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Research Article

Computer Simulation Feasibility for Newton's Law Learning

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Abstract: The purposes of this research is to test the feasibility of a Computer Simulation of Motion and Force (SKGG), Computer Simulation of Action and Reaction Force (SKGAR), for learning Newton's Law. The specific objectives of the study are: 1. Describe the validity of the SKGG and SKGAR for learning Newton's Law to improve students' understanding on the concept of motion and force. 2. Describe the practicality of the SKGG and SKGAR for learning Newton's Law. 3. Describe the effectiveness of the SKGG and SKGAR for learning Newton's Law.Data collection techniques are used to obtain materials that are relevant, accurate, and can be used appropriately according to research objectives. The data collection techniques used in this study are: (1) validation techniques; (2) observation; (3) test; and (4) questionnaire.Data analysis in this study describes the validity, effectiveness, and practicality of computer simulation prototypes. The data analysis is inductive based on the facts used to answer the problem formulation that has been formulated in the study, which emphasizes the meaning more than generalizationThe results of this study indicate that Based on the results of the analysis, discussion, and research findings, it can be concluded that the computer simulations that have been developed are valid, practical, and effective to improve understanding on the concepts of motion and force in relation. to Newton's Law.

Keywords: Computer simulation, Motion and Force, Action and Reaction Force,learning Newton's Law

1. Introduction (Times New Roman 10 Bold)

Newton's Law is the most important and useful concept in mechanics. The Newton's First Law is related to the concept of inertia, which the resultant of acting force is equal to zero. The object can be at rest or move in a straight line, if the resultant force is zero. Newton's Second Law expresses the relationship between motion and force. Newton's Third Law is related to the concept of action force and reaction force. Several researchers have shown that students have difficulty to understand the concepts of motion and force as stated in Newton's law **(Saglam-Arslam, A. &Davecioglu, Y. 2010; Sari, D. P., Madlazim& Sanjaya, I. G. M. 2015a**). For some students, it has been understood that force is the cause of motion. Their misconception about the relationship between motion and force is the evidence that their common sense is resistant to change. It is very important for students to fight the misconceptions resistance about the relationship between motion and force. Newton's Laws are treated in many high school textbooks abstractly and students cannot reach an understanding of Newtonian principles about the relationship between motion and force. If the discussion of all types of movement is carried out through Newton's Second Law, and is not an integral part, then the students' attitudes, conceptual understanding and skills are believed to increase.

Students are familiar with Newton's First, Second and Third Law because they have learned them from Middle School or High School. Most students can memorize Newton's Laws and can say every word of Newton's Laws. Indeed, there is no difficulty in formulating Newton's first law, where F = 0, Newton's Second Law of motion and applying the simple equation: F = ma and Newton's Third Law, the force of action is equal to the force of reaction, but its direction is opposite one another. However, students do not have a clear and correct understanding about Newton's Laws. This is because students have a concept they think makes sense about motion and in most cases. Students take a long time to change their understanding, for example understanding the Aristotelian concept of motion to Galileo's concept who believed that force changes due to motion, for example, that the net force is needed to keep an object moving at a constant speed (**Savinainen, A.2004**).

To improve students' understanding on the concept of motion and force, this study use the open source Easy Java Simulations (EJS) software (https://www.um.es/fem/EjsWiki/). EJS is a software that can be obtained free of

charge and is easy to use to simulate scientific phenomena that are easily developed by science teachers according to the indicators of learning outcomes that have been developed based on the basic competence and student characteristics. This open source EJS software allows users to develop computer simulations in accordance with the conceptual competences of science that they already have. The EJS can serve as both an effective learning and resource when it is used in an appropriate learning environment. This study aims to implement an open source EJS-based computer simulation for learning to improve Newton's Law competence for physics education students in semester 1 of Surabaya State University. There are two computer simulations that have been tested for their feasibility, they are the Computer Simulation of Motion and Force (SKGG), Computer Simulation of Action and Reaction Force (SKGAR)

2.Significance Of The Study

With the implementation of this research, the expected benefits are as follows: 1. For teachers, as input in providing alternative solutions to problems for improving the teaching and learning process to improve students' understanding on the concept of motion and force. 2. For students, this study is an alternative that can improve students' understanding on the concept of motion and force. 3. For readers, it can increase knowledge and can be used as a guide for motion and force. 4. Computer simulations developed in this study are believed to help not only to improve understanding on the concept of straight motion and force, but also to improve skills and attitudes if the computer simulations are implemented in learning through a scientific approach.

3.Review Of Related Studies

EJS software for science learning makes it very easy to achieve learning objectives, **Sari, D. P. & Madlazim (2015b)** show that students who are treated in Experiments by using only computer simulations or Computer Simulations Experiment (CSE) with students who were given a combination treatment of CSE and hands-on experiment (HoE) (CSE + HoE) were much better than students who were given HoE treatment only. In addition, it is interesting to note that the difference in mean scores between those treated with CSE + HoE and those treated with CSE only was very small and not statistically significant. This is consistent with the findings of **Zacharia, Z. C. & Anderson, O. R. (2003; 2007)**. Their findings indicated that students who studied physics through experiments by using computer simulations experienced a deeper conceptual understanding compared to students who were treated by using conventional laboratories. Computer simulation-based learning can be used to help students to understand the concepts of physics through physics experiment activities **(Zacharia, Z. C. & Anderson, O. R.2003; 2007)**.

4.Objectives Of The Study

The general objective of this research is to test the feasibility of a Computer Simulation of Motion and Force (SKGG), Computer Simulation of Action and Reaction Force (SKGAR), for learning Newton's Law. The specific objectives of the study are: 1. Describe the validity of the SKGG and SKGAR for learning Newton's Law to improve students' understanding on the concept of motion and force. 2. Describe the practicality of the SKGG and SKGAR for learning Newton's Law. 3. Describe the effectiveness of the SKGG and SKGAR for learning Newton's Law.

5.Hypotheses Of The Study

- Computer Simulation of Motion and Force (SKGG) and Computer Simulation of Action and Reaction Force (SKGAR) have valid validity to be applied in learning Newton's law.
- Computer Simulation of Motion and Force (SKGG) and Computer Simulation of Action and Reaction Force (SKGAR) are practically feasible to be applied in learning Newton's law.
- Computer simulation of motion and force (SKGG) and computer simulation Action and Reaction Force (SKGAR) are effective to be applied for learning Newton's laws

6.Population And Sample

Subjects in the computer simulation trial were 27 students in semester 1 of the Surabaya State University majoring physics education study program. After the computer simulation was developed, it was validated and tested to produce a viable product as stated by Nieveen, N. &Plomp, T.**(2007)**. Nieveen stated three aspects that are needed to be considered in assessing the quality of a development research product, they are validity, practicality, and effectiveness.

6.1. Data Collecting Techniques Used in the Present Study

Data collection techniques are used to obtain materials that are relevant, accurate, and can be used appropriately according to research objectives. The data collection techniques used in this study are: (1) validation techniques; (2) observation; (3) test; and (4) questionnaire.

6.2.Data Analysis and Interpretation

Data analysis in this study describes the validity, effectiveness, and practicality of computer simulation prototypes. The data analysis is inductive based on the facts used to answer the problem formulation that has been formulated in the study, which emphasizes the meaning more than generalization **(Sugiyono, 2014)**.

6.3.Computer Simulation Validity

The results of the computer simulations development are used to support the teaching and learning process in accordance with the characteristics of students and the characteristics of the motion and force material. Validation needs to be done in the development of this computer simulation to determine the its feasibility. The validation process of computer simulations is carried out through theoretical validation. Theoretical validation is validity that is determined based on expert judgment, so the developed computer simulation will be validated based on the validator's consideration. To obtain theoretical (logical) validity, a search was carried out in terms of structure (construct validation) **(Nieveen, N. &Plomp, T. 2007)**. The developed computer simulations include: content, navigation, interactive, feedback, and screen design from computer simulations (**Gambari, I. A. and, Yusuf, M. O.2014**).

The results of computer simulations development (Table 1) were validated by 2 validators with the average result of the computer simulations validation was 3.72 in the very valid category (**Ratumanan, G.T. & Laurens 2006**). This result indicates that the developed computer simulation is valid to be used by teachers in learning after being revised according to suggestions from the validator. Data analysis of the computer simulation validation results is in Table 1 below.

Table.1. Results of the Computer Simulation Validity Evaluation by 2 Expert Validators**.**

No	Scored Aspect	Scoring		Average
		V1	V2	4,0
1.	Content	4	4	3,5
2.	Navigation	4	3	3,5
3.	Interactive	4	3	3,5
4.	Feedback	4	3	3,5
5.	Screen design	4	3	3,5
Average				3,6
Compatibility				88,8%

Notes:V1: Validator 1; V2: Validator 2

Based on Table 1, the results of the assessment by two validators on the computer simulation get a value of 3.6 means that it is very valid and the suitability of the assessment by the two validators is 88.8%, then the computer simulation developed by the next researcher can be used in trial II. The results of the validation in the form of suggestions and input by the validator and the improvements made by the researcher are presented in Table 2 below:

Table.2. Results of the Computer Simulation Validity Evaluation by 2 Expert Validators**.**

No	Suggestions/Inputs	Revision
1.	Content (content): In order to pay close attention for finding numbers, objects are made more rational.	It has been observed both the discovery of numbers and texts and symbols of physical quantities and their rationality.
2.	Navigation: The data input format should be made a slider and still input numbers for a certain quantity	Sliders have been made to input data.
3.	Interactive: -	-

No	Suggestions/Inputs	Revision
4.	Feedback: Make it easier for the button to create the initial conditions, t = 0.	A button has been created for t = 0.
5.	Screen design: We recommend that the screen can be minimized and maximized.	Minimized and maximized buttons have been created
6.	Guide: We recommend that it starts from how to install	It has been given an explanation how to install this computer simulation, it is very easy to be installed.

Table.3. EKGG Validation Results**.**

Component	No	Statement	Scoring		
			V1	V2	Average
A. MATERIAL	1	The problem is according to indicator	3	3	3
	2	There is a limit to the question or statement that leads to the expected answer	4	4	4
	3	The answer choices are homogeneous and logical	4	4	4
	4	There is one answer that is the most correct	4	4	4
B. CONSTRUCTION	5	There are clear instructions on how to solve the problem	4	3	3,5
	6	There is a scoring guide	4	3	3,5
	7	Tables of figures, charts, maps, or the like are presented clearly and legibly	3	4	3,5
	8	Contain precise and efficient statements	3	3	3
	9	The statement has no clue to the answer	4	3	3,5
	10	Does not have a double negative statement	4	4	4
	11	The length of the answer formulation is relatively the same	4	4	4
	12	The answer choices contain the contents of the material instead of repeating all true or all false	4	3	3,5
	13	Consecutive use of numbers and times	4	4	4
	14	Not sequencing questions between numbers	4	3	3,5
C. LANGUAGE	15	The question formulation uses simple / communicative language	3	4	3,5
	16	Item questions use language in accordance with the rules of the language in the subject	3	3	3
	17	The formulation of the questions uses words / sentences that do not cause multiple interpretations or misinterpretations	3	3	3
	18	The formulation of the questions does not contain words that can offend the test takers	4	4	4
	19	The formulation of questions uses denotative / non-connotative language	3	3	3
Average					3,6
Compatibility					**94,8%**

Notes:V1: Validator 1; V2: Validator 2

Table.4. Summary of the revised ECGG by the validator**.**

No	Suggestions/Inputs
1.	The instructions for filling out the questions need to be clarified
2.	There is a picture that needs to be adjusted to the

	question

6.3.1.Practicality of The Computer Simulation

Two observers observed the practicality of using computer simulations as a learning tool. The implementation of the guided discovery model lesson plan in the second trial was carried out for 3 meetings which are the implementation of the lesson plan. The summary of the observation results on the implementation of the lesson plan by two observers in the trial II is presented as follows.

6.3.1.1.The Implementation of Lesson Plan in Trial II

In summary, the implementation of the guided discovery model lesson plan in the second trial can be seen in Figure 1.

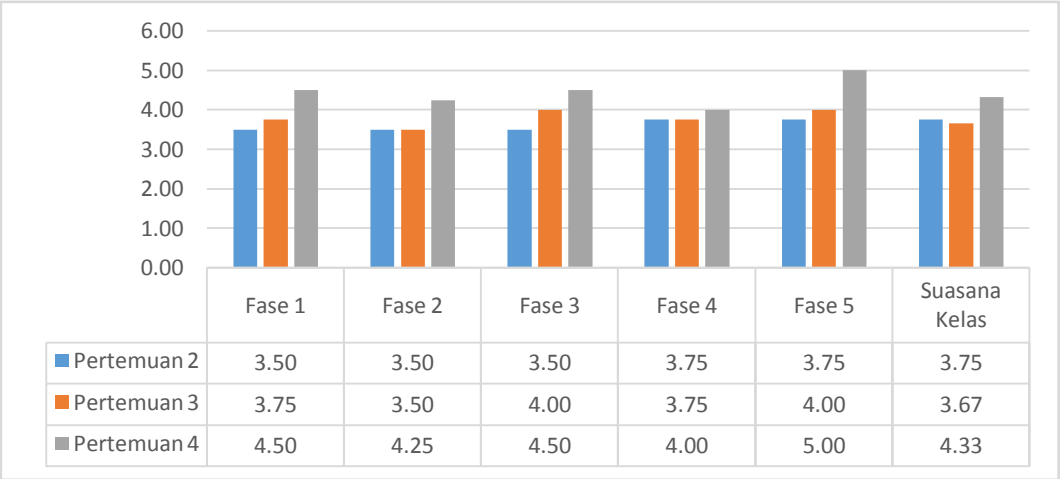


Figure.1. Results of The Lesson Plan Trial II.

Information:
Phase 1: Delivering motivation and goals, and presenting some problem information
Phase 2: Explaining the steps for discovery and organize student in studying.
Phase 3: Guiding students to work on investigation activities / results of discovery activities.
Phase 4: Guiding students to present the results of the investigation / the results of discovery activities.
Phase 5: Analysing the discovery process and provide feedback.

Based on Figure 1, all the activity stages in the lesson plan in the trial I are carried out and the overall average score of implementation is 3.8 in the good category (**Ratumanan, G.T. & Laurens 2006**). The lesson plan implementation instrument has an average suitability of 96.5% and is categorized as good (**Borich, G. 1994**).

6.3.1.2.The Responds Toward Computer Simulations

In summary, student responses toward the computer simulations used by students during learning in trials I and II are presented in Table 6 below**:**

Table.5. Summary of the revised ECGG by the validator**.**

No.	Component	Respondent's Opinion			
		Trial I		Trial II	
		Easy	Not Easy	Easy	Not Easy
1	Content	100%	0%	100%	0%
2	Navigation	100%	0%	100%	0%
3	Interactive	100%	0%	100%	0%
4	Feedback	100%	0%	100%	0%
5	Screen Design	100%	0%	96%	4%

Student responses to the students learning components are interested in the given learning components, feel new to these components, easily understand the learning components and state that learning with the guided discovery model can improve their understanding on the concept of motion and force.

6.3.2.Effectiveness of Computer Simulation Instrument to Evaluate the concept of Motion and Force

To test the effectiveness of computer simulations in learning Newton's law, an instrument to evaluate the concept of motion and force is needed. The test of student learning outcomes about motion and force in the form of an Evaluation on the Concept of Motion and Force (EKGG) was made in the Indonesian version based on the motion and force indicators of the Force Motion Concept Evaluation (FMCE) instrument (**Thornton, R. K. &Sokoloff, D. R. 1998**). The Indonesian version of motion and force concept (EKGG) has been validated by two expert validators. The results of the average assessment of 2 expert validators on the student's motion and force concept (EKGG) product assessment sheet is 3.55 in the very valid category (**Ratumanan, G.T. & Laurens2006**) and 94.8% compatibility was reliable. The results of the feasibility assessment for the assessment of product learning outcomes can be seen briefly in Table 3 below.

The result of motion and force concept learning outcomes test are given to students before and after the learning in the classroom by using the computer simulation. The learning outcome tests are given before the learning activity to see students' initial abilities. The learning outcome test is given after the learning activity to see the ability of students' competency in the concept of motion and force after being taught with a guided discovery model. Students are said to be complete in understanding the concepts of motion and force, if the minimum achievement is (B) with a minimum score of 70. In summary, the analysis of learning outcomes in the students' understanding of the motion and force concept is shown in Tables 6 and 7.

Table.6. Completeness and N-gain of The Students' Understanding on Motion and Force Concept in The Trial I in class**.**

Student's Number	Completeness of *Pre-test*		Completeness of *Post-test*		*N-Gain*	Category	Notes
	U1	P	U2	P			
1	3,33	D	0,66	Medium	0,66	Medium	Complete
2	16,67	D	0,84	High	0,84	High	Complete
3	6,67	D	0,82	High	0,82	High	Complete
4	20,00	D	0,67	Medium	0,67	Medium	Complete
5	10,00	D	0,67	Medium	0,67	Medium	Complete
6	13,33	D	0,77	High	0,77	High	Complete
7	3,33	D	0,76	High	0,76	High	Complete
8	10,00	D	0,74	High	0,74	High	Complete
9	6,67	D	0,68	Medium	0,68	Medium	Complete
10	6,67	D	0,64	Medium	0,64	Medium	Complete
11	3,33	D	0,79	High	0,79	High	Complete

Notes: P: Predicate; U1: *Pre-test*; U2: *Post-test*

Table.7. Completeness and N-gain of The Students' Understanding on Motion and Force Concept in The Trial II in class**.**

Student's Number	Completeness of *pre-test*	Completeness of *Post-test*	*N-Gain*	Category	Notes
	O_1	O_2			
1	19	81	72.22	High	Complete
2	33	81	78.26	High	Complete
3	15	78	70.00	High	Complete
4	26	85	80.95	High	Complete
5	22	81	76.19	High	Complete
6	22	85	82.61	High	Complete
7	15	81	73.68	High	Complete

8	30	85	77.78	High	Complete
9	33	81	78.26	High	Complete
10	15	89	85.71	High	Complete
11	22	85	80.00	High	Complete
12	26	85	80.95	High	Complete
13	22	81	75.00	High	Complete
14	26	89	83.33	High	Complete
15	33	78	68.42	Medium	Complete
16	30	85	80.00	High	Complete
17	26	81	75.00	High	Complete
18	26	85	78.95	High	Complete
19	30	89	85.00	High	Complete
20	26	85	80.00	High	Complete
21	26	93	90.48	High	Complete
22	22	85	82.61	High	Complete
23	15	89	85.71	High	Complete
24	22	78	70.00	High	Complete
25	26	89	85.00	High	Complete
26	26	89	85.00	High	Complete
27	26	85	85.19	High	Complete

Notes:O1: *Pre-test*; O2: *Post-test*

7.Discussion

The developed computer simulations in this study consist of two parts, they are the computer simulation of motion and force (SKGG) as shown in Figure 1 and Figure 2 and the computer simulation of action and reaction force (SKGAR) as shown in Figure 3. The developed SKGG and the SKGAR designs followed the simulation development design by using the open source Easy Java Simulations (EJS) software, in which its details steps following the stages described by **Madlazim & Sari, D.P.(2014)**.

force, speed and acceleration versus time so that the user can understand more about the concepts of motion and force. There are five aspects, namely aspect of content, navigation, interactive, feedback, and screen design (**Gambari, I. A. and, Yusuf, M. O.2014**) which are taken into consideration in developing the sim

Figure.2a. SKGG for the application of Newton's First Law for objects moving in a regular straight motion on a flat plane.

ulation.

In this study, a computer simulation of the motion and force concept has been developed, as in Figure 2. The

simulation shown in Figure 2 describes the application of Newton's First Law about regular straight motion on a flat plane (Fig. 2a) and on an inclined plane (Fig. 2b). The simulation shown in Figure 2, which explains the application of Newton's Second Law about accelerated straight motionon a flat plane (4a) and on an inclined plane (Figure 4b). This computer simulation is also equipped by a graph of the relationship between the total working.

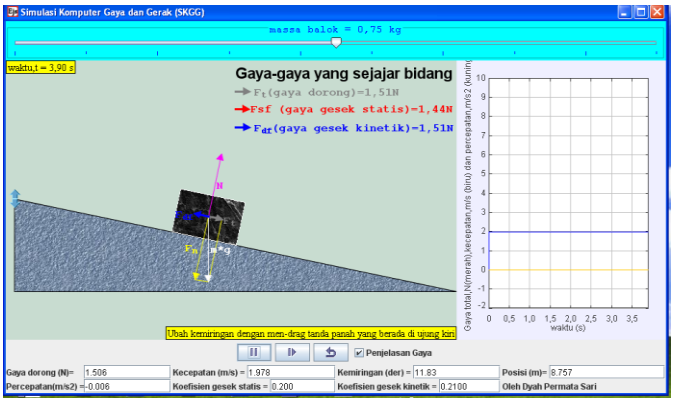
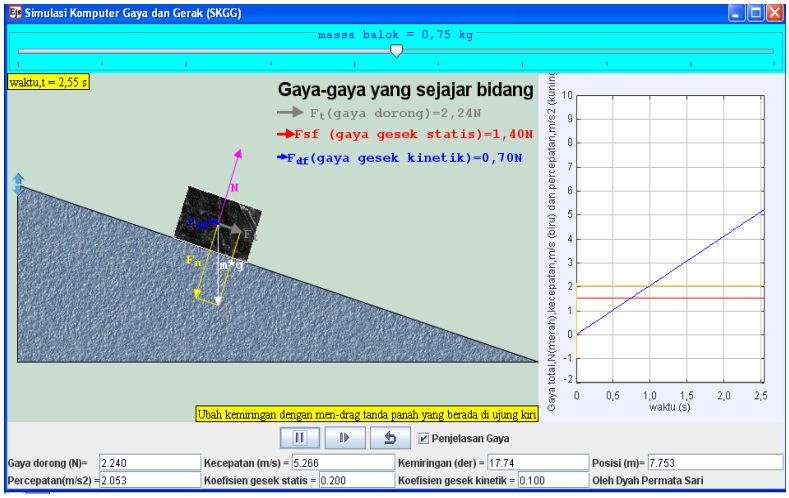


Figure.2b. SKGG for the application of Newton's First Law for objects moving in a regular straight motion d plane.

Figure.2c. SKGG for the application of Newton's Second Law for objects moving in a regular straight motion on a flat plane.

Figure.2d. SKGG for the application of Newton's First Law for objects moving in a regular straight motion on an inclined plane.



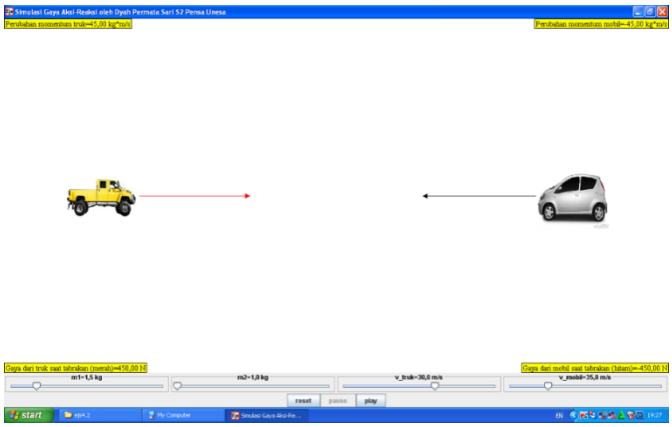


Figure.3. SKGG for the application of Newton's First Law for objects moving in a regular straight motion on an inclined plane.

The validation results of the computer simulations development that have been validated by 2 expert validators with the average result of the computer simulations validation are 3.72 with the very valid category (**Ratumanan, G.T. & Laurens 2006**) and the reliability of two validators' assessment is 92.47% which means reliable, then the computer simulations developed by researchers can then be used in trial II. These results indicate the developed computer simulation is valid to be used by teachers in learning activity after being revised according to suggestions from the validator.During the learning activity, one thing that makes students feel happy is the practicum activities by using SKGG and SKGAR and by using an approach in the form of guidance during learning when students experience difficulties.

Based on the analysis results, the learning media usage is observed by two observers. Observations are made during 3 meetings which were the implementation of the lesson plan in the developed computer simulation. Based on several learning syntaxes that have been written by several experts, the guided discovery learning syntax was adapted from the teaching and learning process stages adapted from **Nur, M. (2011), Madlazim and Supriyono (2014)**. In the lesson plan, there are five learning phases, they are 1) conveying motivation and objectives, and displaying problem information, 2) explaining the steps for discovery and organizing students in learning, 3) guiding students to work on investigating / finding activities, 4) guiding students to present the results of the investigation / the results of discovery activities and 5) analysing the discovery process and provide feedback. Overall, all the activity stages in the lesson plan in the trial II were carried out and the overall average score of implementation was 3.8 in the good category (**Ratumanan, G.T. & Laurens 2006**). The lesson plan implementation instrument has an average reliability of 96.5% and is in good category (**Borich, G. 1994**).

The high average score and with the good category is due to all stages of learning being carried out and several other things, they are, in the first phase the teacher starts the teaching and learning process by praying to instil awareness and gratitude for God's greatness, the teacher motivates students with initial activities related to the material of motion and force, the teacher conveys the learning objectives and orientates students to the problem. So that students are motivated and enthusiasm to take part in learning motion and force, this can be seen from the interest of students in the learning process. The problems that are presented at the beginning of the activity are problems related to everyday life so that the learning activities are more personally meaningful for students according to their intellectual level. This is in accordance with the opinion of **Nur, M. (2008)** that students who are motivated to learn something will use a higher cognitive process in studying the material, so that the student will absorb and listen to the material better (**Hariyono et al., 2016)**. Top-Down Learning, students start with complex problems to solve and then solve or find (with the help of lecturers) the needed basic skills (**Slavin, E. R. 2006; Sunarti, T. et al., 2018**). This is in line with the research results of **Lavine, R. A. (2005)** which show that the use of Guided Discovery serves to focus attention on real problems, making them relevant and motivating to master the basic science of related information. As well as increasing student motivation to learn.

The increase in students' understanding completeness of the motion and force concept is 100% and based on the analysis of normalized gain scores, it has been obtained that 25 students have achieved an increase in scores in the high category and 2 students have achieved an increase in their scores in medium category. Overall, all students (27 students) have achieved an increased understanding of the motion and force concept. The achievement of increased understanding of the motion and force concept can be achieved because this learning is supported by computer simulations and learning medias that provide opportunities for students to reduce student difficulties in understanding the concepts of force and motion as the findings of **Saglam-Arslam, A. &Davecioulu, Y. (2010)** and **Sari, D. P., Madlazim& Sanjaya, I. G. M. (2015a)**.

8.Conclusion

Based on the results of the analysis, discussion, and research findings, it can be concluded that the computer simulations that have been developed are valid, practical, and effective to improve understanding on the concepts of motion and force in relation to Newton's Law.

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