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## Reducing Cognitive Bias of Pre-Service History Teachers through Augmented Reality

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**Abstract**—Cognitive biases can be problematic and dangerous in history learning. This study aimed to identify the extent to which the independent variables of the case study method and augmented reality influence the dependent variables, as well as evaluate the strength and direction of the relationship between these variables in reducing the cognitive biases of pre-service history teachers. The method used is multiple linear regression to identify the extent to which the application of the case method and the use of augmented reality in learning affect the dependent variable under study. The results showed that augmented reality contributed to the understanding of the history of prospective pre-service history teachers more than the case study method. The effect of the case study method was 7.6% on historical knowledge, and augmented reality media had a 13.9% effect on historical experience. Lecturers can use augmented reality in learning for prospective pre-service history teachers to increase student understanding of history learning material and reduce cognitive biases. This research has implications for using technology and digitalization in history learning for prospective pre-service history teachers to understand history, conceptions, and past events and reduce bias. Understanding history is essential for prospective pre-service history teachers. Prospective pre-service history teachers must also understand a historical event broadly and from various perspectives. Technology-based learning in history learning is one of the right ways to avoid cognitive bias.

**Keywords**— Augmented reality; bias cognitive; history learning; pre-service history teacher.

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### I. INTRODUCTION

Cognitive bias in history learning is a phenomenon that cannot be ignored because it dramatically affects the understanding of historical learning. Students who are prospective history teachers often misinterpret the information they get, resulting in an inaccurate understanding of a historical event. As a discipline that relies heavily on interpretation and analysis, history is a field of science prone to many types of cognitive biases [1], [2]. One of the cognitive biases that occurs in history learning is confirmation bias [3]. This confirmation bias arises when college students look for evidence supporting their previous views or beliefs while ignoring conflicting information. For example, when studying a particular war or conflict, students may prefer to look for facts supporting a specific viewpoint. In contrast, information that challenges their views is ignored. The effect of salience also plays a vital role in the study of history. College students

are more likely to be captivated by dramatic or emotionally memorable events than by more complex and less flashy events. As a result, they can overlook important aspects of history that are not so emotionally striking but significantly impact the development of events.

Prospective pre-service history teachers need to understand history as a whole because they will practice directly in school to teach high school students [4]. If students who are prospective history teachers misrepresent a historical event, it will have an impact on how they teach high school students in school. This cognitive bias must be avoided so that perceptions of historical events can correspond to actual events even though they can be viewed from various points of view [5]. By preventing cognitive biases, students can also avoid negativity bias, which can also damage students' understanding of history, where students tend to remember more negative information than positive, which causes an imbalance in historical interpretation. This can obscure progress or achievements in history, as the focus tends to be

more on tragic events or conflicts [6]. Single-source bias can also be avoided if students do a good historical analysis. Students will not rely on one source of information or point of view to understand an event without seeking variety or other perspectives. This can result in a narrow and limited understanding and an inability to appreciate the complexity of an event. An approach that focuses on developing critical thinking skills is essential to overcome these cognitive biases. Students should be invited to question sources of information, consider different points of view, and understand the historical context thoroughly [7]. Presenting a variety of sources and approaches in teaching history can help students see a more complete picture and its nuances, thus promoting a deeper understanding of the past.

The history of teaching and learning can generate unconscious cognitive biases for teachers and students. Cognitive bias refers to a systematic but purportedly flawed pattern of responses to society's judgment and decision problems [8]. Cognitive bias is the systematic deviation that is not random and predictable from rational judgment or decision-making. Cognitive bias can be examined by describing a similar and more easily explained phenomenon: visual illusions [9]. The result of cognitive biases is the presence of predictable forms of irrational behavior. This bias can result from misunderstanding and simplifying concepts, abstractions, and perspectives. Therefore, it cannot simply be attributed to intelligence, cognitive, or verbal abilities.

Educators and education practitioners agree that reducing cognitive biases is very important. Bias can divert facts and perspectives, leading to student confusion. In the case of pre-service history teachers, cognitive biases become problematic and dangerous because there are many abstractions and conceptions in the process of learning history [10]. In addition, learning materials in history subjects are primarily controversial, which scientifically results in biases, especially in some controversial learning materials, such as those about colonialism and imperialism.

The problem that arises when the understanding of prospective history teachers is biased is that they tend to convey inaccurate information to students. This can lead students to get an incomplete or incorrect picture of specific historical events or figures, affecting their understanding of historical events. The tendency to refer to more than one understanding and ignore diverse viewpoints in history will occur if the prospective history teacher has a biased understanding of history [11]. This leads students to overlook the complexity and diversity of historical events. Learning that hones the thinking skills of prospective teachers will affect their ability to understand prospective teachers of history learning. This research differs from existing research because it focuses on understanding prospective history teachers obtained through case methods and augmented reality. Both ways of learning emphasize diverse perspectives.

The case method is one approach to teaching that uses historical cases or events to facilitate students' understanding of specific historical topics. This method allows students to analyze and reflect on historical events directly. The application of the case method in historical learning is to analyze historical events from various points of view, identifying the event's causal factors, effects, and implications

[12]. Students may also investigate backgrounds, attitudes, and decisions taken by relevant historical figures and identify impacts on historical development. Augmented Reality combines real and virtual objects in the real world that run interactively and in real-time. It has an integration between three-dimensional objects and virtual reality integrated with the real world [13]. Augmented Reality can be defined as a virtual environment in which virtual objects are added with the integration of computer technology. This technology can bring user-friendly interactions because users can feel real virtual objects. Augmented Reality systems are developed for various educational applications, namely learning about technology, 3D animation, health, and engineering.

Previous research has found that combining augmented reality technology with educational content provides effectiveness and appeal to teaching and learning for students in the real world [14]. Augmented Reality offers unique affordability by combining the physical and virtual worlds with continuous user control from a vantage point and interactivity [15]. Augmented Reality has potential and positive advantages that can be adapted to the world of education [16]. Augmented Reality is a learning medium with great potential to help students learn history, including the ancient history of Indonesia, so that students can learn about Indonesia's ancient historical relics by displaying 3D models on their smartphone screens. The result is that Augmented Reality is effective as a historical learning medium in increasing student grades. Augmented Reality is a technology that allows the environment to convey new information [17]. This research aims to study the effect of combining Augmented Reality technology with traditional details to create excitement in learning history. Augmented reality is believed to minimize bias in understanding historical conceptions and perspectives. Digital technology is a newly modeled approach to cognitive bias reduction. In organizational situations, this approach is usually adopted to reconnect entrepreneurs with digital transformation, especially when innovative learning approaches are adopted.

Previous research has tackled to minimize the possibility of cognitive biases and promoted a model of metacognition self-evaluation that included an evaluation of thought processes [18]—devised a multifactorial process that involves acknowledging memory limitations, seeking perspective when making decisions, being able to criticize oneself, and choosing strategies to prevent cognitive errors. In addition, it summarizes efforts to reduce cognitive biases into a general concept, namely Cognitive Bias Modification (CBM), that provokes more experimental tools to evaluate the assumption of clinical phenomena and causal relationships between cognitive processing and emotions [19].

Cognitive mitigation efforts have also been studied in the context of history learning, in particular, and education in general. Direct instruction in formal logical rules cannot reduce cognitive biases [20]. In addition, the most promising technique for de-biasing is a metacognitive strategy that should be considered otherwise. This means a more holistic and broader perspective is needed. This study follows the holistic understanding approach by using case and augmented reality methods to reduce cognitive biases in history learning for pre-service history teachers.

The contribution of this research to education is in the diet

of history learning, especially for students who are prospective history teachers. Cognitive biases often occur in history learning because of various factors, such as the number of perspectives. They can be seen from multiple points of view and will be avoided by mature learning. Students who are prospective history teachers will have good history skills and can be open to various new things if they have broad insight and are not biased. This study identifies learning using case methods and augmented reality that most significantly forms new understanding for prospective teacher students in understanding history.

The authors perceive that using augmented reality can reduce the cognitive biases of pre-service history teachers, especially in learning about controversial issues such as the learning topics of colonialism and imperialism. This study aimed to identify the extent to which independent variables of case methods and augmented reality contribute to avoiding the cognitive biases of prospective pre-service history teachers so that the spread of such misinformation does not occur when they become history teachers in schools. The study also examined the strength and direction of the relationship between these variables in reducing the cognitive biases of pre-service history teachers.

## II. MATERIALS AND METHOD

History learning is essential for students at the senior high school level [21], [22]. Therefore, it is essential for prospective history teachers who will later become history teachers in senior high schools to have the proper knowledge about historical material. Augmented reality helps prospective pre-service history teachers better understand concrete abstract historical material [2], [22]. The case study method can also improve the ability of prospective history teachers to think more creatively and critically, so these two methods have good value for enhancing the cognitive skills of prospective history teachers. Cognitive bias can be avoided in this study, which will be analyzed further. The method used in this study is multiple linear regression. The multiple linear regression research method is a statistical technique used to explore the relationship between one dependent variable and two or more independent variables [23], [24].

In this study, regression methods were carried out for independent variables, case study methods, and the use of augmented reality in history learning, as well as variables bound to cognitive biases in history learning. This method aims to identify the extent to which the independent variable affects the dependent variable and to predict the value of the dependent variable based on the values of the given independent variable. The research subject was pre-service history teachers at Universitas Negeri Padang. The data were collected through a cognitive bias instrument based on the cognitive taxonomy [25]—the indicator of the instrument covered. The data were analyzed through a classical assumption data analysis that covers normality, multicollinearity, Heteroscedasticity, autocorrelation, and linear regression test by using SPSS 25 for Mac. Calculations using multiple linear regression must meet the classical assumption. The normality test in this study refers to the assumption in statistical analysis that the data must be normally distributed. If the residual does not follow the normal distribution, it can affect the validity and accuracy of

the analysis results. In this study, the data is usually distributed, characterized by distribution around the diagonal line.

Another condition for multiple linear regression calculations is to avoid multicollinearity. Multicollinearity calculations are performed using a correlation matrix or calculating each independent variable's VIF (Variance Inflation Factor). If the VIF is more than 10, the multicollinearity is high. In this study, the VIF was 1.017, so this study avoided multicollinearity. In multiple linear regression, the assumption of homoscedasticity states that residual variability must be constant. Heteroscedasticity can cause problems in the interpretation of regression results and hypothesis testing. This study used scatterplot graphic images and tended to be random to avoid heteroscedasticity. Autocorrelation or serial correlation occurs when there is a correlation between residual values at previous times and current residual values in time series regression models (time series). Significant autocorrelation can interfere with the validity of regression results and can lead to inaccuracies in confidence intervals and hypothesis tests.

## III. RESULTS AND DISCUSSION

### A. Normality test

The diagram above shows that residual values are typically distributed because data distribution lies around a diagonal line and follows the diagonal direction from left to top right.

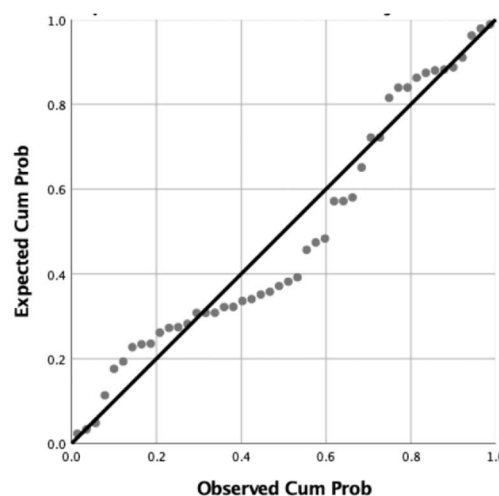


Fig. 1 Normal P-P Plot of Regression Standardized Residual

### B. Multicollinearity

The results of the Multicollinearity Assumption Test can be seen in the table below.

TABLE I  
COEFFICIENTS<sup>a</sup>

No.	Model	Collinearity Statistics	
		Tolerance	VIF
1.	(Constant)		
2.	Case Method	.983	1.017
3.	Augmented Reality	.983	1.017

<sup>a</sup>\* Dependent Variable: History Understanding

The table above shows that the VIF value is 1.017, which means the value is <10 and the tolerance value is 0.983.

Likewise, the variables X1 and X2 have a VIF value of 1.017 each because the value is smaller than 10, so it can mean there is no multicollinearity. So, it can be concluded that there is no multicollinearity in the independent variable studied.

### C. Heteroscedasticity Test

The scatterplot graph image above shows that the data distribution tends to be random and does not form a specific pattern. This shows that the regression model used is not heteroscedastic.

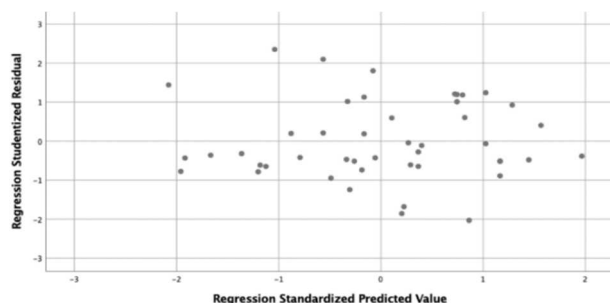


Fig. 2 Scatterplot

### D. Autocorrelation Test

The data processing results shown in the figure above obtained Durbin-Watson numbers from the Case Method and Augmented Reality of 2.174. This can mean no autocorrelation because Durbin-Watson is between -2 and +2.

TABLE II  
MODEL SUMMARY<sup>b</sup>

No.	Durbin-Watson
1	2.174

- a. Predictors: (Constant), Augmented Reality, Case Method  
b. Dependent Variable: History Understanding

### E. Linear Regression Test

Table 3 shows that Case Method (X1)  $0.031 < 0.05$  affect the historical understanding (Y). Augmented Reality (X2)  $0.006 < 0.05$  affects historical understanding (Y).

TABLE III  
COEFFICIENTS<sup>a\*</sup>

No.	Model	t	Sig.
1.	Constant	10.625	.000
2.	Case Method	2.235	.031
3.	Augmented Reality	2.878	.006

<sup>a\*</sup> Dependent Variable: History Understanding

Based on these results, it can be concluded that the Media Case Method (X1) and Augmented Reality (X2) simultaneously affect the dependent variable Historical Understanding (Y).

TABLE IV  
ANOVA<sup>a</sup>

No.	Model	F	Sig.
1.	Regression	5.902	.005 <sup>b</sup>
2.	Residual		
3.	Total		

- a. Dependent Variable: History Understanding  
b. Predictors: (Constant), Augmented Reality, Case Method

Based on Table 4, it can be concluded that H0 is rejected and H1 is accepted. It is based on a calculated F value of 5.902, while the resulting significance value is 0.005, which is  $< 0.05$  so that the Case Method (X1) and Augmented Reality media (X2) simultaneously affect the dependent variable Historical Understanding (Y).

TABLE V  
MODEL SUMMARY<sup>b</sup>

No.	Model	R	R. Square
1		.464 <sup>a</sup>	.215

- a. Predictors: (Constant), Augmented Reality, Case Method  
b. Dependent Variable: History Understanding

The table shows that the value of Adjusted R Square is  $0.215 \times 100 = 21.5\%$ , affecting the independent variable against the dependent variable.

TABLE VI  
REGRESSION AND CORRELATION

Variable	Regression Coefficient (Beta)	Correlation Coefficient	R square
X1	0.305	0.254	21.5
X2	0.395	0.352	

TABLE VII  
CASE METHOD AND AUGMENTED REALITY

Case Method (X1)	7.60
Augmented Reality (X2)	13.90
R2	21.5

TABLE VIII  
THE CASE METHOD AND MEDIA AUGMENTED REALITY

Case Method (X1)	35.35
Media Augmented Reality (X2)	64.65
Entire	100.00

Based on the table, it can be seen that the total simultaneous influence of X1 and X2 is 21.5%, with details of X1 affecting 7.6% of historical understanding and augmented reality media affecting 13.9% of historical experience. In addition, it can be seen that the relative contribution (SR) of the case method (X1) to understanding history (Y) is 35.35%, and the relative contribution (SR) of augmented reality (X2) to understanding history (Y) is 64.65%. Total SR is 100% or equal to 1.

The study results show that augmented reality contributes to students' understanding of history. Augmented reality makes a higher contribution than the case method learning model. The contribution of augmented reality can reduce cognitive biases. Thus, this study supports the results of Hertel and Matthews' (2011) study, which shows the importance of cognitive bias modification in overcoming cognitive biases [26]. Cognitive modification through augmented reality has proven effective in improving students' understanding of prospective history teachers. Augmented Reality (AR) is a technology that combines real-world elements with virtual or digital elements, creating an enhanced experience for users [27], [28]. In the context of avoiding cognitive biases, AR can be an effective tool because it can provide interactive and immersive learning experiences and influence how users process information [29].

The interactive experience that history teachers get allows students to interact directly with information through visual elements placed on top of the real world. In this way, learners

can be more actively involved in the learning process, avoiding cognitive biases such as confirmation bias or negativity bias that may arise due to passive interpretation. Augmented reality can also make complex data visualizations easier to understand [30]. Through interactable 3D objects and graphics, AR helps avoid cognitive biases such as single-source bias and the salience effect, as users can view data from multiple viewpoints. Students must get a reality simulation of different historical events to teach concepts, principles, and facts. By providing real-life experiences of situations that may be difficult to imagine, augmented reality can avoid contemporary and nostalgia bias by providing deeper insights into historical context. Students can view information from multiple perspectives to help prevent bias that arises from fixating on one point of view with sensory experience. This experience not only involves visuals but can also involve elements of sound, movement, and even touch. By using a variety of senses, learners can understand and remember information better, helping to overcome biases arising from reliance on one type of information. Collaborative learning allows aspiring history students to interact with the same content simultaneously. This can promote broader discussion and exchange, helping overcome single-source and confirmation biases.

Augmented reality supports students' confirmation of complex histories through visualization and digital technology [31], [32]. Thus, this study also confirms the use of digital technology in reducing cognitive biases, especially in education. Visualization and digital technology reduce bias in understanding historical events and conceptions. Holistic/opposite approach: Augmented reality provides a holistic approach for students to understand certain concepts and abstractions from the past more deeply [33]. On the other hand, using case method learning models also contributes to students' historical understanding, although it has a lower contribution than augmented reality approaches. The direct instruction in formal logical rules, represented in the case method, cannot optimally reduce cognitive biases.

While not as much as augmented reality affects students' understanding of history teachers to avoid cognitive biases, case studies account for 7.6%. This means that the case study method involves an in-depth investigation of certain events or phenomena through in-depth analysis of relevant data. This makes the case study method also influential in avoiding cognitive biases towards historical understanding. In history learning, this method allows students to respond critically to situations and events that have occurred and develop critical thinking skills essential to understanding complex aspects of history. More importantly, the case study method allows learners to identify and address cognitive biases that may arise in historical interpretation [34], [35]. This case study method can be implemented by selecting historical cases or events with significant impact and implications. It can involve controversial or complex events that can give rise to different points of view. Students can also collect data and information from various sources, including primary and secondary sources covering multiple points of view, background, and interpretation. Students who are aspiring history teachers perform critical data analysis, looking for evidence that supports or ignores certain biases. They are directed to identify potential cognitive biases that may appear in

interpretation. The interpretation results were discussed, allowing students to share their views.

#### IV. CONCLUSION

This research shows that augmented reality improves students' historical understanding more than the learning model of the case method. It confirms advanced approaches to reducing cognitive biases by using Cognitive Bias Modification and adopting digital technologies. Visualization of reality and digital technology support students' understanding of historical events, conceptions, and abstractions in historical learning. Based on this study, the authors suggest that teachers use digital and visualization approaches to reduce cognitive biases in learning history. Digitizing technology can take the form of augmented reality historical events, places, and figures, especially in controversial topics. Although augmented reality models contribute to students' understanding of history, technology, and digitization cannot be separated from epistemic cognition in history education, which can affect students' and teachers' understanding of the past. Therefore, this study has limitations in assessing epistemic aspects of teachers and students that determine historical experience and cognitive biases in history. Thus, further research should examine teachers' beliefs and attitudes towards history and learning subjects and their relationship to cognitive biases.

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