisa.founda@gmail.com> Fri, Dec 28, 2018 at 7:09 PM
To: iji@ogu.edu.tr

Dear IJI Editor,

We have carefully read the reviewers' comments on our manuscript.
Here, we send the reply letter and revised manuscript.

We look forward the feedback from reviewers and editors to our revised manuscript.

Thank you
[Quoted text hidden]
--
With sincere regards,

Elisabeth Pratidhina Founda Noviani

---

2 attachments

REPPLY LETTER.docx
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Article 391018_revised_for revision.doc
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International Journal of Instruction Article Evaluation Form

Mr. /Mrs.

It is to acknowledge you that the Executive Committee of *International Journal of Instruction* has decided that the article mentioned below would be reviewed by you. Thank you very much for your contributions.

December 18, 2018
Asım ARI
Editor in Chief

Name of the article: Developing Computer Program as Learning Resource on Gas Law Topics for High School Students

After reviewing the attached article, please read each item carefully and select the response that best reflects your opinion. To register your response, please **mark** or **type in** the appropriate block.

	Yes	Partially	No
Do you think the title is appropriate?	☒	☐	☐
Does the abstract summarize the article clearly and effectively?	☐	☒	☐
Are the objectives set clearly?	☒	☐	☐
Is the issue stated clearly?	☒	☐	☐
Is the literature review adequate?	☐	☒	☐
Is the design of the research appropriate, and the exemplary, if any, suitable?	☐	☒	☐
Is the methodology consistent with the practice?	☐	☒	☐
Are the findings expressed clearly?	☐	☐	☐
Is the presentation of the findings adequate and consistent?	☐	☒	☐
Are the tables, if any, arranged well?	☒	☐	☐
Are the conclusions and generalizations based on the findings?	☒	☐	☐
Are the suggestions meaningful, valid, and based on the findings?	☒	☐	☐
Are the references adequate?	☒	☐	☐
Is the language clear and understandable?	☐	☒	☐
Is cohesion achieved throughout the article?	☐	☒	☐
Is the work contributing to the field?	☐	☒	☐

Evaluation:
☐ The article can be published as it is.
☐ The article can be published after some revision.
☒ The article must undergo a major revision before it can be resubmitted to the journal.
☒ The article cannot be published.

Would you like to see the revised article if you have suggested any revisions? ☒ Yes ☐ No

Please write your report either on the this paper or on a spare paper.

REPORT

the article cannot be published for the following reasons:
1. The text still needs proofreading in terms of language use, grammar.
2. There is no report on the valıdity and reliability of the instrument except a statement saying that
'The items were contextually and constructively validated by our colleagues who are expert in thermodynamics and in physics education'
3. There is no information on the theoretical underpinning of the questionnaire.
4. There is no information on the sampling technique and the participants.
5. The discussion section is quite short, the author needs to explain how his research is

different from or similar to the previous studies.

International Journal of Instruction Article Evaluation Form

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It is to acknowledge you that the Executive Committee of *International Journal of Instruction* has decided that the article mentioned below would be reviewed by you. Thank you very much for your contributions.

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Asım ARI
Editor in Chief

Name of the article: Developing Computer Program as Learning Resource on Gas Law Topics for High School Students

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	Yes	Partially	No
Do you think the title is appropriate?	☒	☐	☐
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Is the literature review adequate?	☒	☐	☐
Is the design of the research appropriate, and the exemplary, if any, suitable?	☒	☐	☐
Is the methodology consistent with the practice?	☒	☐	☐
Are the findings expressed clearly?	☐	☒	☐
Is the presentation of the findings adequate and consistent?	☒	☐	☐
Are the tables, if any, arranged well?	☒	☐	☐
Are the conclusions and generalizations based on the findings?	☒	☐	☐
Are the suggestions meaningful, valid, and based on the findings?	☐	☒	☐
Are the references adequate?	☐	☐	☒
Is the language clear and understandable?	☒	☐	☐
Is cohesion achieved throughout the article?	☒	☐	☐
Is the work contributing to the field?	☐	☒	☐

Evaluation:

☐ The article can be published as it is.
☒ The article can be published after some revision.
☐ The article must undergo a major revision before it can be resubmitted to the journal.
☐ The article cannot be published.

Would you like to see the revised article if you have suggested any revisions? ☒ Yes ☐ No

Please write your report either on the this paper or on a spare paper.

REPORT

Reference writing needs to be adjusted because it does not consistently follow the APA Style 6th Edition and needs to edit Mendeley's metadata.

1. Reference no. 1 (Barrie): Please edit metadata.
2. Reference No. 2 (Chang): OK
3. Reference number 3 (De Witte): OK
4. Reference No. 4 (Eko): Please edit the metadata
5. Reference number 5 (Erdogan): title writing needs to be corrected (please example number 2)
6. Reference number 6 (Gunawan); title writing needs to be corrected (please example

number 2) and needs to be completed with DOI and / or article URL.
7. Reference no. 7 (Hake): OK
8. Reference number 8 (Hofstein): writing the title needs to be corrected, see no. 7
9. Reference number 9 (Jimoyiannis): The name of the journal does not exist?
10. Reference number 10 (Kleij): the title writing needs to be corrected, see no. 7
11. Reference no. 11: OK
12. Reference no. 12: OK
13. Reference no. 13: OK
14. Reference no. 14: OK
15. Reference no. 15: OK
16. Reference no. 16: the title writing needs to be corrected, see no. 7
17. Reference no. 17: the title writing needs to be corrected, see no. 7 and the name of the journal does not yet exist.
18. Reference number 18: the title writing needs to be corrected
19. Reference No. 19: the name of the journal written in the title.
20. Reference no. 20: OK
21. Reference no. 21: Title written repeatedly (Double)
22. Reference no. 22: the title writing needs to be corrected, and the author's name written in the end of the title.
23. Reference no. 23: OK
24. Reference no. 24; OK
25. Reference no. 25: OK
26. Reference no 26: the title writing needs to be corrected and needs to be completed with DOI and / or article URL.
27. Reference no. 27: See how to write references originating from the internet!

Reply to Reviewer #1 (391018a)

1. **Abstract**

Comment)
Reference writing needs to be adjusted because it does not consistently follow the APA Style 6th Edition and needs to edit Mendeley's metadata

Author Reply)

To address this issue, the author has revised the references following the APA Style 6th edition. The revised references become:

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Reply to Reviewer #2 (391018c)

Comment)

There is no information on the sampling technique and the participants.
Reply)

The field testing involves senior high school students in SMA Negeri 1 Klaten and SMA Negeri 2 Yogyakarta. There are 4 students involved in the preliminary testing and 64 students in second testing. The participants in the field testing has been explained in the method:

After experts' appraisal and evaluation from physics teachers, the computer media was tested to high school students. The preliminary testing was done to a smaller group consisting of 4 students. The students' response in the preliminary testing was used as a consideration for the improvement of computer program. after several revisions, the computer program was tested to a larger group consist of 64 high school students. We used one group pretest and posttest design in the field testing. Finally, from the field testing in the larger group of students, students give response to the computer program that they used. The response was used as consideration for the final revision. The final version of computer program was distributed in some schools.

Comment)

The author needs to explain how his research is different from or similar to the previous studies.

Reply)

It has been included in the Discussion section.

Re: Acceptance Article 391018 decision

Inbox

iji@ogu.edu.tr
to me

Tue, Jan 15, 2019, 4:50 PM

Dear author

This article has been completed the reviewing process and has been accepted for publication. Your manuscript is tentatively scheduled for publication in 2019.

We wish you all the best.
Editorial
International Journal of Instruction

From: "Elisabeth Founda" <elisa.founda@gmail.com>
To: "iji" <iji@ogu.edu.tr>
Sent: Tuesday, January 15, 2019 8:42:41 AM
Subject: Article 391018 decision

Dear IJI Editor,
I would like ask about the decision for my submitted article entitled "Developing Computer Program as Learning Resource on Gas Law Topics for High School Students" (Article 391018). Is there any decision for my submitted article?

International Journal of Instruction

Acceptance Letter

Date: January 31, 2019
Ref. No.: IJI-19-319
Subject: “Developing Computer Program as Learning Resource on Gas Law Topics for High School Students”

Elisabeth Pratidhina
Department of Physics Education, Widya Mandala Catholic University, Surabaya, Indonesia,
elisa.founda@ukwms.ac.id

This article has completed the reviewing process and has been accepted for publication. Your manuscript is tentatively scheduled for publication in April 2019, Volume 12, Number 2.

Yours Faithfully,

Prof. Asim Ari

Editor in Chief

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