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Application of Augmented Reality Based on Cognitive Conflict and Stem to Improve Students' Attitudes in 21st Century Learning

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ABSTRACT

This research seeks to ascertain the efficacy of incorporating cognitive conflict-based Augmented Reality into STEM curricula on students' views towards the content of Newton's Law of Gravity and Kepler's Law. The method used is pre-experimental with a One-Group Pretest-Posttest design, involving 17 students of phase F of SMA Negeri 1 Candung. The instrument used is an attitude questionnaire adapted from the Colorado Learning Attitudes about Science Survey (CLASS) and has been validated by experts. Data were analyzed using the Shapiro-Wilk normality test and Hypothesis testing using the Paired t-test. The results showed a significant increase in students' attitudes after AR-based learning, with a significance value (p = 0.005) <0.05. These findings indicate that the use of AR integrated with cognitive conflict and the STEM approach shows the potential for a positive impact on students' attitudes in physics learning. With the goals of enhancing students' emotional elements within the framework of 21st century learning, this research adds to the development of technology-based physics learning innovations.

Keywords: Augmented Reality, Konflik Kognitif, STEM, Attitude, Hukum Newton, Hukum Kepler.

I. INTRODUCTION

Education is the main foundation in shaping individuals and society. Along with the development of the era and technological advances, the educational paradigm has undergone significant transformation [1]. Education is also required to always be at the forefront, especially in meeting the expectations of the 21st century through the presentation of relevant and contextual learning [2]. Strong scientific literacy, together with the ability to think critically, creatively, and collaboratively, is now valued in educational practice [3]. This encourages the need to utilize technology in learning that focuses not only on cognitive aspects, but also on students' affective aspects.

One of the relevant technologies to support modern learning is Augmented Reality (AR). In order to connect theoretical ideas with tangible examples, this technology enables the real-time interactive display of virtual things in a physical setting [4]. In the context of physics learning, AR provides a more interesting learning experience and can increase student engagement in material that is considered difficult and boring, such as Newton's law of gravity [5].

However, sophisticated learning media alone is not enough. A pedagogical approach is needed that can stimulate students' critical thinking. One of them is the cognitive conflict approach, which works by creating a discrepancy between students' initia STEM encouragesl understanding and scientific facts, thus encouraging a more scientific reconstruction of the concept [6]. When this conflict is visualized through AR, the potential for changes in students' attitudes and understanding becomes greater.

STEM (Science, Technology, Engineering, and Mathematics) integration further strengthens the learning design. STEM encourages students to think across disciplines and apply concepts applicatively to solve real problems [7]. Within this framework, AR based on STEM-integrated cognitive conflict is seen as a strategic combination that not only improves conceptual Low positive attitude understanding but also forms a positive attitude towards physics.

Students' attitudes towards physics learning are still negative. Many students view physics as a difficult, abstract, and boring subject [8]. This low positive attitude towards science has implications for low motivation and active participation of students in learning [9]. This condition is exacerbated by the minimal use of interactive teaching materials in schools, which results in a lack of student involvement in understanding physics concepts in depth.

Research by Mariyadi and Idam R.W in [10] revealed that 66.7% of students have misconceptions about gravitational force. In addition, Hikmah's research in [11] showed that 56% of students still do not understand the concept of particle dynamics, including gravitational force. This shows the low understanding of students about the concept of Newton's Law of Gravity. As a result, the learning process becomes less meaningful and boring so that students' learning motivation is low.

Based on the results of interviews with teachers at SMA Negeri 1 Candung, a direct learning model is still being applied that relies on teaching materials such as textbooks and blackboards. Furthermore, pupils are less invested in their own learning due to the still-limited usage of instructional tools. As a result, students have difficulty understanding physics concepts in depth and developing the necessary science skills. This causes many students to consider physics as a difficult and confusing subject. Because they find it difficult to understand the material, students become less motivated to learn, and even tend to ignore physics lessons.

Previous researchers by Mufit et.al in [12]. Have developed AR-based teaching materials that integrate cognitive conflict and STEM approaches, and have proven their feasibility through expert validation tests. Although AR-based media have been widely developed, most other studies focus more on improving conceptual understanding or scientific literacy [13]; [14]. Aspects such as students' attitudes towards physics are still rarely the main focus. Therefore, this study aims to test the effectiveness of using AR based on STEM-integrated cognitive conflict in improving students' attitudes on the material of Newton's Law of Gravity and Kepler's Law.

II. METHOD

In this research, pre-experimental designs were used. The purpose of this research is to observe changes in outcomes after therapy is administered to one group using a pre-experimental approach using a One-Group Pretest-Posttest Design. A total of seventeen pupils from a single class participated in this research. The sample class was given treatment with Augmented Reality based on the STEM integrated cognitive conflict model. The initial learning activity of students was given an initial assessment to determine the initial attitude of students, after which the class was given treatment using Augmented Reality based on STEM integrated cognitive conflict. After being given treatment, the class was given a final assessment to determine changes in student attitudes. This study's design is summarised in the table below:

Table 1. Research Design

Initial Assessment	Treatment	Final assessment score
O_1	X	O_2

(Source: Ref [15])

Description

O_1 : Initial assessment score

O_2 : Final assessment score

X : Treatment using Augmented Reality based on STEM integrated cognitive conflict model

1. Research Procedure

Research procedure is a series of orderly steps used to collect information and answer research questions. This research was conducted through three main steps, namely preparation, implementation, and completion. In the preparation phase, the researcher selected the school and research schedule, prepared a permit letter, determined the population and sample, and prepared the research instrument. The implementation stage was carried out on one sample class that was given treatment using Augmented Reality teaching materials based on STEM integrated cognitive conflict.

This treatment aims to see its impact on student attitudes. The final stage is the completion stage, which includes collecting research data, processing and analyzing data, and discussing the results obtained during the research process. This discussion aims to explain the results, and evaluate the implementation of the learning that has been implemented. This stage is closed by drawing conclusions from the entire research activity process.

2. Population

According to Sugiyono, the population is the subject of the research as a whole [15]. The population used as the object of research in this study was all Phase F (science-physics) students of SMA Negeri 1 Candung who were registered in the 2024/2025 academic year.

3. Sample

Saturated sampling, which was performed in this research, involves taking a random sample from the whole population that fits the requirements. This technique was chosen because the number of participants in the population is relatively small and homogeneous[16].

The sample consisted of 17 Phase F students at SMA N 1 Candung in the 2024/2025 academic year, which included 10 male students and 7 female students. all students in this class were directly involved in the learning process using Augmented Reality based on STEM integrated cognitive conflict, as well as in the initial and final assessments aimed at measuring changes in attitude.

4. Data Collection Technique

Data collection in this study was carried out by distributing student attitude questionnaires before and after treatment. This method is applied to evaluate the extent to which students' attitudes change towards physics lessons after participating in Augmented Reality (AR)-based learning integrated with the cognitive conflict model and the STEM approach.

The tool used is a closed questionnaire consisting of 30 statements arranged based on student attitude indicators in physics learning [17]. Using a 5-point Likert scale, students are requested to provide their replies. The entire data collection process is carried out directly in class during the learning process, with guidance from the researcher to ensure clarity of instructions and honesty of responses.

Table 2. Data Collection Techniques

Data Type	Instrument	Collection techniques
Attitude Questionnaire	Attitude questions according to attitude indicators	Initial assessment and final assessment

5. Research Instruments

The Research in this research relied on a physics-themed student attitude questionnaire developed by modifying the CLASS tool [18]. This tool is designed to assess students' views on physics lessons, how they learn physics, and the alignment of their views with scientific thinking.

The questionnaire consists of 30 closed-ended statements that reflect five attitude indicators, namely: the relevance of physics in daily activities, knowledge and use of physics principles, interest and motivation in learning physics, independence in learning physics, collaboration and learning strategies. A 5-point Likert scale is used to evaluate each statement; 1 indicates a strong disagreement and 5 indicates a strong agreement. Before being used, the instrument has gone through a content validation process by physics education experts to ensure the representativeness of the indicators and the clarity of the statement items. The validation results show that the instrument is suitable for measuring affective aspects in the context of technology-based physics learning.

6. Data Analysis Technique

Data obtained from the initial assessment and final assessment in the form of student attitude scores were analyzed quantitatively to measure changes after treatment. The attitude questionnaire was developed using a Likert scale with five response categories: strongly agree (score 5), agree (score 4), neutral (score 3), disagree (score 2), and strongly disagree (score 1) [15]. The Likert scale is a tool widely used in educational research to assess attitudes because it produces data that can be easily analyzed statistically [19]. Interpretation of student attitude levels is based on the average score obtained. If the average score is in the range of 3.68 to 5.00, the attitude is categorized as high. If the score ranges from 2.34 to 3.67, the attitude is categorized as moderate. Meanwhile, if the score is between 1.00 and 2.33, the attitude is categorized as low[20].

There were two phases to the analysis: testing prerequisites and testing hypotheses. Before anything further, we made sure the data was normal by running it through the Shapiro-Wilk test. This test was chosen because the number of samples was below 50 [21]. If the data is proven to be normally distributed, then a parametric test is used, while if not, then a nonparametric test is used. In this study, because the data were normally distributed, the analysis was continued using the Paired t-test which was appropriate for comparing two groups of paired data (initial assessment and final assessment in one group). Using STEM-integrated cognitive conflict as a framework, this test seeks to ascertain whether or not students' opinions alter significantly before and after studying using AR. All analyses used SPSS software version 25.0, with a significance level (p = 0.05).

III. RESULTS AND DISCUSSION

Results

This study aims to determine the impact of the implementation of Augmented Reality (AR) based on STEM integrated cognitive conflict on students' attitudes in the material of Newton's Law and Kepler's Law. Data were obtained through initial and final assessments measured using a validated attitude questionnaire adapted from the CLASS instrument. The Attitude Questionnaire consists of five indicators, namely: the relevance of physics in daily activities, knowledge and use of physics principles, interest and motivation in learning physics, independence in learning physics, collaboration and learning strategies.

Table 3. Descriptive analysis of scores before and after treatment

		Minimum		Maximum		Mean		Std. Deviation	
	N	Pre	post	Pre	post	Pre	post	Pre	post
Relevance of physics	17	2.50	3.00	4.00	5.00	3.29	4.01	.458	.606
Understanding of physics	17	3.00	3.00	4.25	5.00	3.48	3.89	.333	.596
Interest and motivation	17	2.60	2.60	4.20	5.00	3.37	3.76	.494	.775
Independence	17	2.60	2.60	4.00	5.00	3.43	3.74	.348	.817
Collaboration and strategy	17	2.50	2.33	4.17	4.83	3.26	3.54	.416	.758
Valid N (listwise)	17								

(Source: Ref [22])

Based on Table 3, there is an increase in the average score on each student attitude indicator after the treatment was given. To clarify the changes, Table 4 presents a comparison of the average attitude scores before and after the treatment based on the category. This comparison aims to provide a more comprehensive picture of the qualitative improvement in student attitudes, so that it can be seen which indicators have experienced the most significant changes.

Table 4. Comparison of average attitude scores before and after treatment

Indicator	Pre-treatment		Post-treatment	
	Average	Category	Average	Category
Relevance of physics	3.29	Currently	4.01	Tall
Understanding of physics	3.48	Currently	3.89	Tall
Interest and motivation	3.37	Currently	3.76	Tall

Independence	3.43	Currently	3.74	Tall
Collaboration and strategy	3.26	Currently	4.54	Currently

The descriptive analysis revealed that the average attitude rose from 3.37 before treatment to 3.79 after treatment. The highest value before treatment was in the Understanding of Physics indicator (3.48), while after treatment the highest value was in the Collaboration and Strategy indicator (4.54), which showed a significant increase in attitude in all aspects. The analysis began with a normality test through Shapiro-Wilk which showed that the data followed a normal distribution ($p > 0.05$). Then a paired t-test was carried out.

1. Normality Test

A normality test must be conducted before hypothesis testing to guarantee that the data is normally distributed. In this study, the Shapiro-Wilk test was selected because the number of samples is less than 50. The findings of the normality test that was performed on the data pertaining to the students' attitudes are as follows:

Table 5. Results of the Attitude Questionnaire Normality Test

		Shapiro-Wilk		
	Kategori	Statistic	df	Sig.
Skor *angket* attitude	sebelum	.970	17	.813
	setelah	.899	17	.066

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

(Source :Ref [22])

The data in the table shows the results of the normality test calculation before and after being given treatment in the experimental class using the Shapiro-Wilk Test. The significance value before ($p = 0.813$) > 0.05 and after ($p = 0.066$) > 0.05. The data is normally distributed before and normal after treatment. These results indicate that the data is suitable for parametric statistical tests. Therefore, further analysis can be conducted using the paired t-test to compare the mean scores before and after treatment.

2. Test Results of Attitude Hypothesis Test

Hypothesis testing of the initial assessment and final assessment in the prerequisite test resulted in the conclusion that the data tested using the Shapiro-Wilk Test were normally distributed. Thus, the next step can be done with the Paired t-test, to determine whether there is a significant difference in student attitudes before and after treatment. This test helps evaluate the effectiveness of AR-based learning interventions. The results are presented in Table

Table 6. Results of the Paired t-test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	skor sebelum - skor setelah	-8.46275	10.57906	2.56580	-13.90200	-3.02349	-3.298	16	.005

(Source:Ref [22])

Based on the output table above, it is known that the sig. value (2-tailed) is 0.005 < 0.05, so h_0 is rejected and h_a is accepted. This result indicates a statistically significant improvement in students' attitudes towards physics. The negative mean difference confirms that the post-treatment scores are consistently higher. This supports the hypothesis that STEM-integrated AR learning positively influences student attitudes. So it can be concluded that there is an average difference between the attitude scores before and after using augmented reality.

Discussion

This study aims to determine the impact of the use of Augmented Reality (AR) based on STEM-integrated cognitive conflict on students' attitudes in the material of Newton's Law of Gravity and Kepler's Law. Data were obtained through initial assessments and final assessments that measured students' attitudes. The results of the analysis showed a statistically significant increase. This finding confirms the positive potential of using AR technology in physics learning.

As mentioned in other studies, according to Osborne et al. in [23] stated that attitudes towards science are influenced by learning experiences, perceived relevance, and comfort during the learning process. Another study by Pambayun et al in [24] stated that limitations in technology generally have greater appeal and motivation to learn science while negative experiences can hinder students' interest and involvement in learning . Therefore, creating a fun and meaningful learning experience plays an important role in building students' positive attitudes towards science.

Although the findings of this study show the advantages of using AR, there are several limitations that must be considered. One of them is the dependence on technological devices, where some students experience difficulties in operating the AR application because they are not yet familiar with the technology. In addition, this study was only conducted for a period of one month, so it has not been able to measure the long-term impact of using AR in learning. Consistent with previous studies that AR can lead to significant increases in student engagement, knowledge retention, and skill development over time. However, the long-term effectiveness of AR depends on various factors, including the quality of the AR design, the level of institutional support, and the availability of competent educators [25].

This study has several limitations that can be used as references for future research. First, this research was only conducted in one school, namely SMA Negeri 1 Candung, so the generalization of the results is still limited. Second, limitations in technological infrastructure are also a problem, especially for students who do not have compatible devices to run AR applications. Third, the relatively short research time makes it impossible to analyze the long-term impact of using AR in physics learning comprehensively. Fourth, the attitude aspect of students was only measured in one class, without any comparison from the control class. Therefore, for future research, it is suggested that the attitude aspect be measured in both groups, and involve more schools and other variables to be more comprehensive and representative. So, in order to improve the quality of high school physics education, this study is anticipated to be useful for researchers, educators, and policymakers.

IV. CONCLUSION

Based Data analysis and discussion led to the conclusion that students' attitudes towards Newton's Law of Gravity and Kepler's Law were improved via the use of Augmented Reality (AR) teaching materials based on cognitive conflict combined with the STEM philosophy. This is indicated by an increase in the average score of students' attitudes from 3.37 (moderate category) to 3.79 (high category) after being given treatment. The statistical analysis using the Paired Sample t-Test revealed a statistically significant difference, with a significance level of 0.005 <0.05. The increase occurred evenly in all attitude indicators, with the highest achievement in the physics understanding and learning strategy indicators. These findings support the development of technology-based physics learning innovations that are in line with the demands of 21st century learning, especially in the affective aspects of students. Therefore, learning with a similar approach has the potential to be implemented more widely. However, given the limitations of the research design, further studies are needed involving control groups and a larger sample coverage to strengthen the generalization of the findings.

REFERENCES

[1] F. Wajdi, Suanto, K. Rinaldi, and bunga deli Saravistha, *Pengantar Pendidikan Antikorupsi (Teori, Metode dan Praktik)*, vol. 11, no. 1. Bandung: Widina Media Utama, 2024.

[2] B. Trilling and C. Fadel, *21St Century Skills: Learning for Life in Our Times*. san fransisco: jossey bass, 2009.

[3] S. N. Pratiwi, C. Cari, and N. S. Aminah, “Pembelajaran IPA abad 21 dengan literasi sains siswa,” *J. Mater. dan Pembelajaran …*, vol. 9, pp. 34–42, 2019.

[4] F. Mufit, Y. Hendriyani, and M. Dhanil, *Augmented reality dan virtual reality berbasis konflik kognitif, sebagai media pembelajaran abad ke-21 [Augmented reality and virtual reality based on cognitive conflict, as 21st century learning media]*. 2023.

[5] D. A. Permatasari *et al.*, “Penerapan Augmented Reality (AR) Sebagai Media Pembelajaran Interaktif Di MI Sunan Gunung Jati Malang,” vol. 2, no. 12, pp. 3980–3990, 2024.

[6] F. Mufit, F. Festiyed, A. Fauzan, and L. Lufri, “Impact of Learning Model Based on Cognitive Conflict toward Student’s Conceptual Understanding,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 335, no. 1, 2018, doi: 10.1088/1757-899X/335/1/012072.

[7] Y. A. Alkhabra, U. M. Ibrahem, and S. A. Alkhabra, “Augmented reality technology in enhancing learning retention and critical thinking according to STEAM program,” *Humanit. Soc. Sci. Commun.*, vol. 10, no. 1, pp. 1–10, 2023.

[8] F. Handayani, N. E. Wijaya, E. J. Astuti, R. Wandani, and T. Sandari, “Hubungan Sikap Siswa Terhadap Hasil Belajar Fisika di SMA N 10 Kota Jambi,” *Media Penelit. Pendidik. J. Penelit. dalam Bid. Pendidik. dan Pengajaran*, vol. 15, no. 1, pp. 1–6, 2021.

[9] T. Sandari, “Analisis Minat Siswa Terhadap Mata Pelajaran Fisika Di Sma N 1 Batanghari,” *EduFisika*, vol. 5, no. 02, pp. 118–123, 2020.

[10] M. Mariyadi and I. R. WA, “Analisis Miskonsepsi Peserta Didik Kelas Vi Sekolah Dasar Pada Pembelajaran Ipa Materi Gaya Gravitasi,” *LENSA (Lentera Sains) J. Pendidik. IPA*, vol. 13, no. 1, pp. 77–85, 2023.

[11] A. N. Putri *et al.*, “Analisis Miskonsepsi pada Pembelajaran IPA pada Materi Gelombang Bnyi Siswa kelas VI SD Negeri 060884 Medan,” pp. 872–879, 2025.

[12] F. Mufit, W. S. Dewi, S. Riyasni, and M. Dhanil, “Augmented Reality with A Cognitive Conflict Model and STEM Integration on Newton ’ s Universal Law of Gravitation : Does Practicing Practical Learning Support Scientific Literacy ?,” vol. 15, no. 2, 2025.

[13] F. Mufit and M. Dhanil, “Effectiveness of Augmented Reality with Cognitive Conflict Model to Improve Scientific Literacy of Static Fluid Material,” *Int. J. Inf. Educ. Technol.*, vol. 14, no. 9, pp. 1199–1207, 2024, doi: 10.18178/ijiet.2024.14.9.2149.

[14] F. Bakri, Oktaviani Marsal, and D. Muliyati, “Textbooks Equipped with Augmented Reality Technology for Physics Topic in High-School,” *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 5, no. 2, pp. 113–122, 2019.

[15] Sugiyono, *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*, 19th ed. Bandung: Alfabeta, 2013.

[16] Nasution, *Metode Penelitian Naturalistik Kualitatif*. Bandung: Tarsito. Library. Fis. Uny. Ac. Id/Opac/Index. Php., 2003.

[17] W. K. Adams, K. K. Perkins, N. S. Podolefsky, M. Dubson, N. D. Finkelstein, and C. E. Wieman, “New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey,” *Phys. Rev. Spec. Top. - Phys. Educ. Res.*, vol. 2, no. 1, 2006.

[18] J. M. Badeo and D. A. Duque, “Reliability and Validity of Colorado Learning Attitudes about Science Survey (CLASS),” *Int. J. Res. STEM Educ.*, vol. 5, no. 1, 2023.

[19] S. Azwar, *Sikap manusia: teori dan pengukurannya*. Yogyakarta: Pustaka Pelajar, 2016.

[20] Riduwan, *Skala Pengukuran Variabel-Variabel Penelitian*. Bandung: Alfabeta, 2015.

[21] A. Ghasemi and S. Zahediasl, “Normality tests for statistical analysis: A guide for non-statisticians,” *Int. J. Endocrinol. Metab.*, vol. 10, no. 2, pp. 486–489, 2012.

[22] I. Ghozali, *Aplikasi Analisis Mutivariate dengan program IBM SPSS 25*. Semarang: Badan Penerbit Universitas Diponegoro, 2018.

[23] J. Osborne, S. Simon, and S. Collins, “Attitudes towards science: A review of the literature and its implications,” *Int. J. Sci. Educ.*, vol. 25, no. 9, 2003.

[24] P. P. Pambayun and N. Shofiyah, “Sikap Siswa terhadap STEM : Hubungannya dengan Hasil Belajar Kognitif dalam Pembelajaran IPA,” *J. Paedagogy*, vol. 10, no. 2, 2023.

[25] M. Sirakaya and E. K. Cakmak, “Effects of augmented reality on student achievement and self-efficacy in vocational education and training,” *Int. J. Res. Vocat. Educ. Train.*, vol. 5, no. 1, pp. 1–18, 2018, doi: 10.13152/IJRVET.5.1.1.