Adobe Flash Development Using Interaction Treatment Aptitude to Improve the Reasoning of Kinetic Theory of Gas and Thermodynamic Materials

IOP Conf. Series: Journal of Physics: Conf. Series **1467** (2020) 012012 doi:10.1088/1742-6596/1467/1/012012

Adobe Flash Development Using Interaction Treatment Aptitude to Improve the Reasoning of Kinetic Theory of Gas and Thermodynamic Materials

P Aswirna[1], P Yulianti[1], R Fahmi[1], N A Agustin[1]

[1]Universitas Islam Negeri Imam Bonjol, Padang, Indonesia
Corresponding Researcher: **primaaswirna@uinib.ac.id**

Abstract. This research aims to develop an adobe flash learning media using aptitude treatment interaction to improve reasoning. The research method was Research and Development (R&D) with 4D model design, to increase the reasoning ability, Quasi-Experimental research with a 2x2x2 Factorial research design was used. The population of this research was the entire class XI MIPA SMAN 1 Pantai Cermin in the academic year of 2018/2019. The sampling technique used was cluster random sampling. The data analysis technique used to test the hypothesis was ANCOVA. The results showed that (1) physics learning media is valid, very practical, and effective, (2) the average physics learning outcomes integrated reasoning ability on the kinetic theory of gas at XI MIPA 1 is 92 (independent) and 87.56 (re-teaching), while XI MIPA 2 is 88.83 (independent) and 90.56 (re-teaching). Learning outcomes in class XI MIPA 1 thermodynamic material are 89 (independent) and 88.31 (reteaching) while XI MIPA 2 is 85.92 (independent) and 86.78 (re-teaching). It can be concluded that the Aptitude Treatment Interaction model assisted by Adobe Flash media affects the increase in integrated learning outcomes of students' reasoning abilities which are categorized as faster students who are taught in self-learning and reteaching.

Keywords: Aptitude Treatment Interaction (ATI), Adobe Flash, Reasoning

1. Introduction

In the 21st-century, the development of science and technology is rapid. Resulting in a change in learning paradigm marked by changes in curriculum, media, and technology. Information communication technology encourages all elements of education to adapt to address the challenges in the world of education. One of 21st-century learning considered is the integration of technology as a learning medium for developing learning skills. In the 21st-century, the curriculum is not only beneficial for students and teachers but also needed to prepare a new generation [1]. The development of science and technology requires teachers to provide learning media for students.

Good learning media interpret abstract concepts that are easy to understand. With the emergence of Communication and Information Technology, especially multimedia, teachers have begun to use it to improve student learning outcomes [2]. Computer learning media as an intermediary between teachers and students in understanding the subject matter more effectively and efficiently. Computers can simulate difficult material to present, especially regarding physical phenomena that are abstract.

The use of media can make students more active in learning, especially in organizing, choosing, and integrating verbal and visual information [3]. This is proven by research conducted by Jatmika that visual learning media is quite effective and efficient to increase students' enthusiasm in learning.

The learning media used are Adobe Flash media. Adobe Flash in learning is an animation of learning media software to help teachers in conveying learning to make it more interesting and easier for students to understand and its application using a computer and LCD Projector.

Adobe Flash is an animation software that is widely used by animators to create animation professionally. Adobe Flash with its advantages can be used to create a variety of interesting animations. the use of Adobe Flash media is still very rarely used for abstract physics material making it suitable for use in gas kinetic theory and thermodynamic laws. The use of media in the learning process can foster students' interest in learning and can improve student achievement. Adobe Flash media is suitable for independent study for smart students according to the Aptitude Treatment Interaction model.

Aptitude Treatment Interaction (ATI) is a learning model that contains several effective learning strategies used for specific students according to their ability characteristics. In this learning model students are divided into two groups, namely high and low ability students.

According to Janicki & Peterson, the achievement of high -ability students are more successful in learning when they are allowed to work in seats in small mixed-ability groups rather than working alone[4]. As a result, students seem to learn more effectively in the environment in which they participate and collaborate in the learning process [5].

The giving of the ATI model of treatment has an interaction on the attitudes and emotions of students [6]. Teachers who use the ATI model must consider the treatment effect because it interacts with several characteristics of students [7].

In 1977, Cronbach and Snow stated that "As a theoretical framework, ATI (aptitude treatment interaction), is the search for a treatment that is tailored to individual differences in aptitudes, that is, treatments that are optimally effective for students of different aptitude levels" [8]. With this, Cronbach defines ATI as a model that seeks to find and find treatments that match the different abilities of students, i.e treatments that are optimally and effectively applied to students of different levels of ability.

In another article found Snow's writing which revealed that "the fact that the characteristics of person sometimes moderate the effects on those persons of instructional conditions administered to them In turn, the importance of some personal characteristics concerning some valued educational outcomes often depends on what instructional conditions are administered".

Snow's statement above illustrates a reciprocal relationship between learning outcomes obtained by students with the conditions of learning. This means that academic achievement or learning outcomes obtained by students are influenced by the learning conditions created by teachers in the classroom. Thus, implicitly means that the more suitable treatment, learning methods, treatment, which is applied by teachers with differences in the ability (aptitude) of students, the more optimal the learning outcomes of students.

Lalley & Gentile stated that certain decades of difference give the impression of using the term Aptitude Treatment Interaction (ATI) learning [9], while in other decades the term Trait Treatment Interaction (TTI) is used. So that the basic essence of the two is the same, namely carrying out learning by prioritizing the awareness that each individual is different from one another. So, according to the explanation above the writer can conclude that the ATI learning model (Aptitude Treatment Interaction) is one of the effective learning models used for certain individuals according to the abilities possessed by students.

The strengths of the ATI (Aptitude Treatment Interaction) model are that students receive services according to their needs, students who have high ability to learn independently so that they can continue the next material without waiting for the participants to be educated, students with moderate and low ability can explore their knowledge with optimal guidance from teachers, students with low ability are given additional learning (tutorials) so that they can be freer to ask about material that is not yet understood.

The lack of the ATI (Aptitude Treatment Interaction) model, which requires very careful planning to determine the treatment of each group, requires a place of study for high groups that are close to low and medium-class groups. Additional time allocation is required to conduct tutorials or re-teaching for low groups. I needed a way to give an understanding of the process. teachers must be able to show that there is no difference in learning. differences in the treatment of students. The more suitable the learning model (treatment) applied by teachers in the classroom with differences in the ability of students, the more optimal the learning achievement achieved in learning physics.

Physics learning places more emphasis on students so teachers are expected to be able to develop students' thinking abilities (reasoning). Thinking is one of the most important tools that humans use to understand and control the world around them [10]. Reasoning skills enhance the ability to build on past knowledge and experience to overcome new problems [11]. The ability of reasoning can increase the ability to build knowledge and experience of the past to overcome new problems [11].

According to Jones, the reasoning is a thought process carried out in a way to conclude. Reasoning has different meanings as suggested by experts [12], Jacob & Willis shared they thought about the meaning of reasoning as "a special form of thinking in an attempt to draw conclusions drawn from the premise, conclusions of various current knowledge and beliefs [13, 14], transforming information provided to study conclusions [15]. Therefore, to understand and master concepts, principles, and theories, as well as physical laws, require reasoning abilities. Physics questions require students' reasoning abilities to use their logical thinking in answering or solving physics problems. So far in SMA N 1, Pantai Cermin has never done learning using the Aptitude Treatment Interaction (ATI) learning model for students. Therefore, the researcher tries to research the Effect of Aptitude Treatment Interaction (ATI) Model with Adobe Flash- Based Media to Improve the Reasoning Ability of Class XI Science Students.

2. Method

This method used was Research and Development (R&D) with a 4-D model. The steps of the 4-D development model include, (1) defining, this stage consists of the initial analysis, student analysis, task analysis, concept analysis, and specification of learning objectives. (2) Design, this stage consists of instrument preparation, media selection, format selection, and initial design. (3) Development, this stage consists of two things, first, the validation of experts conducted by several experts consisting of linguists, media and content/material; second, development trials in the form of product practicality tests on Physics teachers and some students. The product practicality test is seen from the assessment of the practicality questionnaire. (4) Dissemination, this stage consists of packaging, distribution, and adoption. A product effectiveness test that has been declared valid and practical is carried out. Test the effectiveness of the product seen from the questionnaire assessment of the interests of students after using multimedia physics learning by students.

The instruments used in this study were the validity questionnaire, the practicality questionnaire, and the effectiveness questionnaire. A media validity test was given to 5 expert validators assessed from the aspect of material/content, media/construction, and language. A media practicality test is given to 2 teachers and students.

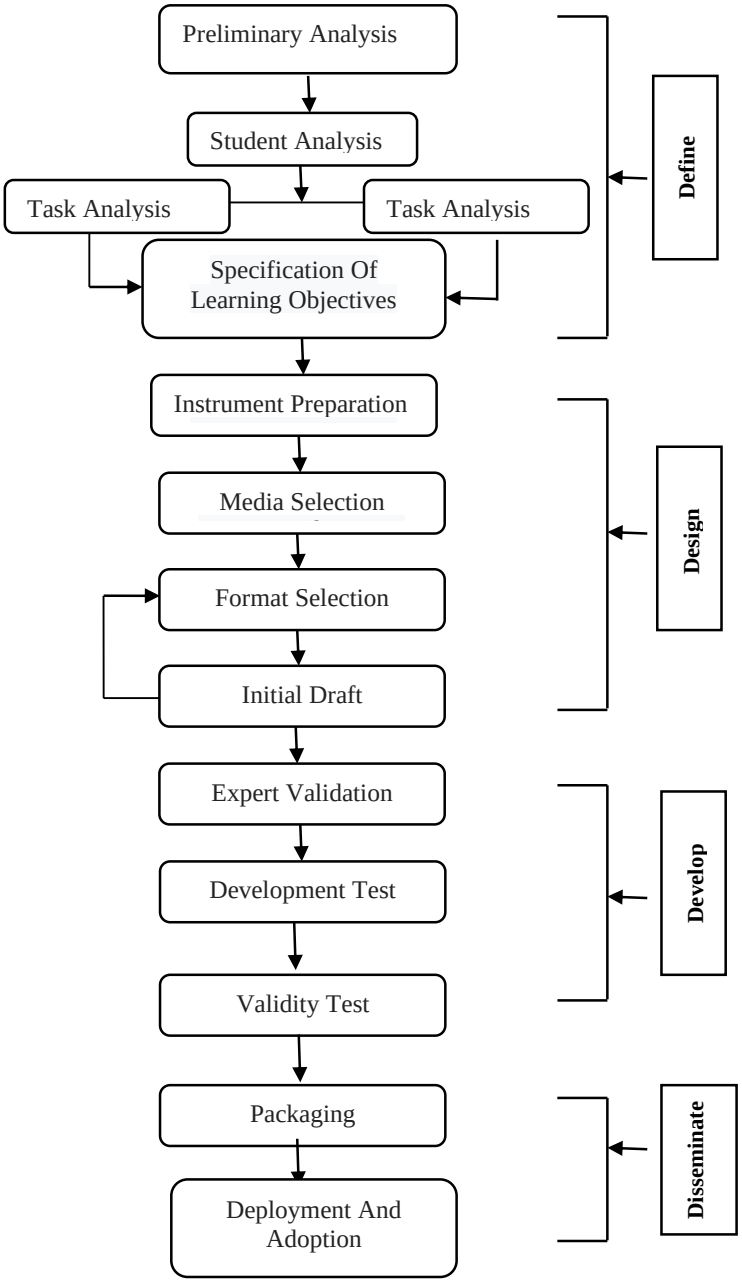

Figure 1. Development Steps

This research is quasi-experimental (quasi-experiment). The population of this research was the entire class XI MIPA SMAN 1 Pantai Cermin in the academic year of 2018/2019. The sampling technique was cluster random sampling and obtained class XI MIPA 1 as a fast ability experimental class and class XI MIPA 2 as a slow ability class. In each class, some groups have high and low abilities.

The data analysis design used in this study was a 2×2×2 factorial design with the sorting factor being the moderator variable, namely the students' initial ability.

Table 1. Factorial Design 2 x 2 x 2

Treatment		Variable	
Group / Class	Learning Variations	Covariate (X)	Bound (Y)
Class XII IPA 1	Independent learning (self-learning)	X1	Y1
	Regular teaching + tutorial	X2	Y2
Class XII IPA 2	Independent learning (self-learning)	X1	Y1
	Regular teaching + tutorial)	X2	Y2

Data collection techniques using the method of observation, interviews, and tests. Learning tools were used: (1) The syllabus, (2) Learning Implementation Plan (RPP), (3) a matter of TPA (Academic Potential Test), (4) Learning media based on Adobe Flash, and (6) about integrated reasoning capabilities. The research instrument was validated by 2 validator lecturers and 1 teacher who was able to study physics.

Before testing the hypothesis, the requirements test which includes a normality test, homogeneity variance test, and linearity test are carried out first. Hypothesis testing conducted in this study is ANCOVA using SPSS 17,0. ANCOVA is a statistical method that provides control over some of the controlling variables (covariables) that can confound the relationship between the independent variable and the dependent variable.

Analysis of covariance or ANCOVA is an advanced design (advance) of ANOVA. There are 4 requirements to conduct data analysis using ANCOVA, namely: the data used must be normally distributed, the data used must be homogeneous, and the data have an average similarity and the presence of covariate variables. The covariate in this study is the initial ability of students. ANCOVA is also used to determine whether there is an average difference between the dependent and independent variables that are influenced by the moderator (covariate) variable. The decision-making criteria, if the value α 0.05 > is significant, then H_a is rejected and H_0 is accepted, and vice versa, if Sig. <0.05 then H_0 is rejected and H_a accepted.

3. Results and Discussion

The product that has been developed is a physics learning media. This media is packaged in the form of Compact Disc (CD) with *SWF format that can be opened using a computer. Learning media products have several display pages, namely the home page, user manual page, competency page, material page, evaluation page, game page, and bibliography page.

Presentation of physics learning media data at the development stage consists of validation tests by expert experts and practicality tests by teachers and some students. Data validation results of physics learning media conducted to several experts including 1 linguist, 2 material experts, and 2 media experts. The data obtained in the form of qualitative and quantitative data.

Qualitative data in the form of suggestions and comments from the validator: During the process of validity, media development of learning physics through several revisions based on feedback from expert lecturers. The revision was carried out four times both from the media, material, and language.

3.1Validity test

A media validity test is used to measure the accuracy or validity of media use. After the media validity test is done, the validation results are obtained as shown in Figure 2.

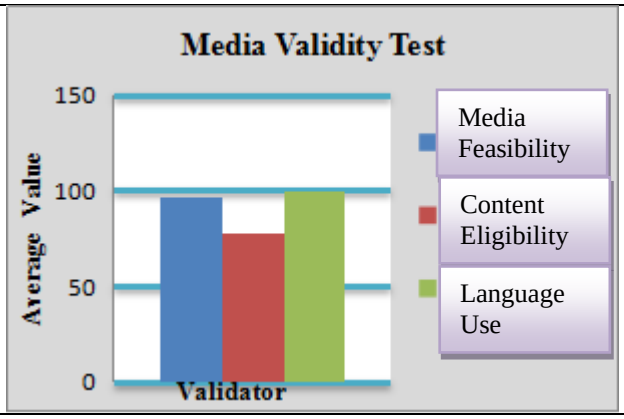

Figure 2. Average Test Results of Validity, Practicalities, and Effectiveness

Judging from the results of validation, it can be stated that the three indicators of physics learning media are in a very valid category. The validation analysis results obtained by the validator percentage of the validity of physics learning media is 91, 58 %. Based on the results of the validation it can be revealed that the physics learning media is very valid.

3.2 Practicality Test

Practicality tests are used to measure the practicality of the media. The results of the practicality test can be seen in Figure 3.

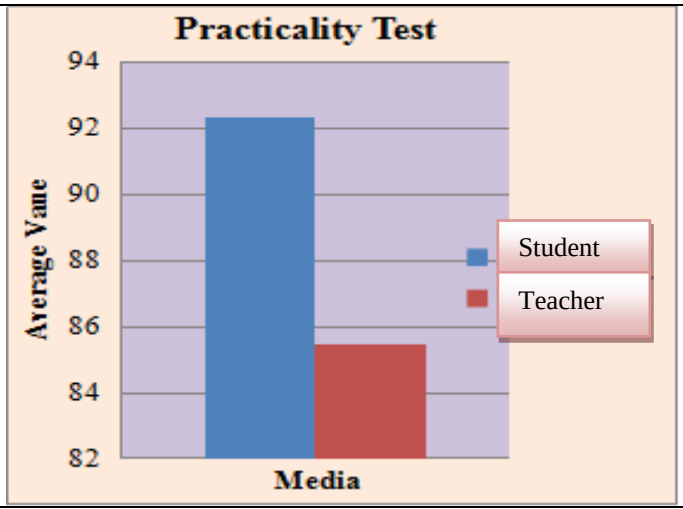

Figure 3. The Results of the Practicality Test

3.3 Effectiveness Test

The effectiveness test is used to measure the use or effectiveness of the media. The results of the media effectiveness test are based on an effectiveness questionnaire filled out by students. The results obtained effectiveness analysis is 87,3 % to the category of very effective.

On physics learning outcomes students were analyzed using ANCOVA with the SPSS program. Criteria for decision-making if the significance value> 0.05 then H0 is accepted and H a rejected, and vice versa if the significance value <0.05 m aka H0 is rejected and Ha accepted.

Table 2. Hypothesis Test Calculation Results on the Gas Kinetic Theory Material

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	817.981[a]	7	116.854	20.654	.000
Intercept	482944.817	1	482944.817	85360.190	.000
X	51.551	1	51.551	9.112	.004
Learning Variation	80.230	1	80.230	8.041	.041
Reasoning	676.395	1	676.395	119.552	.000
Class	13.244	1	13.244	2.341	.132
Learning Variation * Reasoning	40.456	1	40.456	7.151	.010
Error	294.202	52	5.658		
Total	484057.000	60			
Corrected Total	1112.183	59			

a. R Squared = .735 (Adjusted R Squared = .700)

Table 2 presents an ANCOVA test analysis on student learning outcomes integrated reasoning ability on the kinetic theory of gas. The calculations show significantly landfill is 0,004, because its value is far below the level of significance 0.05, then H_0 is rejected and H_a accepted. This means that there is an influence on the value of TPA (the initial ability of students) there is an integrated learning outcome of students' reasoning ability. Calculation of the significance of variation learning is 0,041 below the significance level of 0,05, then H_0 is rejected and H_a accepted. This means that there is an influence of learning variation on integrated learning outcomes of students' reasoning abilities.

Calculation of the significance of the class is 0.132 more than the height of the significance level of 0,05, then H_a is rejected and H_0 is accepted. This means that there is no influence between the classes on integrated learning outcomes of students' reasoning abilities. Calculation of significance corrected models is 0,000 below the significance level of 0,05, then H_0 is rejected and H_a accepted. This means that all variables jointly influence the learning outcomes of students' integrated reasoning abilities.

Based on the results of the ANCOVA test, the learning outcomes of integrated reasoning ability in the kinetic theory of gas material increased by 73,5 %. Differences in integrated learning outcomes of students' reasoning abilities using learning variations (independent and reteaching) can be seen in Figure 4 and 5:

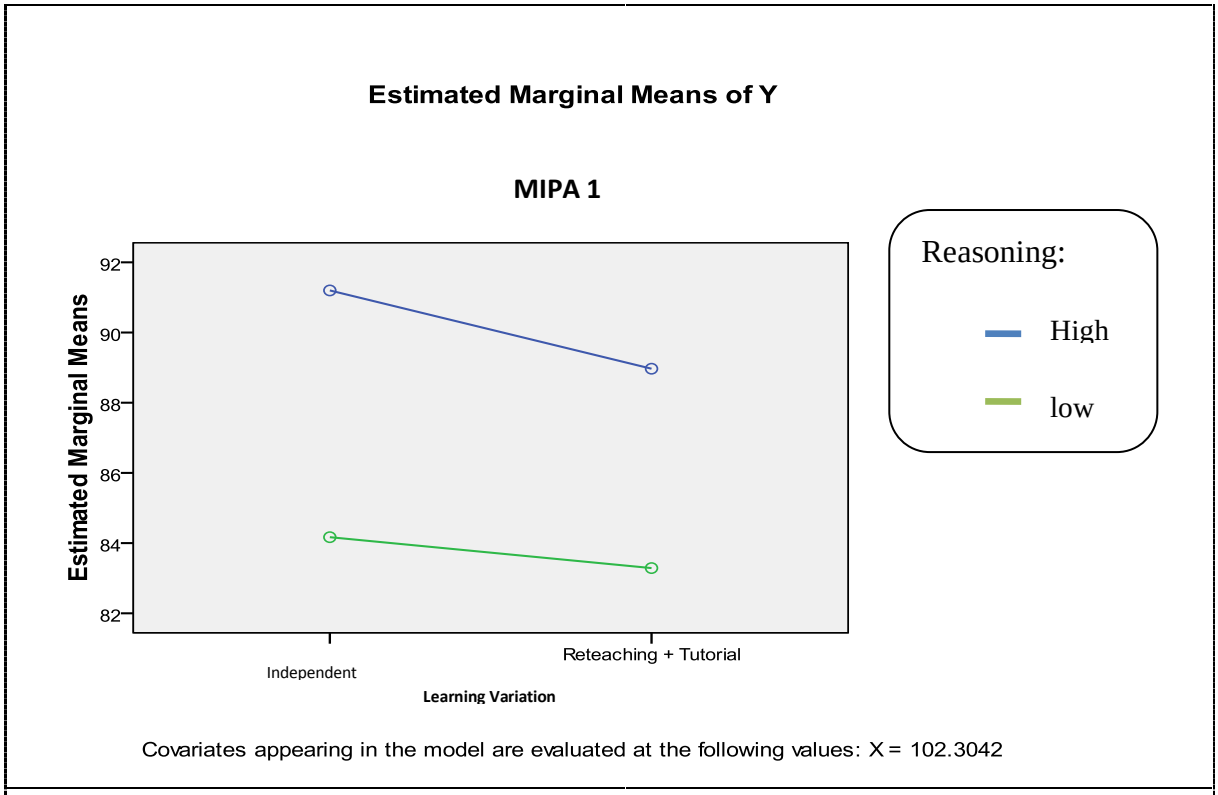

Figure 4. The Results of Students' Reasoning Ability in MIPA 1

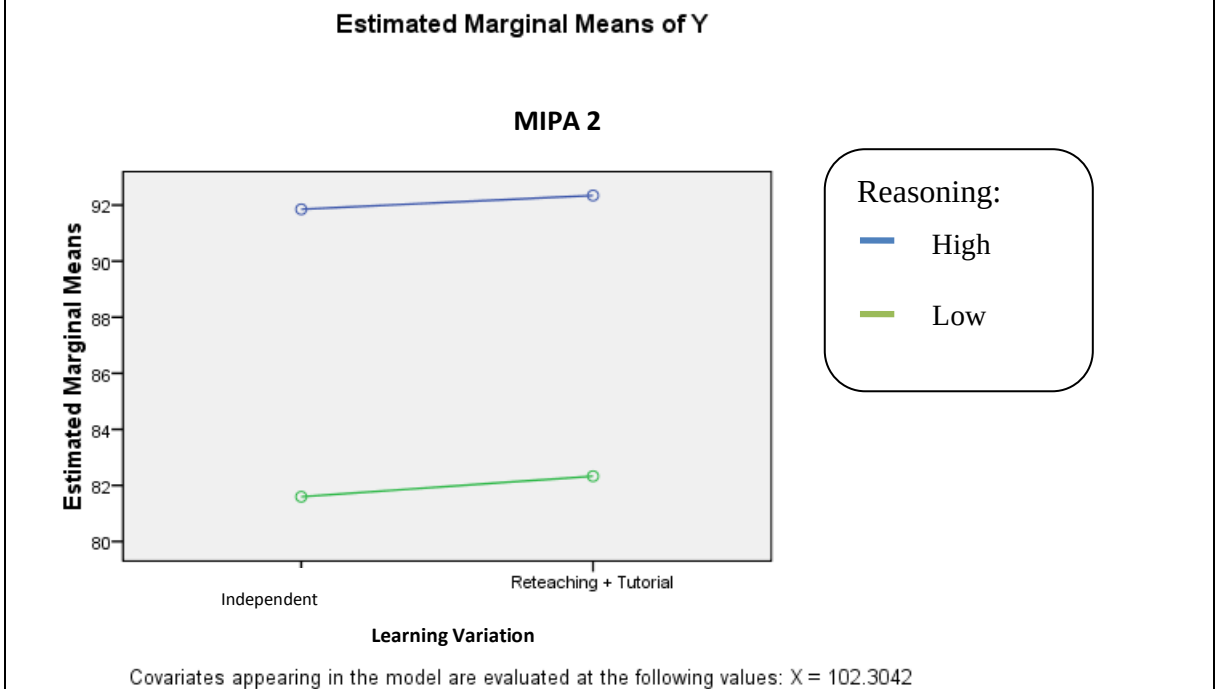

Figure 5. The Results of Students' Reasoning Ability in MIPA 2

Figures 4 and 5 show the variation of learning, namely independent learning with reteaching learning in the fast ability class (XI MIPA 1) and slow ability class (XI MIPA 2) on the kinetic theory of gas. The integrated learning outcomes of students' reasoning abilities in fast learning classes independently learned are higher (92) than in students who learn reteaching (89). In slow ability classes, students who learn by reteaching (92) are higher than students who are taught independently (89).

Table 3. Hypothesis Test Calculation Results on Thermodynamic Material

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	812.744[a]	8	101.593	12.024	.000
Intercept	457801.350	1	457801.350	54183.147	.000
X	532.011	1	532.011	532.001	.042
Learning Variation	23.020	1	23.020	9.002	.032
Reasoning	622.579	1	622.579	73.685	.000
Class	57.128	1	57.128	6.761	.112
Learning Variation * Reasoning	22.474	1	22.474	2.660	.019
Error	430.906	51	8.449		
Total	459045.000	60			
Corrected Total	1243.650	59			

a. R Squared = .654 (Adjusted R Squared = .599)

Table 3 presents an ANCOVA test analysis on student learning outcomes integrated reasoning abilities on thermodynamic material. The calculations show that a significant landfill is 0,042 because its value is far below the significance level of 0,05, then H_0 is rejected and H_a accepted. This means that there is an influence on the value of TPA (the initial ability of students) there is an integrated learning outcome of students' reasoning ability. Calculation of the significance of variation learning is 0,032 below the significance level of 0,05, then H_0 is rejected and H_a is accepted. This means that there is an influence of learning variation on integrated learning outcomes of students' reasoning abilities.

Calculation of the significance of the class is 0.112 more than high than the significance level of 0,05, then H_a is rejected and H_0 is accepted. This means that there is no influence between the classes on integrated learning outcomes of students' reasoning abilities. Calculation of significance corrected models is 0,000 below the significance level of 0,05, then H_0 is rejected and H_a accepted. This means that all variables jointly influence the learning outcomes of students' integrated reasoning abilities.

Based on the test results ANCOVA, learning outcomes integrated reasoning skills on the material the kinetic theory of gases has increased by 65,4 %. Differences in integrated learning outcomes of students' reasoning abilities using learning variations (independent and reteaching) can be seen in Figure 6.

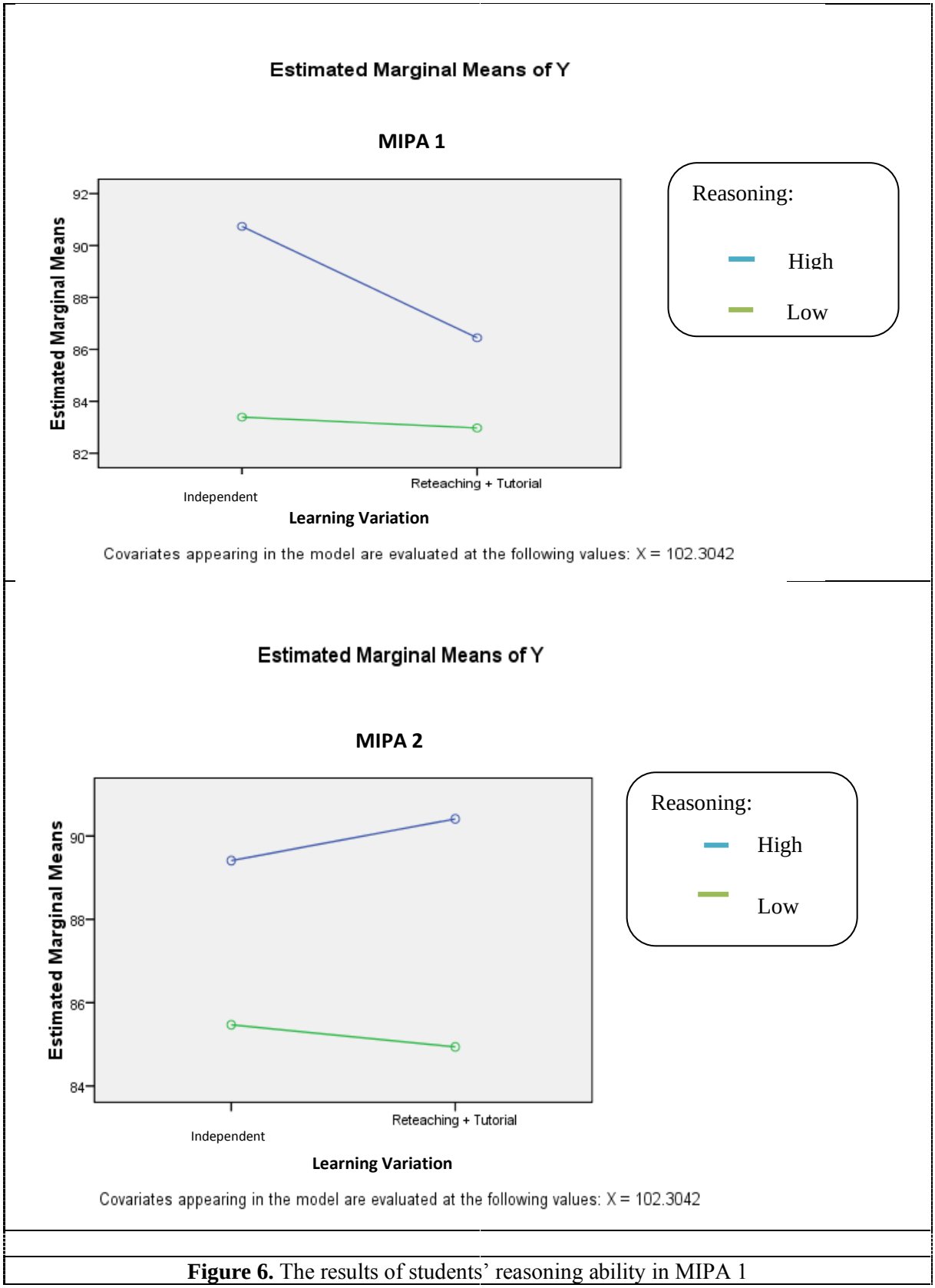

Figure 6. The results of students' reasoning ability in MIPA 1

Figure 6 shows the variations in learning, namely self-learning with reteaching + learning in the fast ability class (XI MIPA 1) and slow ability class (XI MIPA 2) on thermodynamic material. The results of the integrated learning of students' reasoning ability in the fast ability class independently learned are higher (91) than for students who learn by reteaching + tutorial (87). In slow ability classes, students who learn by reteaching + tutorial (90) are higher than students who are taught independently (89).

Results of learning using self-learning (self-learning) give the effect a relatively higher be used on a group of students with the ability to quickly (faster student), while regular learning + learning tutorial gave the effect of a relatively higher used in groups of students with the slow ability (slower student). According to Janicki & Peterson (2010) The achievement of highly capable students are more successful in learning when they are allowed to work in small groups rather than working alone.

The results of the above research are also supported by several previous studies, namely: research conducted by Dongoran about the effects of ATI (Aptitude treatment interaction) learning on students' physics activities and generic physics [16]. The results of the study stated that the activities of students taught by the ATI learning model were better than those of students taught using the direct/conventional learning model. Another research showed an increase in high school physics learning outcomes that were learned using the ATI model[17]. Likewise, the results of Putra's (2014) research on the effect of the ATI model on science learning outcomes also gave the same results[18]. From the results of these studies, the researchers conclude that the application of the ATI model can improve student learning outcomes.

The results of research conducted by Di Vesta on Trait-Treatment Interactions, Cognitive Process and Research on Communicative Mediaindicate that Trait Treatment Interaction (TTI) oriented media has a significant and promising impact on the communication process and also the understanding of human behavior [19]. In line with Bernard's research in 2016 about increasing reasoning ability through Adobe Flash media showed there was an increase in reasoning ability compared to conventional learning [20]. Based on relevant research can be seen p use of total media can make students more active participants in learning, especially arranging, selecting, and integrating verbal and visual information and can improve the reasoning abilities of students [21, 22].

Improving students' reasoning ability can build on their knowledge and past experiences to overcome new problems [11]. According to Jones, the reasoning is also a thought process carried out in a way to conclude. Reasoning ability is also used to link various aspects that can be interpreted in physics problems [12]. Therefore, to understand and master concepts, principles, and theories, as well as the laws of physics, require reasoning abilities [23]. If students are allowed to use their reasoning skills to make predictors based on their own experience or knowledge, so it is easier to understand the concept.

Based on the explanation above, it can be concluded that: integrated learning outcomes of physics reasoning ability of SMA N 1 Pantai Cermin students on cognitive aspects of fast ability class (XI MIPA 1) is suitable to use independent learning variation rather than reteaching learning variation and slow ability class (XI MIPA 2) it is more suitable to use reteaching learning variation rather than independently by applying the Aptitude Treatment Interaction (ATI) Learning model using Adobe Flash media . This condition states that applying the ATI model can improve student physics learning outcomes in the cognitive aspects.

4. Conclusion and Suggestion

4.1 Conclusion

Based on the explanation, it can be concluded that: physics learning outcomes of SMA N 1 Pantai Cermin students on the cognitive aspects of fast ability class (XI MIPA 1) is suitable to use independent learning variation rather than reteaching learning variation and slow ability class (XI MIPA 2) is more suitable for using reteaching learning variations rather than independently by applying the Aptitude Treatment Interaction (ATI) Learning model using Adobe Flash media . This

condition states that applying the ATI model can improve student physics learning outcomes in the cognitive aspects. The results obtained in the two aspects above proved that the application of the Aptitude Treatment Interaction (ATI) learning model using Adobe Flash media was able to improve students' learning outcomes in the cognitive aspects of class XI MIPA SMA N 1 Pantai Cermin.

4.2 Suggestion

Based on the conclusions of the study, the researchers suggest several things as follows:
There are differences in student learning outcomes using the Aptitude Treatment Interaction (ATI) learning model assisted by Adobe Flash media. This can be used as an alternative for teachers in their efforts to improve students' physics learning outcomes. It is expected that prospective teachers or educational students to develop further research will assess other aspects, namely affective and psychomotor aspects. Researchers themselves are still limited to the kinetic theory of gas and thermodynamics, so it is hoped that further researchers will apply it to other physics learning materials. The next researcher is expected to be able to use and share time as efficiently as possible so that the learning process can run better and provide more satisfying results. For researchers who use learning media, make sure the learning media is in accordance with the conditions of the school.

Reference

[1] H. A. Alismail and P. McGuire 2015 21st Century Standards and Curriculum: Current Research and Practice J. Educ. Pract. **6** 6 150–155
[2] J. G. S. Goldie 2016 Connectivism: A knowledge learning theory for the digital age? Med. Teach. **38** 10
[3] Z. Ivcevic and J. D. Mayer 2006 Creative Types and Personality Imagin. Cogn. Pers. **26** 1 65–86
[4] T. C. Janicki and P. L. Peterson 1981 Aptitude-Treatment Interaction Effects of Variations in Direct Instruction Am. Educ. Res. J. **18** 163–82
[5] M. Granescu and R. Literat 2013 Learning Variables and Individual Differences in Student-Centred Learning Publ. USAMV Cluj-Napoca **70** 2
[6] L. Corno, A. Mitman, and L. Hedges 2010 The Influence of Direct Instruction on Student Self-Appraisals: A Hierarchical Analysis of treatment and Aptitude-Treatment Interaction Effects Am. Educ. Res. J. **18** 01 39
[7] K. J. Preacher and S. K. Sterba 2018 Aptitude-by-Treatment Interactions in Research on Educational Interventions Except. Child. vol. October
[8] L. Cronbach and R. Snow 1977 Aptitudes and Instructional Methods: A Handbook for Research on Interactions (New York: Irvington)
[9] J. P. Lalley and J. R. Gentile 2009 Classroom Assessment and Grading to Assure Mastery Theory Pract. **48** 1
[10] H. Y. Mumcu and T. Aktürk 2017 An Analysis of The Reasoning Skills of Pre-service Teachers in The Context of Mathematical Thinking Eur. J. Educ. Stud. **3** 5
[11] S. Lapkin, T. Levett-Jones, H. Bellchambers, and R. Fernandez 2010 Effectiveness of Patient Simulation Manikins in Teaching Clinical Reasoning Skills to Undergraduate Nursing Students: A Systematic Review Clin. Simul. Nurs. **6** 6
[12] G. A. Jones, C. A. Thornton, C. W. Langrall, and J. E. Tarr 1999 Understanding Students' Probabilistic Reasoning. Understanding Students' Probabilistic Reasoning
[13] L. Jacob and S. Willis 2003 The Development of Multiplicative Thinking in Young Student in Annual conference of the Mathematics Education Research Group of Australasia
[14] A. Glass and K. Holyoak 1986 Cognition (America: McGraw-Hill)
[15] K. M. Galotti 1989 Approaches to studying formal and everyday reasoning Psychol. Bull. **105** 3331

[16] F. R. Dongoran 2014 Paradigma Membangun Generasi Emas 2045 dalam Perspektif Filsafat Pendidikan J. Pendidik. Tabularasa **11** 1

[17] A. Saregar, R. Diani, and R. Kholid 2017 Efektivitas Penerapan Model Pembelajaran ATI (Aptitude Treatment Interaction) Dan Model Pembelajaran TAI (Team Assisted Individualy) : Dampak Terhadap Hasil Belajar Fisika Siswa *J. Pendidik. Fis. dan Keilmuan.* **3** 1

[18] A. A. N. M. Putra, N. T. Renda, and S. Syahruddin 2014 Pengaruh Model Pembelajaran ATI (Aptitude Treatment Interaction) Berbantuan Peta Konsep terhadap Hasil Belajar IPA Mimb. PGSD Undiksha **2** 1

[19] F. J. Di Vesta 1975 Trait-treatment Interactions, Cognitive Processes, and Research on Communication Media in Educational Technology Research and Development

[20] M. Bernard and S. Chotimah 2018 Improve Student Mathematical Reasoning Ability with Open-ended Approach using VBA for Powerpoint in AIP Conference Proceedings

[21] F.-T. Leow and M. Neo 2014 Interactive Multimedia Learning: Innovating Clasroom Education in Malaysia University PTOJET Turkish Online J. Educ. Technol. **13** 2 99–110

[22] S. Rosamsi, M. Miarsyah, and R. H. Ristanto 2019 Interactive Multimedia Effectiveness in Improving Cell Concept Mastery J. Biol. Educ. **8** 1 56–61

[23] I. Maryam 2016 Surya Edukasi : Pengaruh Pembelajaran Open-Ended Dan Konstruktivis Terhadap Prestasi Belajar Matematika Ditinjau Dari Motivasi Belajar Siswa 26 J. Pendidik. Surya Edukasi 26–41