



Generative Learning Strategy Assisted by Flash Animation to Remediate Students' Misconceptions on Newton's Law of Gravity

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Abstract. The generative learning strategy assisted by *flash* animation had not been applied to overcome learners' misconceptions. This research aims to find out the effectiveness of generative learning strategy assisted by *flash* animation to remediate learners' misconceptions toward the Newton's law about gravity and to determine the way to decrease learners' misconceptions after the intervention. This research applied the quasi-experimental method with *pretest-posttest control group design*. This research was conducted at Public Senior High School 5 Yogyakarta. The population consisted all ten graders, 216 participants. The sample was taken with *purposive sampling* from X-science-mathematics-2 learners as the control group and X-science-mathematics-4 learners as the experimental group. There were seventy-two learners. The applied instruments were *two-tier multiple choice items* and the learner-interview sheet, as the non-test instrument. From the research, the obtained *N-Gain* was 0.476. The hypothesis test showed that the *t-test* obtained the *asympt.sig 2(tailed)* of 0.000 and the probability score was 0.05. The *asympt.sig (2-tailed)* was lesser than the probability score and its effectiveness was 0.988. The decreased misconception after the intervention found in experimental group was 20% while the control group was 2.30%. It meant *generative learning* strategy assisted with *flash* animation was effective to remediate the tenth-graders' misconceptions of Public Senior High School 5 Yogyakarta on Newton's law about gravity.

Keywords: Flash Animation, Generative Learning, Newton's Law of Gravity, Remediate Misconceptions

Introduction

Learning physics essentially emphasizes students to find, determine and analyze facts and principles that are obtained (Permana, 2020). Concepts taught and learned that need to be known in physics consisted of concrete and abstract concepts which are closely related to natural phenomena (Widya, et al., 2019). Abstract concepts tend to be more difficult to learn than concrete concepts (Istiyono, 2017; Pastor-Satorras & Vespignani, 2007). This abstract nature requires a more level of analysis to find the true facts in the concept (Akmam, et al., 2018). One of the abstract concepts in high school physics subjects is Newton's law concept of gravity (Kaltakçı & Didiş, 2007). This abstract concept has an impact on the learning process of students who are experiencing difficulties and in it will

finally cause misunderstanding. This error is called a misconception (Silva & Almeida, 2017; Sözbilir, 2003; Sulistri & Lisdawati, 2017).

Suparno (2013) states that misconception or misconception is an initial concept that is incompatible with scientific concepts. The consequences of misconceptions by students consistently will greatly affect the effectiveness of the student's subsequent learning process (Mustari, et al., 2020; Volfson, et al., 2020). Physics misconception could be grouped into five: (a) preconceived notion, (B) nonscientific beliefs, (c) conceptual misunderstanding, (d) vernacular misconception, and (e) factual misconceptions (Nurulwati, 2014). Misconceptions can occur due to many factors, one of which was found based on the results of observations was the difficulty of students in visualizing or imagining the concepts given (Kurniawan, 2018; Temiz & Yavuz, 2014). One of the efforts to overcome misconceptions is the method of remediation which is an activity to improve learning that is not successful in understanding subject matter (Kusmira, 2018; Widiastuti & Purwanto, 2019). Therefore, an appropriate learning to overcome learners misconception is important (Tarmizi, et al., 2020). One of them by remediating learners with generative learning assisted with flash animation (Khandale & Chavan, 2017; Zukhruf, et al., 2016). This learning can elaborate the misconception after being intervened (Andriana, et al., 2014). One of the remediation efforts that can be done is to use generative learning strategies assisted by flash animation (Khandagale & Chavan, 2017; Zukhruf, et al., 2016). It will elaborate the results on students' misconceptions after treatment (Andriana, et al., 2014).

Based on research done by Lee, et al. (2008) and Santoso & Winarti (2019), generative learning strategies have several advantages in accordance with model criteria that can be used to overcome misconceptions, namely giving students the opportunity to express their understanding of a concept, giving students the opportunity to explore their initial conception, especially students with misconceptions. Then students are expected to be aware of the misconceptions that occur in their minds and be willing to correct these misconceptions, and provide opportunities for students to construct their own knowledge based on conceptual findings in learning science objects (Abdalla, et al., 2004; Caleon & Subramaniam, 2010; Osborne, et al., 2003; Sulistri & Lisdawati, 2017; Winarti, et al., 2017). Primayoga, et al., (2013) in his research revealed that the use of generative learning strategies can significantly reduce misconceptions about physics material. Meanwhile, Andriana, et al., (2014) in his research revealed that using flash animation can reduce student misconceptions by 50.95% and has an effect size of 1.58 with a high category. Generative learning strategy is a learning that emphasizes the affective integration of new knowledge using the knowledge that students already have by fostering curiosity. This learning strategy requires students to be able to construct their own science or concept in a learning environment (Santoso & Winarti, 2019). Multimedia is capable of integrating various media types, both figures and interactive audios. Thus, learning will be more opened and varied and able to maximize the communication process (Zulfa & Haryanto, 2021). As one of learning media, flash animation is one of the products of adobe flash devices that can be used for visualization of objects by creating animated movies equipped with scripts for programming (action scripts). Under the use of this program, it allows the creation of interactive media animations in the form of animations that can be used for learning science and physics at school from teachers to students (Annisa, et al., 2020; Kholiq, 2020).

Based on the results of the identification of misconceptions of class X students at SMAN 5 Yogyakarta, there were 12 categories of misconceptions experienced in Newton's law concept of gravity, including: (1) Students considered there is no gravitational force in outer space, (2) Students considered the acceleration of objects to be influenced by mass objects, (3) Students considered the weight of objects on earth to be inversely proportional to their distance from the center of the earth, (4) Students considered that objects always

pull in a parallel or horizontal position, (5) Students considered the acceleration of gravity and gravitational force to be the same, (6) Students considered that The gravitational force is influenced by the distance between the surfaces of objects, (7) Students assumed that the gravitational force is influenced by the size of the object, (8) Students assumed that the moon will not fall, (9) Students assumed that the gravitational force is the same for all falling objects, (10) Students assumed that the direction of the gravitational force is influenced by the direction of the object's motion, (11) Students assumed that the magnitude of the gravitational force on the satellite is influenced by rotation time, and (12) Students assumed the gravitational force experienced by the earth to be greater than the moon. This shows that it is necessary to remediate the class X students' conceptions of Newton's law material about gravity at SMAN 5 Yogyakarta.

The purpose of this study was to determine the effectiveness of generative learning strategies assisted by flash analysis to remediate the misconceptions of Newton's law material of gravity in class X students at SMAN 5 Yogyakarta and determine the decrease in misconceptions of class X students at SMAN 5 Yogyakarta after being given treatment using strategies generative learning based on flash animation. The results will reflect on the students' misconceptions on physics.

Methods

This research is a quasi-experimental research conducted at SMAN 5 Yogyakarta in the second semester of the 2019/2020 academic year. The research design used in this study is a pretest-posttest control group based on the findings from the field study at school. This research design can be seen in Table 1.

Table 1. Research design

Group	Pretest	Treatment	Posttest
Experiment	Y ₁	O	Y ₂
Control	Y ₁	O ₂	Y ₂

The population in this study were all students of class X MIPA at SMAN 5 Yogyakarta. The population consisted of 6 classes which are X MIPA 1 to X MIPA 6 with a total amount of 216 students. The sampling technique used in this study was non-probability sampling, namely purposive sampling. Based on sampling technique used, class X MIPA 2 was chosen as the control class and X MIPA 4 was chosen as the experimental class respectively. Data collection techniques used in this study were test and non-test techniques. Both were used for respective triangulation.

The test technique used was in the form of a diagnostic test in the form of a multiple-choice test with scientific reasoning (two-tier multiple-choice items) (Kaltakçı & Didiş, 2007; Silva & Almeida, 2017; Sözbilir, 2003). This diagnostic test consists of 6 indicators, namely: 1) determining the effect of the gravitational force, 2) analyzing the line of work and direction of the gravitational force of interacting objects, 3) identifying the gravitational acceleration and gravitational field strength at different positions, 4) analyzing the weight relationship with the distance of the object, 5) analyzing the relationship between the magnitude of the gravitational acceleration and the height of the object, and 6) analyzing the planetary motion in the solar system based on the Kepler law (Aryani, et al., 2019; Nijkamp, 2013). Of the 6 indicators, it was developed into 15 test questions for the pretest and posttest. Meanwhile, for non-tests using an open interview test sheet to follow up on

students' answers on the test answer sheet. From the students' answers then analyzed, they were analyzed with the categories of understanding, misconceptions, and not understanding.

It can be seen from each answer choice and the students' scientific reasoning of the questions for the possible answers from students can be seen in Table 2 (Jauhariyah, et al., 2018; Mustari, et al., 2020; Volfson, et al., 2020).

Table 2. Category of students' conceptual understanding level

No.	Students' Answer Pattern	Conceptual Understanding Category
1	Correct Answer – Correct Reasoning	Understand the Concepts
2	Correct Answer – Incorrect Reasoning	Misconceptions
3	Incorrect Answer – Correct Reasoning	Misconceptions
4	Incorrect Answer – Incorrect Reasoning (related)	Misconceptions
5	Incorrect Answer – Incorrect Reasoning (not related)	Do Not Understand the Concepts

The procedure of this study consisted of three stages, namely: 1) the preparation stage, 2) the implementation stage, and 3) the final stage.

Preparation Stage

The steps taken during the preparation stage included: 1) making observations at SMAN 5 Yogyakarta for teachers and students and formulating research problems; 2) preparing learning tools in the form of learning implementation plans with generative learning strategies assisted by flash animation and diagnostic test questions of misconceptions; and 3) conducting logical validation in the form of a learning implementation design with a generative learning strategy assisted by flash animation and misconception diagnostic test questions and empirical validation for diagnostic test questions (Irwansyah, et al., 2018). The preparation was done based on pilot study (Barak & Dori, 2009).

Implementation Stage

The implementation stage consisted of: 1) providing a pretest to 6 class X MIPA at SMAN 5 Yogyakarta; 2) analyzing the misconceptions based on the results of the students' answers, then 2 classes were selected with the highest percentage of misconceptions as research subjects, namely X MIPA 2 as the control class and X MIPA 4 as the experimental class; 3) conducting treatment activities (intervention) in the form to remediate to class X MIPA 2 students using generative learning strategies assisted by flash animation and X MIPA 4 with conventional learning assisted by using the help of Powerpoint; 4) providing a final test (posttest); and 5) conducting interviews with students to validate the students' answer on test (Merta, et al., 2017; Parinduri, et.al., 2017).

Final Stage

The final stage consisted of: 1) analyzing data on the results of the initial and final tests to determine the level of student misconceptions before and after being given the treatment or intervention; 2) performing the normality test, homogeneity test, t test, and effect size to determine the effectiveness of remediation; 3) drawing conclusions based on the results of data analysis; and 4) inferring and compiling research results. The analysis of this study was drawn by the end of the stage (Creswell & Garrett, 2008; Lincoln & Guba, 1985; Singhal, et al., 2003; Smith, et al., 2011; Soemartono, 2014).

Results and Discussion

Pretest Results

The initial test (pretest) was given to class X MIPA 1 to X MIPA 6 to determine the profile of misconceptions in each class, presented in Figure 1.

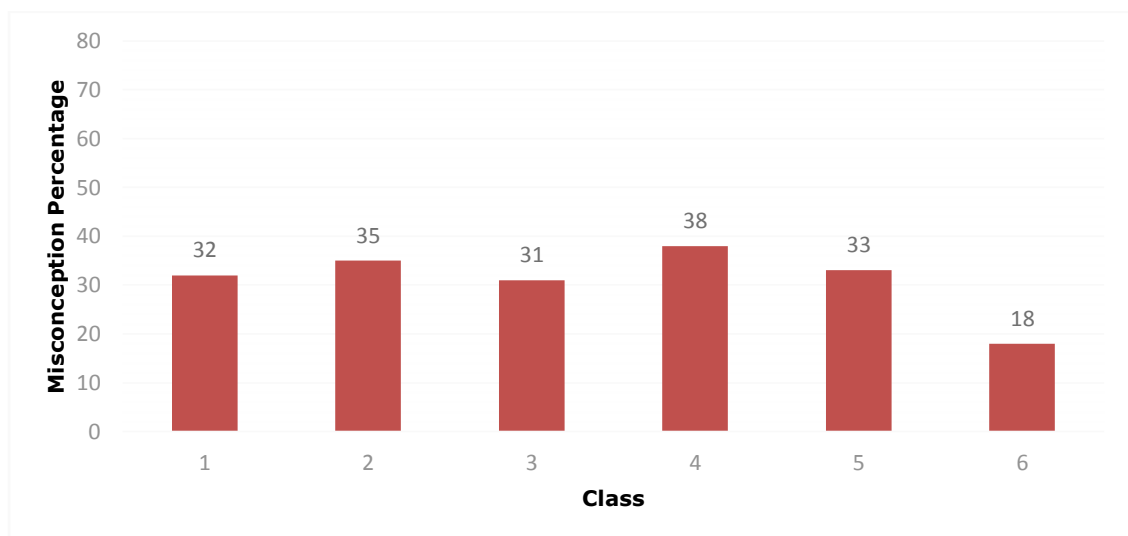


Figure 1. Students' misconceptions profile on pretest results

Based on Figure 1, it is known that each class experiences misconceptions with varying percentages. The highest misconception experienced by students of class X MIPA 2 and X MIPA 4 so that these classes were selected through purposive sampling. Meanwhile, the students' misconceptions were also drawn from lesson plan indicators. The profile of students' misconceptions from class X MIPA 1 to X MIPA 6 on each indicator on the chapter studied during the research is shown in Figure 2.

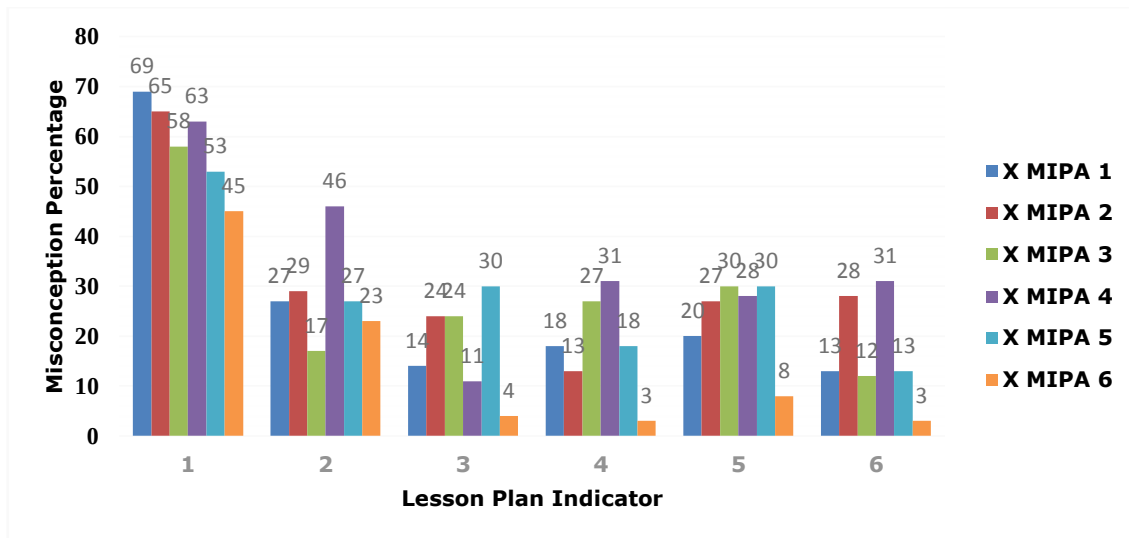


Figure 2. Students' misconceptions profile on pretest results of on each indicator

Based on Figure 2, it is known that students experienced the highest misconception on indicator 1, namely determining the effect of gravitational force while the lowest is on the indicator 3, namely analyzing motion in planets in the solar system based on Keppler's law. These results will be continued to posttest.

Posttest Results

The final test (posttest) is carried out after being given treatment or intervention using generative learning strategies for the experimental class and conventional learning for the control class. The following shows the results of the final test (posttest) of the control and experimental classes in Figure 3.

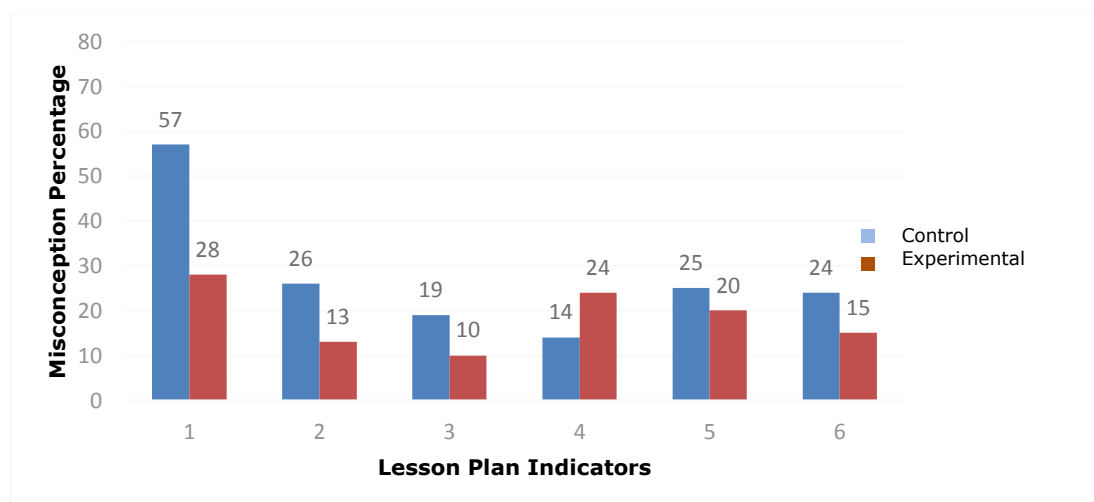


Figure 3. Students' misconceptions profile on posttest results of on each indicator

Misconception Data Recapitulation on Pretest and Posttest at Control and Experimental Classes

Based on the results of the pretest and posttest that have been carried out, the recapitulation of data is obtained as in Table 3.

Table 3. Students' level of conceptual understanding in both control and experimental classes per indicator

No.	Data condescending	Frequency of students experienced misconceptions per indicator			
		Pretest		Posttest	
		Control class	Experimental class	Control class	Experimental class
1	The highest misconception	10 (67%)	8 (50%)	10 (67%)	6 (40%)
2	The lowest misconception	0 (0%)	2 (13%)	1 (7%)	0 (0%)
Mean		0.35	0.40	0.32	0.20

Table 3 showed the data on the number of students experienced misconceptions per indicator decreased based on the average score (mean score) of data condescending. In the control class, it decreased from 0.35 to 0.32. Meanwhile, the data on the number of students experienced misconceptions per indicator in the experimental class decreased from 0.40 to 0.20. Furthermore, the data on the number of students who experienced misconceptions is presented in Table 4.

Table 4. Students' level of conceptual understanding in both control and experimental classes

No.	Data condescending	Frequency of students experienced misconceptions			
		Pretest		Posttest	
		Control class	Experimental class	Control class	Experimental class
1	The highest misconception	11 (73%)	10 (67%)	10 (67%)	6 (40%)
2	The lowest misconception	0 (0%)	1 (3%)	1 (7%)	0 (0%)
Mean		5.833	5.167	4.833	2.889

Based on Table 4, The data obtained by the number of students who experienced a decrease in the average misconception in the control class was 5.833 to 4.833 while the number of students who experienced a decrease in the average misconception in the experimental class was 5.167 to 2.889.

Data Recapitulation on Misconception, Understand the Concept, and Do Not Understand the Concept

There were differences in student data results before and after being given treatment due to pretest and posttest as shown in Figure 4. Figure 4 shows the data of

control and experimental classes on conceptual understanding pattern of misconception, understand the concept, and do not understand the concept.

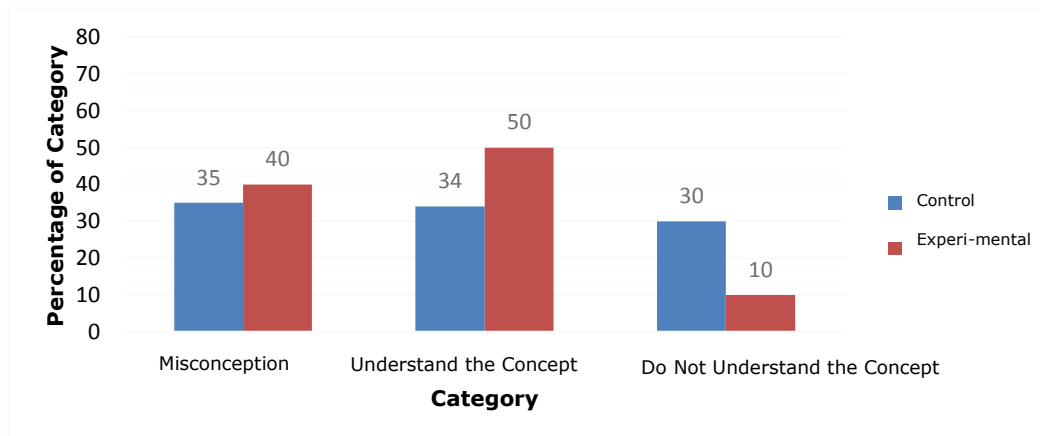


Figure 4. Students' misconceptions profile on pretest results at control and experimental classes on each category

Figure 4 shows the students' misconceptions profile on pretest results. Both control and experimental classes showed different results. Experimental class was classified mostly on the "understand the concept" category, while control class was classified mostly on the "misconception" category. Figure 5 shows the posttest results of students' misconceptions on posttest results after the intervention.

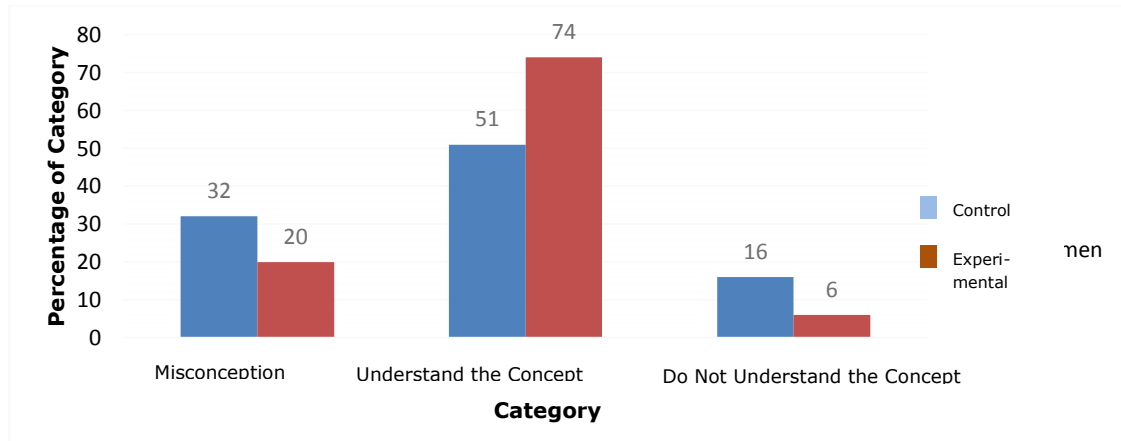


Figure 5. Students' misconceptions profile on posttest results at control and experimental classes on each category

Based on Figure 5, it shows that between the two classes at the time of the pre-test they experienced the level of "misconception", "understand the concept", and "do not understand the concept" which tended to be equal. After being given different treatments between the control class and the experimental class, the result is a difference in the percentage of results on the final test (posttest). It shows that experimental class held the "understand the concept" category more than control class. Students who did not understand the concept decreased.

The test results obtained are then carried out the normality test, homogeneity test, t test, N-Gain and effect size test, as shown in Table 5.

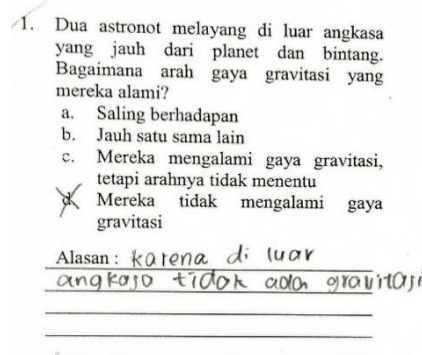
Table 5. Students' level of conceptual understanding in both control and experimental classes

Statistics test	Pretest		Posttest	
	Control class	Experimental class	Control class	Experimental class
Normality	0.176	0.530	0.063	0.129
Homogeneity		0.710		0.402
t test		0.157		0.000
N-Gain score	-0.022	0.476	-0.022	0.476
Effect size		0.272		0.998

Based on the following table, it appears that the two classes of students are normally distributed. This is because the class significance value shows more than 0.05. Meanwhile, the test for homogeneity indicates that the two classes were homogeneous or had the same variant because the significance value on the Levene's test showed more than 0.05. Furthermore, the t test is carried out. The Sig. (2-tailed) value is obtained. After being given treatment in the control class, the Sig. (2-tailed) 0.157 is greater than the Alpha value of 0.05 while the experimental class is 0.000 smaller than the Alpha value. The N-Gain test score in both classes was obtained in the control class of -0.022 with the low category and in the experimental class of 0.998 with the moderate category. And on the test effect size of the two classes at the pretest is 0.272 and at the posttest is 0.998.

Analysis of Students' Misconceptions on Chapter Newton's Law of Gravity

Based on the research, the high percentage of misconceptions experienced by students is because the information provided is not in depth and students tend to only accept the material as in indicator 1 determines the effect of the force of gravity. Students assumed that there is no gravity in outer space, as shown in Figure 7.

**Figure 6.** Sample of students' pretest answer about gravity on outer space

Based on the picture of Figure 8, the questions given was to determine the effect of gravitational force. At pretest results, students assumed that there was no gravitational force in outer space on the grounds that it was so far away that objects were not attracted as they were on the earth's surface and seemed to be floating.

After being given treatment with generative learning strategies assisted by flash animation and given the same concept at the posttest there was a change in student understanding. The change of the answer results was shown in Figure 7.

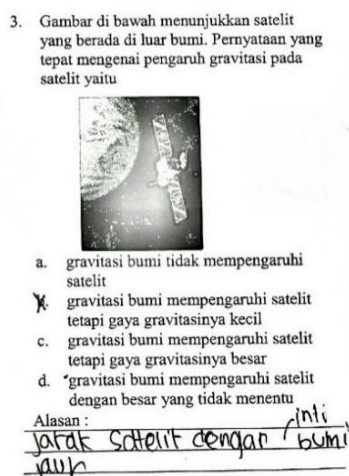


Figure 7. Sample of students' posttest answer about gravity on outer space

Students are able to answer correctly that in outer space there is a gravitational force because the distance is very far. As by addressing the answer, students stated that the reasoning was related to the small value of distance between matters. The students' conceptual understanding was being better and increased after intervention. It shows that the treatment given is effective to the progress.

This research obtains that the use of generative learning strategies can be used to remediate or reduce the level of student misconceptions compared to conventional learning implemented in these schools. This is in line with the research results of Primayoga, et al., (2013) found that generative learning is able to decrease and ease students' misconceptions on understanding the physics concepts at learning. The form of learning media varied from visual, audio, and audio-visual media. One of the types of learning media is flash animation based on javascript coding program.

Flash animation is also used as an learning tools which is able to provide a more concrete learning experience through the creation of imitation forms of experience that are closer to the actual atmosphere and take place in an atmosphere without risk and can also be used as a means of sharpen the explanation of the phenomena demonstration activity using props (Zukhruf, et al., 2016). However, it can help students to improve and construct their conceptions, so that they will avoid misconceptions. This is in line with the research results of Muharrifa, et al., (2018) who was being able to remediate misconceptions in the physics concepts on high school students and one of the concepts was the law of gravity. These findings were also strengthened by Noviana (2016). The research found that the use of computer simulation media is also able to reduce student misconceptions on physics concepts compared to the use of Powerpoint as one of learning media to studying physics.

The highest misconception experienced by students in both the experimental class and the control class occurred in the indicator "determining the effect of the force of gravity". In this indicator, students were asked on question to choose the correct statement regarding the effect of the gravitational force and its reasons. As in the statement "why do astronauts appear to be hovering when in space?", the majority of students answered that in outer space there is no gravitational force because of the distance from the earth. Several indicators that have high misconceptions include analyzing the relationship between the magnitude of the acceleration of gravity and the height of the object where students still experience a misconception that the mass of objects affects the motion of

falling objects and assumes that the force of gravity is the same as the acceleration of gravity.

Interviews were conducted with several students before intervention or treatment was carried out to find out whether these students had actually experienced misconceptions. Interview can be placed to confirm students' answer. From the results of interviews, students still assume that there is no gravity in outer space and assume that when falling objects are affected by gravitational acceleration, they are influenced by the mass of the object (Nijkamp, 2013). After being given treatment, students experienced a decrease in misconceptions (20%). It is also proven that the results of interviews conducted after students get treated so students are able to explain the concept well, such as the influence of gravitational force that students explain that in outer space there is only a small value of gravitational force so that astronauts appear to be hovering, while for the influence of mass to the acceleration due to gravity and free fall motion (Dinçer, 2018). Students were able to explain that there is no relationship between the two which is proven by a mathematical equation (Naimah, et al., 2019; Nurdin, 2019).

Based on the explanation above, generative learning assisted with flash animation has brought many advantages compared to conventional learning assisted by Powerpoint which is applied in the school. Generative learning learning strategies are able to make students continue to get information and raise curiosity and various questions, with the form of clarification in scientific form regarding the correct answer by the teacher making students who were previously wrong in understanding the concept become correct because previously they have continued to think about it and are attached to it (Irwandani, 2015; Lee, et al., 2008). As the findings revealed, there is a process of mixing new and correct knowledge after carrying out the learning. This generative learning strategy has several advantages for overcoming student misconceptions, including: a) providing opportunities for students to express their understanding of a concept; b) preserving opportunities for students to explore their initial conceptions (especially students with misconceptions) then students are expected to realize the misconceptions that happens in his mind and is willing to correct these misconceptions; and c) provides opportunities for students to construct their own knowledge (Winarti, 2016; Zulfikar, et al., 2019). On the other hand, the flash animation designed in this study is made complete and interactive, not only in the form of material but also learning videos and interesting learning evaluations as evaluation materials. In addition, students become more interested in learning with the many learning visualizations provided. Based on the explanation above, it can be concluded that generative learning assisted with flash animation is effective in reducing student misconceptions on Newton's law concept of gravity which is also indicated by a decrease in the percentage of student misconceptions. The success of generative learning in physics learning were also supported by previous studies (Kusmira, 2018; Lee, et al., 2008; Muharrifa, et al., 2016; Santoso & Winarti, 2019; Yuli, 2017). As the findings drawn, generative learning strategy could be implemented on the other chapters of physics learning at school.

Conclusion

Based on the results of hypothesis testing using the t test calculation, it is found that asymp sig (2-tailed) is 0.000 less than 0.05. The N-Gain value is 0.476 and it is categorized in the medium category. The effect size value is 0.998 and it is categorized in the large effect category. To resume, it can be concluded that generative learning assisted with flash animation is effective in remediating the misconceptions experienced by class X students at SMAN 5 Yogyakarta on physics chapter Newton's law of gravity. After being given treatment with generative learning assisted by flash animation in the experimental class, the decrease in misconceptions that occurred in the experimental class was superior

to the control class. The finding can be seen from the average decrease in misconceptions in the experimental class was 20%, while in the control was 2.30% as a whole the students.

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