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THE DEVELOPMENT OF MOMENTUM CONSERVATION LAW LABORATORY KIT BY USING TRACKER SOFTWARE AS LEARNING TOOL OF PHYSICS AT SMAN 12 SURABAYA

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Abstract

A learning tool is considered can help students to understand the physics phenomenon. A learning tool in a class has to provide activities to promote students' knowledge and skills. The final project reported in this publication is intended to develop a certain laboratory kit which was integrated with Tracker Software and acted as the learning tool. This certain kit is projected to help students' understanding in the concept of Momentum conservation law. The aspect of validity, effectiveness, and practicability of the developed kit were examined by research and development (R&D) method. In this case, the first prototype kit was validated to the two experts before being tested to limited number of students, and the feedback was used to upgrade the preciseness and the accuracy of the kit. Fifteen number of senior high school students in Science-2 class participated in this research for two weeks. The result revealed that the overall students' achievement is 87 %. This percentage is above the minimum standard score. In addition, both students' knowledge and skills in operating and analyzing the experimental results have passed the minimum standard score. Having the above results, the developed kit can be regarded as an effective learning tool. The students' feedback also indicated that the kit is practical with score 92 % (very good). Moreover, according to the two validators this developed kit is valid by percentage of 87.5 % (very good). Therefore, the developed kit is applicable to support students' understanding in Momentum conservation law concept.

Keywords: laboratory kit, Tracker software, Momentum conservation law concept.

INTRODUCTION

Education is considered help to improve the quality of life and human value. Therefore, education can create potential, high quality, and skilled human. There are many subjects in education, one of them is Physics. Physics is the knowledge that learn about natural phenomena and it's mechanism. Therefore, physics contribute to develop many aspect for instance: medical, meteorology, and technology.

Concept of physics based on experiential observation and quantitative measurement, hence to understand physics need to conduct experiment. In order to conduct experiment, need certain laboratory kit. Moreover it can assist student to understand the Physics concept (Kustandi, 2013).

There are many kind of laboratory kit, for example virtual experiment (virtual lab) and real experiment. Virtual lab work by using computer to conduct experiment. Virtual lab have ability to setting the variables and automatically show the results.

In the other hand, virtual lab have three weakness. 1 Students don't need to calibrate the kit and checking the kit, thus they can't acquire the skill competence. 2 The visualization of virtual labs are cartoonist consequently, student can't investigate the real situation. 3 The virtual lab uses a programming algorithm, where this algorithm can't explain the real natural phenomenon.

On the other hand, the real experimental tool also has some weakness if done manually, i.e. there are quantities that are difficult to retrieve data, for example speed at each point and acceleration of moving object. In addition, to analyze the data also takes a long time. Therefore, a real laboratory kit that integrated with the computer are needed. Experiments with computer simulations allow students to visualize objects and processes that are normally beyond user control when in the real world (de Jong, Linn, & Zacharia, 2013). The example of computer simulation is video analysis.

Video analysis is a type of application that can analyze the movement of the real lab experiment, hence students keep doing real experiments. Because of that, this experimental tool can trained the skills of the use of tools on students. This is because the workings of this laboratory kit analyze videos from real experiments, so students keep doing real lab experiments then the experiments are recorded and inserted into the video analytics app to get the data. The advantages of this video analytics experiment is a very easy and practical. This

video analysis is very effective when accompany real lab experiments. The example of video analysis is Tracker.

Tracker has several modeling capabilities as follows: 1) creating a kinematic and dynamic model of the mass point of the particles and the two-body system is a movement system consisting of two masses, 2. experiment and fold multi point data at every point on a moving object, 3. the presentation of the model is automatically synchronized and calibrated according to the video to compare with the real world (www.physlet.org).

The use of video tracker has been used for physics study. Based on a research publication conducted by Loo Kang Wee entitled "Using Tracker as a Pedagogical Tool for Understanding Projectile Motion", concluded that video analysis allows students to discover the concept of projectile motion based on events and models proposed by themselves. Video analysis has gradually improved the modeling of experiments better so as to explain the concept of projectile motion. In addition, based on scientific publication entitled "Attractiveness of Learning Physics by Means of Video Analysis and Modeling Tools" conducted by Peter Hockicko, concluded that the learning of interactive methods with video analysis using Tracker application can facilitate students in studying Physics.

Based on the observation in SMA Negeri 12 Surabaya, there are many laboratory kit of Physics which one of them is impulse and momentum kit. This kit is used by students to find the relationship between impulse and momentum of moving objects and also to study the law of conservation of momentum. The experiments used consisted of trajectories and two miniature cars. The workings of this tool is to push both cars to collide. However, this kit has a weakness because it is conducted manually using stopwatch to measure time and ruler to measure the distance. Therefore the velocity is not accurate and precise

Based on the description above will be conducted development research on laboratory kit that equipped with Tracker applications about Momentum conservation law in SMA Negeri 12 Surabaya.

This research is projected to describe the validity, effectiveness, and practicability of the developed kit. The validity is measured by assessment from two validators and developed kit trial. Effectiveness is reviewed by students' knowledge and skills when using this kit for learning. Practicability is assessed by students' respond of the developed kit after learning.

The benefits of this research for students are: 1 to promote their skill and knowledge competencies about Momentum and Impulse materials, 2 students become more active and motivated in learning activities so this developed kit facilitate students in understanding the concepts studied. At the same time provide alternative learning experiments that teachers can use in conducting experiments Conservation of momentum.

METHOD

This research used research and development (R & D) method, where this research starts from doing research on existing problem then develop a product that can solve the problem. The design used *One shot case study*, which mean the samples (students) are given the treatment and being tested using the product (developed kit). The development carried out in this research is the development of certain laboratory kit of Momentum conservation law experiments integrated with Tracker. The feasibility of the experimental tool is reviewed from the results of the validation from experts, completeness of learning outcomes, student responses, and data of experimental law conservation of momentum with this kit. The population of this study is 10^{th} grade-Natural science in SMA Negeri 12 Surabaya, from the population is taken one Natural-science class as a research sample that is 10 IPA 2 class. In one class will be grouped consists of three groups.

This research is conducted by creating a certain kit. After that, the kit is validated by two experts before being tested to student. The results of validation were used to improve the accuracy and preciseness of kit. Finally the kit was tested to limited number of student and their feedback and score indicated the effectiveness and practicability of the kit.

RESULT AND DISCUSSION

This study aimed to produce a good laboratory kit used as a medium of Physics learning in chapter of Momentum conservation law. To know the laboratory kit that has been developed can be used for learning in terms of three aspects of the validity, effectiveness and practicability. Based on the results of research that has been implemented obtained the results of validity, effectiveness, and practicality as follows

The validation of laboratory kit is used to find out whether the developed kit is valid for learning, the validation also include *LKS* (worksheet) and posttest quiz as instrument of data retrieval. Validation aspects include: a) the relation of kit with teaching materials, b) educational value, and c) some aspects of kit's specifications. The validation results are projected in Figure 1.

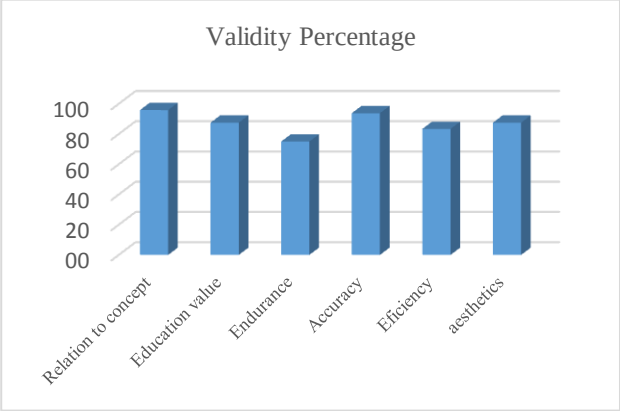


Figure 1. Percentage of validity

Based on the graph in Figure 1, the validation obtained the average percentage of the validity of 87.5 % with very good criteria. The explanation of every aspects are presented as follow: a) This developed tool is in accordance with the concept taught because this tool demonstrates the Law of Conservation of Momentum which includes the concept of impulse, momentum, and collision .b) Aspects of educational value in the validation of this tool include the appropriateness of intellectual development of learners. Based on the validation results of this experimental tool is said in accordance with the intellectual development of learners. This is because this tool can be used by students to take the data until the analysis process, so by using this tool students are trained to analyze the results of the experiment. c) Resilience validation results get a good value, because the experimental tool in this study is made of aluminum for cars and wood for the trajectory. d) Accuracy in this aspect contains two points, namely the suitability of the scale and the accuracy of the experimental tool. Scale used in this measurement there are two magnitudes of mass and speed. The mass used in the measurement is the mass of four loads having different masses that have a gram unit, so that the tool is compatible with the scale used. The total result of momentum before and after the collision is obtained is relatively the same, so this tool has very good accuracy. e) This experimental tool gets 83.3% validation result is relatively smaller than other aspects because there is little deficiency in terms of speed of data retrieval. This is because there are many steps that must be done in operating the tool. f) Aesthetic of this kit is very good because this kit consist of two car and trail which able to demonstrate the momentum conservation law.

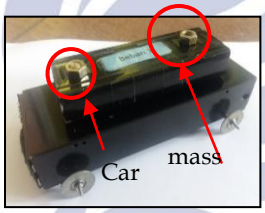
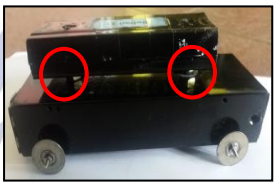
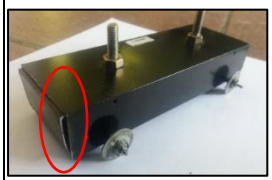
Apart from the validation of experts, the validity of the kit is also observed from the results of trial data experiments (Table 1) .

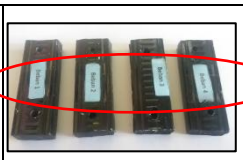
Table 1. Result of trial

No	P initial (kg.m/s)	P final (kg.m/s)	Difference (%)
1	0,1019	0,1013	0,59
2	0,0978	0,0994	1,64
3	0,0978	0,0969	0,92
4	0,1009	0,0941	6,74
5	0,1009	0,0985	2,38
6	0,0998	0,0960	3,81
7	0,0946	0,0922	2,54
8	0,0957	0,0948	0,94
9	0,0936	0,0954	1,92
10	0,0998	0,0989	0,90
11	0,1019	0,1030	1,08
12	0,0905	0,0890	1,66

As shown in the Table 1, the total momentum before and after collision is different from the percentage of ≤ 6.74%, so the experimental tool is still needed upgrade. The revision component (upgrade) is given in Table 2.

Table 2. The result of revision

No	Before revision	After revision
1	 The mass is locked with a nut (on a red circle) mounted on top of the mass to strengthen the mass to keep it off during impact.	 The load does not need to be locked because it is strong and the load lock takes longer to experiment, so the position of the nut (in the red circle) is placed under the load.
2	 The bearing wheels are glued to the ring with only a glue on the touch plane between the bearing and the ring.	 The bearing wheels and the ring are glued together with a mixture of glue and stone pencil powder.
3	 The front of the car is covered with an aluminum slab (in a red circle), but there are still sharp pieces remaining.	 The front of the car is covered with aluminum slabs and given insulation (see red circle) so that the remaining pieces are not sharp and students are safe to use them.

4	 The four different masss are different and have not been labeled yet.	 The four masss are labeled so it will make it easier for students to do the repetition of data retrieval.

After the subsequent revision, the kit was tested for a second time. The percent difference decrease to ≤ 4,06 %. The percentage indicates that the improved experimental tool is performing better than before.

The effectiveness of the experimental tool is reviewed from student learning outcomes. Student learning outcomes are derived from the values of both knowledge and skill. The value of knowledge is taken from the posttest, which was conducted at the end of learning. Posttest given to students consists of fifteen multiple choice questions. Skills are the value of learners during the experiment. Students were said to be complete if the value of student learning outcomes (knowledge and skills) are greater than the *KKM* (standard minimum) of Physics at SMAN 12 Surabaya (i.e. 70).

The result of the students' knowledge in the learning using the media of the developed kit gets the result in Figure 2

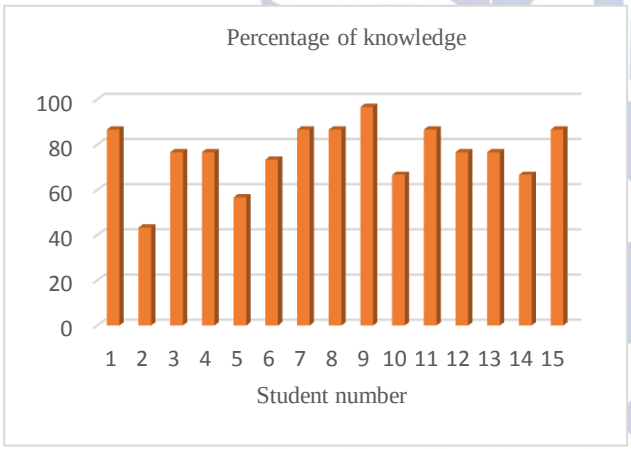
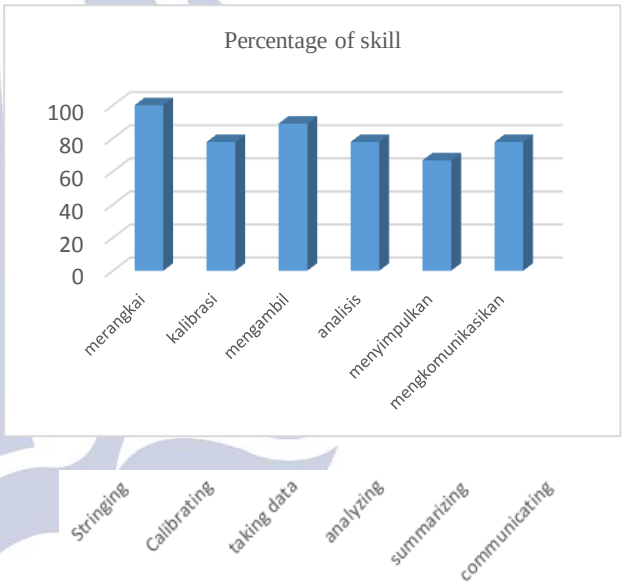


Figure 2. Percentage of knowledge

based on the graph above, there are 11 students who reach the value of 70, while only 4 students who have not reached the value of *KKM*. These results indicate that the students' knowledge has an average above *KKM* of 76. These results are influenced by the media used in the learning. According to Sudjana and Rivai, 2011, The use of media in learning has four advantages, they are: a) can improve motivation and interest in learning, b) Teaching materials will be more clearly defined so that they can be understood by students, and allow students to master better teaching objectives, c) learning methods vary because not only verbal communication, so students do not get bored quickly and teachers also do not get tired quickly, d) Students are more active because of learning activities (student centered), because not only centered on the description of teachers, but also other activities such as observing, demonstrating and others.

The medium in this lesson used an laboratory kit integrated with the computer where the laboratory kit has advantages: a) Student learning time is longer because it can be done anywhere, so it can better understand the concept, b) can simulate a difficult and expensive experiment to do, c) the availability of simulation applications is easily obtained from the internet, d) with computer simulation can overcome misconception (Suparno, 2007). Therefore, this laboratory kit can make



students to achieve the competence of Physics knowledge, especially the Impulse and momentum concept.

The next assessment is skill. Skills assessment includes: assembling tools, calibrating tools, retrieving data, analyzing, summarizing, and communicating. The student skills achieved during the learning are as follows (Figure 3)

Figure 3. Percentage of skill aspects

Based on the graph above shows that the aspect of "summarize the results of student experiments" is still low at 67%. This is because students have not understood what to summarize, other than that the summarizing of students who answered are not based on experimental data and problem formulation. Skills that are still relatively low compared to other skills are calibrating and analyzing. This happens because students are still using the Tracker app for the first time, so students are not proficient enough to operate the Tracker.

Based on the research that has been done, the students' learning outcomes in the knowledge and skills are presented in Figure 4.

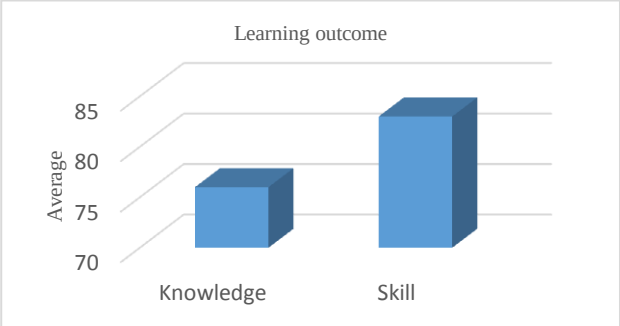


Figure 4. Learning outcomes

Based on the graph above, learning outcomes was obtained the average value of knowledge of 76 and the skills was obtained an average of 83. From the results above the developed kit is able to make students achieved the standard minimum value (*KKM*) of physics lesson (70), so that this kit is said to be effective as a medium of physics learning. Skills acquired by students have a good average of 83. These skills include data retrieval, data processing,, concluding and communicating experimental results. This result is accordance with research conducted by Muller, et al in 2014, which concluded that using experimental tools equipped with Application Tracker was able to make students more independent in solving problems related to experimental physics.

The percentage of overall completeness obtained in this study can be seen in Figure 5

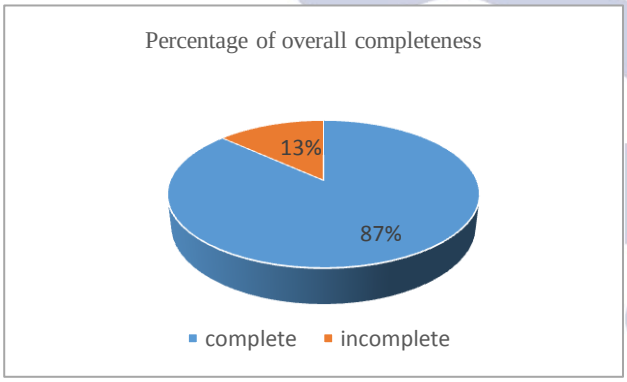


Figure 5. Overall completeness

Based on the graph, the percentage of incomplete student is 13% and complete 87%. The number of students who have not completed as many as two students, while as many as thirteen students were completed. Students' completeness is based on learning outcomes where learning outcomes are obtained from 30% skills and 70% knowledge. Percentage of overall completeness has reached the standard of the school that is greater than 85%, so it can be said developed kit can be used as a medium of Physics learning.

Great classical completeness is because the kit has advantages. The advantages of this kit among others are can illustrate the physical phenomena of real events due to the workings of this tool by analyzing the experimental video recordings, with these advantages make it easier for students to understand experimental visualizations. In addition Tracker is able to display many magnitudes that exist in this experiment example: speed, time, displacement, momentum. These quantities can be identified by using graphs that can be displayed automatically, so students have no difficulty in analyzing the experiment results.

On the other hand there are two incomplete students. One reason is that experimenting with the Tracker app is a novelty for students, so some of them are still having trouble operating it. Another factor is the number of steps that must be performed to display the data have to be done correctly, if there is one step that has not been done or not done correctly then the results of the experiments obtained become less precise and accurate. This makes some students have difficulty in learning the concepts during the experiment.

The practicability in this research is used to know the ease of using the kit and its application. The practicability aspects are consist of 1) the ease of using this kit include: assembling the kit, data retrieval, processing of experimental results, and ease of understanding the material. In addition to convenience, practicality also 2) measures interest, constraints experienced by students, 3) speed in taking data and 4) application of technology in experimental tools developed.

Based on the research results obtained student response as Figure 6.

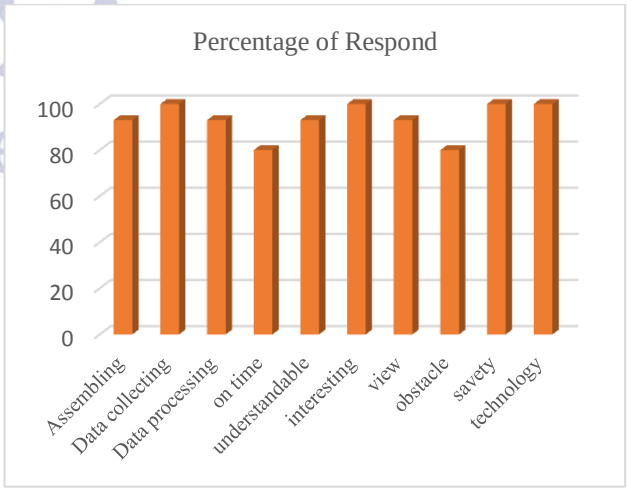


Figure 6. Percentage of respond

The graph shows students' responses to the Momentum conservation law kit which equipped with the

Tracker application. On the graph there are two questions that have the lowest value, they are timeliness and constraints.

Experimental activities with this tool cannot be completed on time, so learners continue to analyze data at home. This is because there are many steps to get the data speed of a moving car from the recording.

In doing this experiment also encountered several obstacles, they are the problem of installation of Tracker application and tracking. At the time of installation, there were some students who had difficulty. This is due to the difference of system operation on each laptop. Some laptop students use Windows 10 operating system, while Tracker app cannot be used in Windows 10. To overcome this obstacle every group of students is required to bring at least two laptops.

Based on Figure 6 of the ten questions regarding student responses obtained an average score of 92% with very good category. From these values can be concluded that this kit received good response from students and practical to be used as a medium of Physics learning.

CLOSING

Conclusion

Based on the results of the research of developing laboratory kit integrated with Tracker application can be used as a medium of Physics learning. This can be seen from the following three aspects: 1) This experimental tool has a validity value of 87.5% (very good), so this tool is valid to be used as a medium of physics learning. 2) Student learning outcomes of overall completeness expressed with the percentage 87 %, because this percentage is greater than the standard of the school (85 %), so this experimental tool can be said to be effective as a medium of physics learning. 3) Student's response to this experimental tool is 92% with very good criteria, so this test tool is said to be practical for Physics learning medium.

Suggestion

Based on the results of this study there are some suggestions for further research on application tracker as follows:

1. Physical learning of impulse and momentum concept should be supported by using a kit equipped with Tracker application
2. Cameras needed to record the movement required high-speed camera (high fps), so that the tracking results of motion by the tracker more accurate.
3. The time required should be considered well, because there are many steps to process the data with the application tracker.
4. For the installation process it is advisable to use the latest version of Tracker to be compatible with all laptops used by students.

BIBLIOGRAPHY

de Jong, T., Linn, M. C., & Zacharia, Z. C. 2013. Physical and Virtual Laboratories in Science and Engineering Education. *Science*, *340*(6130), 305 LP-308. (Online), http://science.sciencemag.org/content /340/6130/305.abstract diakses 17 Februari 2017

Global, Igi. 2017. What is Virtual Lab. (Online), (http://www.igiglobal.com /dictionary/virtual-lab/31699,diakses pada 12 Februari 2017)

Hockicko, P. (2012). Attractiveness of learning physics by Means of Video Analysis and Modeling Tools. *Physics and Engineering*, *23*, 26.

Kustandi. (2013). *Media Pembelajaran*. Bogor: Ghalia Indonesia

Müller, P. K. and S. G. and J. K. and A. 2014. Video analysis of projectile motion using tablet computers as experimental tools. *Physics Education*, *49*(1), 37. (Online) http://stacks.iop.org/0031-9120/49/i= 1/a=37 diakses pada 11 Februari 2017

Sudjana dan Rivai. (2011). *Media Pengajaran*. Bandung: Sinar Baru Algensindo

Suparno, P. (2007). *Metodologi Pembelajaran Fisika Konstruktivistik dan Menyenangkan*. Yogyakarta: Universitas Sanata Dharma

Wee, L. K., Chew, C., Goh, G. H., Tan, S., & Lee, T. L. (2012). Using Tracker as a pedagogical tool for understanding projectile motion. *Physics*