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The implementation of RBL-STEAM with pictorial riddle and augmented reality in improving students' historical thinking skill

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Abstract: The purpose of this study is to analyze how the integration of the RBL-STEAM learning model with the Pictorial Riddle method, supported by Assemblr-Edu media, can enhance students' historical thinking skills in world history courses. This research employs a hybrid methodology, combining qualitative and quantitative approaches. A pretest-posttest nonequivalent group design was utilized, where two groups received different educational interventions. The experimental group was exposed to the RBL- STEAM model integrated with the Pictorial Riddle technique and Assemblr-Edu media, while the control group received only the standard RBL-STEAM instruction. The integration of RBL-STEAM with the Pictorial Riddle technique and Assemblr-Edu media significantly enhances students' abilities to critically analyze, contextualize, and interpret historical events and sources. This approach not only fosters deeper engagement and understanding but also demonstrates a marked improvement in historical thinking skills compared to traditional RBL-STEAM methods. Additionally, student experiences were further analyzed using NVivo software, and Smart-PLS was employed to explore the relationships between RBL-STEAM variables and historical thinking skills. The analysis of the post-test data using SPSS and the independent samples t-test revealed a significant Sig value of 0.015 (<0.05). This indicates a statistically significant difference in the historical thinking skills scores between the experimental and control groups, with the experimental group showing superior outcomes. The results of the study indicate that implementing the RBL-STEAM model of teaching through the use of pictorial riddle and its integration with the Assemblr-Edu augmented reality learning media may enhance students' historical thinking abilities.
Keywords: *Assemblr-Edu, Augmented reality, History courses, Historical thinking skill, Pictorial riddle, RBL-STEAM.*

1. Introduction

Historical thinking skills are instrumental in cultivating critical thinking abilities among students, providing them with tools to understand historical events in depth and apply analytical skills in various contexts [1]. By engaging in chronological reasoning, students learn to sequence events and recognize their interconnections, fostering a structured way of thinking. Comparison and contextualization enable them to draw parallels and understand differences across historical and cultural landscapes, enhancing their comparative analysis skills [2]. Sourcing and interpretation demand a critical evaluation of information, encouraging skepticism and questioning narratives, which are essential aspects of critical thinking. Understanding cause and effect in historical contexts teaches students to identify and assess the factors leading to specific outcomes. This skill is transferable to problem-solving in real-world scenarios.

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Thus, historical thinking skills deepen students' understanding of history and equip them with critical thinking competencies that are invaluable in their academic and personal lives. Historical thinking skills are essential for 21st-century competencies, equipping students to navigate the complexities and prospects of today's world. By promoting critical thinking, these abilities improve students' capacity to analyze, interpret, and assess information, which is especially important in a time characterized by an abundance of information [3]. Historical thinking promotes communication and collaboration, encouraging students to understand and articulate diverse perspectives. Creativity and innovation are stimulated by exploring historical events, enabling students to draw insightful parallels with current scenarios. These skills bolster information literacy, cultural and global awareness, adaptability, and ethical understanding, all of which are fundamental competencies in the 21st century [4]. Ultimately, integrating historical thinking into education deepens students' knowledge of history and equips them with essential skills to navigate and contribute positively to our complex, interconnected world.

Technology's presence impacts learning activities, especially history learning, related to improving historical thinking skills. Learning activities become more attractive, creative, practical, and systematic by using technological advances so that they have a passion for learning [5]. Education is facing very rapid growth, accompanied by various new concepts and ideas through the use of technology [6]. The sophistication of technology provides a realization of how to process information more quickly and offers opportunities to be innovative. Technology provides different aspects of teaching that can benefit students by facilitating technology in learning [7]. Education should adapt technology use, including computers and the internet, to meet the evolving needs of students in the digital era.

Students in the digital era belong to Generation Z, which is the generation born between 1995 and 2012 [8]. Generation Z is a generation that has grown up along with the development of digital technology. Generation Z processes information quickly as a form of technological advancement so that they can be innovative [9]. Maximizing technology in history education is essential to keep students engaged and prevent boredom. Educators need to make history lessons captivating, orienting them towards developing higher-order thinking skills. This involves students memorizing historical facts and extracting significance from historical events [10]. Generation Z is a technologically literate generation, and educators must innovate so students can learn effectively and efficiently.

By studying history, students can develop a sense of nationalism, historical awareness, and academic skills. Understanding historical events allows students to reflect on their actions in the present and future [11]. History subjects in the independent curriculum have a range of standard skills, one of which emphasizes historical thinking skills. In addition, the characteristics of learning history include: 1) the process of teaching and learning history offers students the chance to explore diverse sources; 2) advancing the educational process to grasp the fundamental elements of history and essential skills for analyzing historical events; 3) the freedom for students to identify historical events both nationally and regionally; and 4) the allocation of a semester of history learning for students to study in depth. Thus, history subjects must be emphasized, along with historical thinking skills for students in implementing history learning.

Historical thinking skills are tools that guide participants in thinking critically when relating historical events or facts to current phenomena or conditions [3]. Historical Thinking Skill can be described as the ability of students to construct historical knowledge by searching for evidence, analyzing, identifying, and interpreting to reach conclusions using the scientific method [11]. Historical Thinking Skill in history subjects has the urgency to produce students who can think critically in evaluating evidence and connecting past and present events to take lessons in everyday life. Consequently, it is crucial for students to enhance their historical thinking abilities. Historical Thinking Skills are important for students to improve in the present. Nonetheless, students' Historical Thinking Skills remain comparatively weak. This conclusion is drawn from observations and prior studies. The observation results showed a need for more awareness of students in historical thinking, as evidenced by the average post-test score of 75 [12]. The previous research conducted by Khaldi [13] reported in an observational study that the data needs analysis indicated students' historical thinking skills were at 34.30%. Similarly,

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the study of Pranoto and Efendi [14] obtained a level of Historical Thinking Skill with an average score of 48%, included in the low group. From the results of observation data and previous research described above, the level of Historical Thinking Skills is still relatively low. So, this becomes a problem, and a solution is needed to learn history. The following is presented in Table 1, which explains the indicators and sub-indicators of historical thinking skills.

Table 1.
Historical thinking skill indicators.

Indicator	**Sub-indicator**	**Description**
Chronological thinking	• Sequence (CT1) • Periodization (CT2) • Temporal context (CT3)	• The ability to arrange events or developments in chronological order • Understanding historical periods and their defining characteristics • Recognizing the influence of time on historical events and understanding temporal relationships.
Historical comprehension	• Contextualization (HC1) • Historical perspective (HC2) • Causation (HC3)	• Understanding historical events within their broader social, political, economic, and cultural contexts • The ability to understand historical events from multiple viewpoints and perspectives • Determining and examining the causes and consequences of historical events and developments.
Indicator	Sub-indicator	Description
Historical analysis	• Source analysis (HA1) • Interpretation (HA2) • Corroboration (HA3)	• Evaluating primary and secondary sources for reliability, bias, and perspective • Analyzing and synthesizing historical evidence to develop interpretations and arguments • Comparing multiple sources to verify historical claims and construct a more accurate understanding of events
Historical research skills	• Research design (HR1) • Primary source research (HR2) • Secondary source analysis (HR3)	• Formulating research questions and developing research plans • Conducting research using primary sources, including archival materials, oral histories, and artifacts • Evaluating secondary sources, including books, articles, and documentaries, for their relevance and reliability

Indicator	Sub-indicator	Description
Historical issues	• Historical empathy (hi1) • Synthesis (HI2) • Communication (HI3)	• Understanding and appreciating the experiences, perspectives, and motivations of individuals in the past • Integrating diverse historical evidence and perspectives to construct nuanced and coherent narratives • Effectively communicating historical understanding through speaking, writing, and other forms of expression.

Innovative learning methods can solve the problem of low levels of historical thinking skills [1, 15]. The Pictorial Riddle method is a teaching strategy known to enhance students' engagement and cognitive abilities. It represents a form of inquiry-based learning [16]. The Pictorial Riddle method emphasizes that students solve problems, conduct analysis and discussion, and present the results [17]. The Pictorial Riddle method has a positive influence because it can visualize the learning of history so that students can better master the content of the material taught, thus improving their thinking skills. The application of the Pictorial Riddle Method is maximized through the use of technology. The Educational Process of the Industrial Revolution 4.0 [18]. The technology is in the form of learning media, namely Assemblr-Edu media. Assemblr-Edu media can be applied to learning history, which is identical to the past and conventional perspectives [19]. The advantages of Assemblr-Edu media are that it can improve high-level thinking skills by analyzing information tailored to the needs of its users [20, 21].

The use of Assemblr-Edu technology media helps maximize the application of the RBL-STEAM method integrated with the Pictorial Riddle technique in world history courses. Students can easily find information on world history to improve their thinking skills in world history courses. Given the background information provided, the researcher is motivated to further explore the analysis of implementing the RBL-STEAM integrated Pictorial Riddle technique, supported by Assemblr-Edu media, to enhance students' historical thinking skills. The research objective aims to achieve several interconnected objectives. First, it evaluates the effectiveness of integrating Research-Based Learning (RBL) with the interdisciplinary approaches of Science, Technology, Engineering, Arts, and Mathematics (STEAM) in enhancing educational outcomes in history classes. This includes analyzing how such an interdisciplinary approach contributes to deeper understanding and engagement with historical concepts. Second, the study examines the impact of the pictorial riddle technique on student engagement and motivation. This technique is explored to assess whether it makes abstract historical content more tangible and accessible, thereby enhancing learning. Additionally, the use of Assemblr-Edu, a digital educational media platform, is investigated to determine how it supports the delivery of content and facilitates the learning process through the innovative presentation of pictorial riddles and the support of integrated RBL-STEAM methods.

The primary objective focuses on improving students' historical thinking skills, evaluating whether the aforementioned methodologies enhance abilities such as analyzing primary and secondary sources, identifying historical contexts, evaluating evidence, and developing coherent historical interpretations. Furthermore, the research aims to measure changes in student engagement and academic performance, comparing pre- and post-intervention data to ascertain the effectiveness of these teaching strategies in fostering a deeper understanding of history. Collectively, these objectives aim to provide a comprehensive analysis of innovative teaching strategies in history education, highlighting the potential benefits of modern educational tools and interdisciplinary methods in enhancing critical thinking and learning outcomes.

Supporting this innovative approach is the use of Assemblr-Edu, a digital platform that allows for the creation and sharing of interactive 3D content. In the context of history education, Assemblr-Edu can be utilized to bring historical events and concepts to life, providing a dynamic learning experience that is both engaging and educational. The use of such technology not only supports the RBL-STEAM approach but also aligns with contemporary educational standards that emphasize digital literacy and technology integration. The specific research question in this study is: how is the impact of RBL-STEAM integrated with the Pictorial Riddle technique assisted by Assemblr-Edu media in improving students' historical thinking skills? Therefore, this study aims to analyze the effects of RBL-STEAM integrated with the Pictorial Riddle technique assisted by Assemblr-Edu media in improving students' historical thinking skills.

2. Literature Review of RBL-STEAM

Through this learning model, education becomes more than just a transfer of knowledge; it becomes a journey of discovery that encourages students to become critical and innovative thinkers [22, 23]. Pollard and Director [24] integrated research activities into learning, which can enrich students' learning experiences and equip them with essential skills needed for future academic and professional success. These activities allow students to develop a deeper conceptual understanding, encourage the application of knowledge in real-world contexts, and foster critical and analytical thinking skills. Additionally, participation in research can stimulate curiosity and motivation to learn, making the learning process more engaging and meaningful. This practice can be implemented through various means, such as research projects, case studies, or experiments designed to combine theory and practice [25]. By integrating research activities into the curriculum, students not only passively receive knowledge but are also actively involved in the process of knowledge formation itself [26]. Integrating research activities into learning plays an important role in improving the quality of education [27]. Figure 1 shows the RBL-STEAM syntax framework.

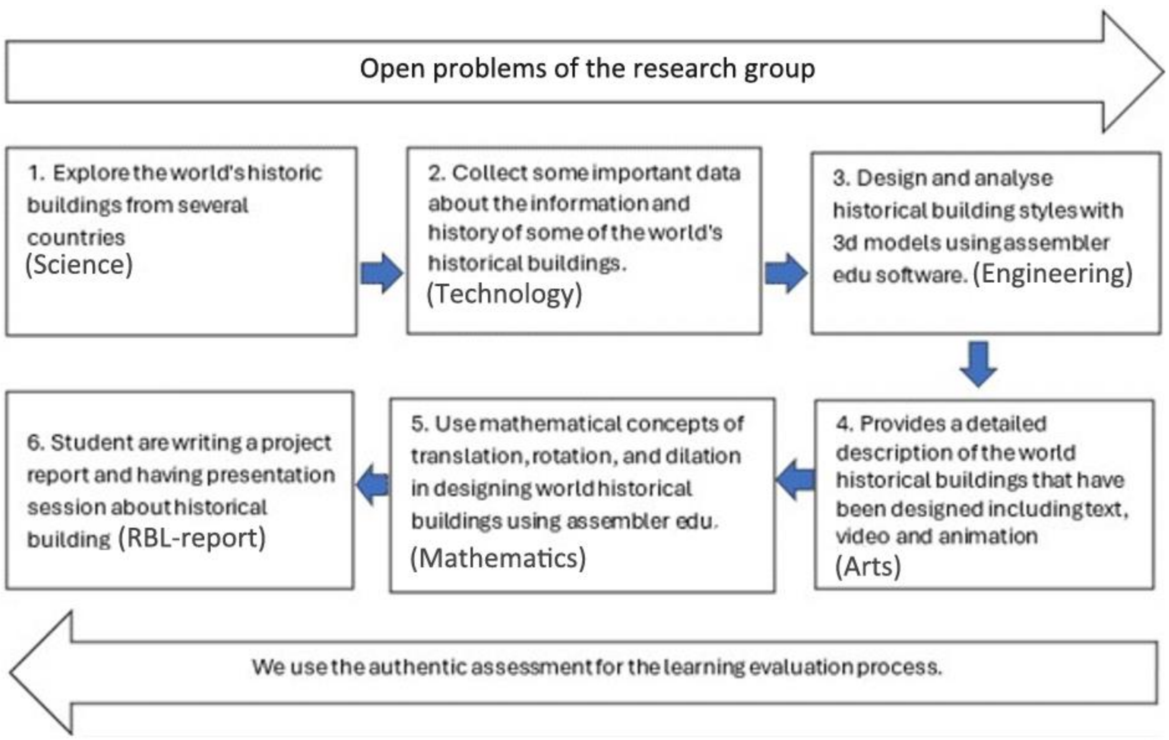

Figure 1.
RBL-STEAM syntax framework.

By emphasizing research-based learning, STEAM (Science, Technology, Engineering, Arts, and Mathematics) helps students develop essential skills such as problem-solving, collaboration, and communication, making them better prepared to face future workplace challenges [28, 29]. Through STEAM, students not only learn theoretical concepts but also apply them in hands-on projects that foster creativity and innovation, thus preparing them for future challenges [30]. The STEAM approach effectively connects theoretical knowledge with real-world applications, enhancing students' interdisciplinary understanding [31]. By integrating five disciplines, STEAM education develops students' critical thinking skills and creativity [32]. This holistic approach combines scientific and mathematical rigor with the freedom of expression found in the arts, encouraging students to think holistically and innovatively. As a result, students are better prepared for careers in a fast-paced, technology-driven global era, making education more dynamic and relevant.

The contemporary educational landscape is witnessing a paradigm shift towards integrating interdisciplinary teaching methods that leverage technology to enhance learning outcomes. Combining Research-Based Learning (RBL) with STEAM (Science, Technology, Engineering, Arts, and Mathematics) fosters a holistic educational environment. This integration is particularly pertinent in history teaching, a subject traditionally reliant on rote memorization rather than critical thinking. The project titled "The Analysis of the Implementation of RBL-STEAM Integrated with Pictorial Riddle Technique Assisted by Assemblr-Edu Media in Improving Students' Historical Thinking Skill" aims to innovate history education by addressing this gap through a novel pedagogical approach.

3. Methods

This study used a hybrid methodology, which combines qualitative and quantitative research. According to Tarnoki and Puentes [33] combining mixed research methods is very beneficial when qualitative and quantitative methods need to be more precise to understand research problems.

3.1. Research Design

This method employs a pretest-posttest non-equivalent group design, involving two groups or classes that undergo different interventions. These groups are designated as the experimental group and the control group. The experimental class will receive special treatment, namely the implementation of RBL-STEAM Integrated with Pictorial Riddle Technique Assisted by Assemblr- Edu Media. The control group also received RBL-STEAM learning but was not integrated with the Pictorial Riddle Technique Assisted by Assemblr-Edu Media. The research design of the quasi-experiment involving two groups can be seen in Table 2.

Table 2.
Research design of quasi-experiment.

Class	Pre-test	Treatment	Post-test
Experiment class of 42 students	O1	X	O2
Control class of 40 students	O3		O4

Note: O1, O3: A pre-test administered to both class groups to assess the baseline historical thinking skills of students in each class.
X: Implementation the RBL-STEAM integrated with Pictorial Riddle technique assisted by Assemblr-Edu media
O2, O4: A post-test provided to both class groups to evaluate the development of students' historical thinking skills in both classes following the application of RBL-STEAM combined with the Pictorial Riddle technique, supported by Assemblr-Edu media.

3.2. Research Population

The subjects of this study were 82 even-semester students in the 2023/2024 academic year of the History Education Program, Faculty of Teacher Training and Education, University of Jember, Indonesia. The subjects of this study consisted of an experimental class of 42 students and a control class of 40 students. The program offers a world history course divided into two classes every semester. The average age of the students in each class was 22 years old, with low and high-ability classifications identified based on pre-test scores (in logarithmic form). An average score of 65 was chosen for categorization, with students scoring below 65 classified as low ability and students scoring 65 or above classified as high ability. The medium of instruction for the World History course is Bahasa Indonesia, with two weekly sessions. The students had similar cultural backgrounds and knowledge of the course. The Research Ethics Committee approved this sample selection - Faculty of Teacher Training and Education, University of Jember, Indonesia. December 2023 (Reff. No 8752/UN25.5.1/LL/2023) The sample selection used proportional random sampling to determine each class according to the research proposal.

3.3. Instrument

The instrument used in this research is a learning outcome test with a score range of 1-100. The second instrument is a questionnaire; the questionnaire in this study was distributed online using Google Forms. The third instrument is the interview text related to students' Historical thinking skills. Before distributing the questionnaires, the indicators that describe each variable need to be considered to obtain the validity and reliability of the questionnaire. A Likert scale from 1 to 5 was used to measure each variable. After collecting the questionnaire data, we used NVivo and Smart-PLS application software to analyze the correlation between variables and indicators.

3.4. Validity and Reliability Test

After implementing the RBL-STEAM method, we evaluated the students using both a pretest and a post-test. The data from these tests were analyzed using SPSS inferential statistical software through an independent samples t-test. This t-test is designed to determine whether the RBL-STEAM integrated with the pictorial puzzle technique, supported by Assemblr-Edu media, significantly affects students' historical thinking skills. A Sig (2-tailed) value less than 0.05 indicates a significant difference in historical thinking skills between students in the experimental and control classes. Conversely, a Sig (2-tailed) value greater than 0.05 suggests no significant difference. Prior to the t-test, we conducted tests for normality and homogeneity of the data. The Kolmogorov-Smirnov test was used to assess normality, with data considered normal if the significance level was greater than 0.05. The homogeneity of the data across the two classes was checked, indicating that if the significance value is above 0.05, the variances of the two groups are equal (homogeneous); if below 0.05, they are different (inhomogeneous). In-depth interviews were also conducted as part of the research further to explore the data analysis findings [34]. Students were selected for interviews based on their post-test scores in historical thinking skills. Selecting subjects with low, medium, and high historical thinking abilities was the first step in creating phase portraits. Questionnaires were used to interview the selected subjects [35]. The respondents' answers were recorded and compared with the interview cards. By adding special coding to the cards, sub-indicators of historical thinking ability were used to develop the cards. After determining logical answers to display a phase portrait of students' historical thinking skills, the interviewer connected the sub-indicators, represented by nodes and ends. This study also examined how students experienced this exercise using NVivo software. In addition, Smart-PLS was used to analyze the questionnaire to determine the relationship between RBL-STEAM variables and students' historical thinking skills.

4. Result of Research

4.1. Learning Process

Before conducting the pretest to the students, we conducted the learning process using Assemblr-Edu media. Previously, we conducted a bibliometric analysis of historical thinking skills. A bibliometric analysis of historical thinking skills reveals various connections between these skills and 21st-century learning, critical thinking abilities, students' learning capabilities, higher-order thinking skills, and the educational media employed. The relationship can be represented in Figure 2. After analyzing the bibliometric of historical thinking skills, we designed Assemblr-Edu media that will be used by students. The following illustration of creating Assemblr Edu media can be seen in Figure 3. Once the design phase is complete, Assemblr-Edu media are tested on students in the classroom. Figure 4 shows the use of Assemblr-Edu media in a world history class.

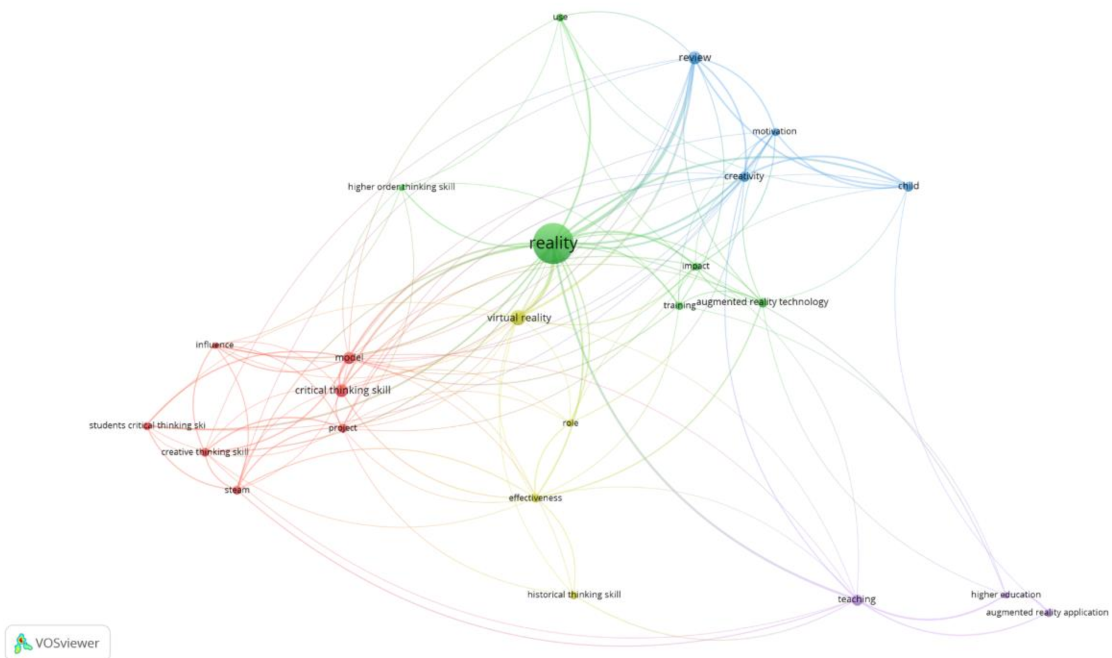

Figure 2.
Bibliometric analysis research about implementation augmented reality in improving student historical thinking skill.

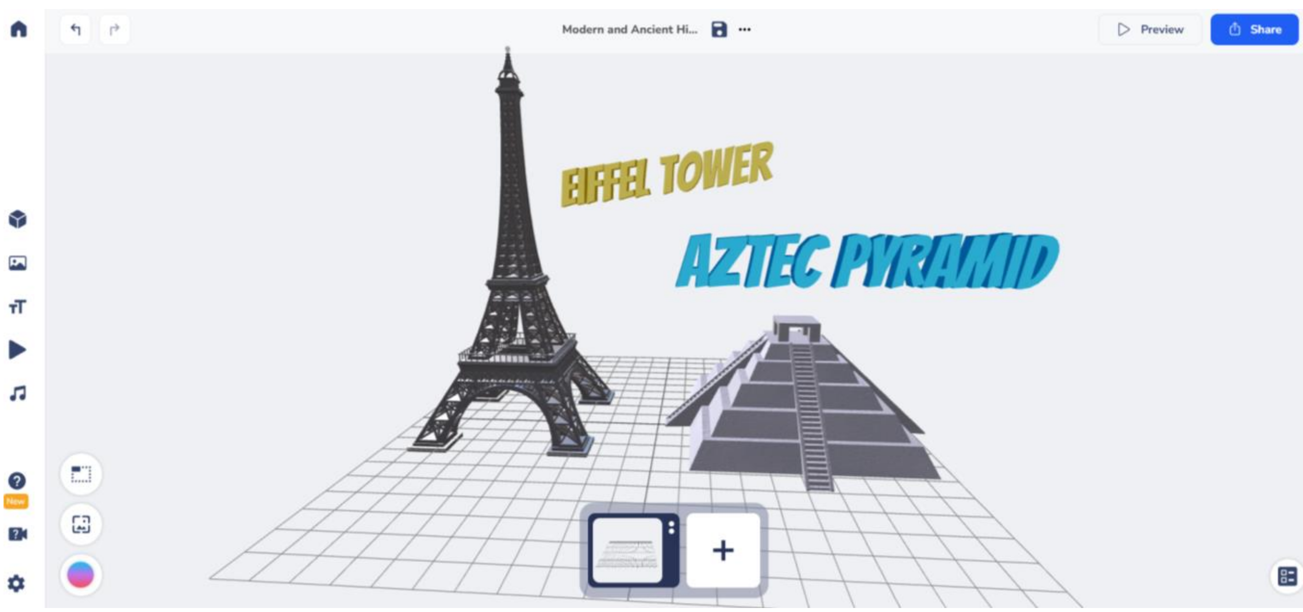

Figure 3.
Design of augmented reality using assemblr edu.

Figure 4.
Implementation of a trial or research.

4.2. Pre-Test Data Analysis

This study used two classes: 42 students from the experimental class and 40 students from the control class. In both classes, both the experiment and control classes were given pretest questions to determine the initial historical thinking skill of students from both classes in the development of students' historical thinking skill. Based on the data analysis of the pre-test results in the experimental class, it can be concluded that there are 9.5% of students who can be classified as having a medium level of historical thinking skill, and 90.5% of students can be classified as having a low level of historical thinking skill. Meanwhile, based on the data analysis of the pre-test results in the control class, it can be concluded that there are 12.5% of students who can be classified as having a medium level of historical thinking skills and 87.5% of students who can be classified as having a low level of historical thinking skill.

Furthermore, two independent samples of the t-test were carried out using SPSS software. Before conducting the two independent sample t-tests, it is necessary to perform two preliminary tests, namely the normality test and the homogeneity test. The first statistical test is the normality test, which determines whether the data from both classes are normally distributed.

Table 3.
Results of normality test on pre-test.

One-sample Kolmogorov-Smirnov test		**Experiment**	**Control**
N	Number of students	42	40
Normal parameters[a,b]	Mean	50.71	50.38
	Std. deviation	9.010	9.086
Most extreme differences	Absolute	0.118	0.123
	Positive	0.118	0.123
	Negative	-0.111	-0.105
Test statistic		0.118	0.123
Asymp. sig. (2-tailed)		0.156[c]	0.130[c]

Note: a. Test distribution is normal.
b. Calculated from data.
c. Lilliefors significance correction

According to Table 3, we can conclude that the data for both classes are normally distributed, as evidenced by the Asymp Sig (2- tailed) values: 0.156 for the experimental class and 0.130 for the control class, both exceeding 0.05. Additionally, a homogeneity test was conducted to verify whether the data variances between the two classes are homogeneous.

Table 4.
Results of homogeneity test on pre-test.

Test of homogeneity of variances					
Description		**Levene statistic**	**df1**	**df2**	**Sig.**
Pretest Score	Based on mean	0.001	1	80	0.976
	Based on median	0.000	1	80	0.996
	Based on the median and with adjusted df	0.000	1	79.971	0.996
	Based on trimmed mean	0.001	1	80	0.974

Based on Table 4, both classes have the same variance as the Sig value. Based on the mean obtained, it is 0.976 > 0.05. This indicates that both classes are homogeneous. After carrying out the normality and homogeneity tests, two independent samples t- tests were carried out to see if there was a difference in the mean score of the historical thinking skills test between the two classes.

Table 5.
Results of two independent samples t-tests on pre-test.

Independent samples test											
Description		**Lavene's test for equality of variances**		**t-test for equality of means**							
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean difference**	**Std. error difference**	**95% confidence interval of the difference**	
									Lower	**Upper**
Pretest score	Equal variances assumed	001	0.976	0.170	80	0.866	0.339	1.999	-3.638	4.317
	Equal variances are not assumed.			0.170	79.734	0.866	0.339	1.999	-3.639	4.318

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The significance Sig value is 0.976 > 0.05 based on Table 5. This indicates that before the start of instruction, there was no change in the mean score on the test of historical thinking skills between the students in the experiment and control classes.

4.3. Post-test Data Analysis

The data analysis from the post-test in the experimental class shows that 21.5% of the students are at a medium level of historical thinking skill, while 78.5% are at a high level. In contrast, the post-test results in the control class indicate that 7.5% of the students have a low level of historical thinking skill, 52.5% are at a medium level, and 40% are at a high level.

Furthermore, two independent samples of the t-test were carried out using SPSS software. Before conducting the two independent sample t-tests, it is necessary to perform two preliminary tests, namely the normality test and the homogeneity test. The first statistical test is the normality test, which determines whether the data from both classes are normally distributed.

Table 6.
Results of normality test on post-test.

One-sample Kolmogorov-Smirnov test		**Experiment**	**Control**
N	Number of students	42	40
Normal Parameters[a,b]	Mean	85.71	75.38
	Std. deviation	9.010	9.086
Most extreme differences	Absolute	0.118	0.123
	Positive	0.118	0.123
	Negative	-0.111	-0.105
Test statistic		0.118	0.123
Asymp. sig. (2-tailed)		0.156[c]	0.130[c]

Note: a. Test distribution is normal.
b. Calculated from data.
c. Lilliefors significance correction.

Table 6 indicates that the data for both classes are normally distributed, as the Asymp Sig (2-tailed) values are 0.156 for the experimental class and 0.130 for the control class, both above 0.05. Additionally, a homogeneity test was performed to assess whether the data variances between the two classes are homogeneous.

Table 7.
Results of homogeneity test on post-test.

Test of homogeneity of variances					
Description		**Levene statistic**	**df1**	**df2**	**Sig.**
Post-test score	Based on mean	0.001	1	80	0.976
	Based on median	0.000	1	80	0.996
	Based on the median and with adjusted df	0.000	1	79.971	0.996
	Based on trimmed mean	0.001	1	80	0.974

Based on Table 7, both classes have the same variance as the Sig value. Based on the mean obtained, it is 0.976 > 0.05. This indicates that both classes are homogeneous. After carrying out the normality and homogeneity tests, two independent samples t- tests were carried out to see if there was a difference in the mean score of the historical thinking skills test between the two classes.

Table 8.
Results of two independent samples t-tests on post-test.

Independent samples test											
Description		**Levene's test for equality of variances**		**t-test for equality of means**							
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean difference**	**Std. error difference**	**95% confidence interval of the difference**	
									Lower	**Upper**
Post-test score	Equal variances assumed	6.221	0.015	10.423	80	0.000	20.664	1.983	16.719	24.610
	Equal variances are not assumed.			10.425	79.865	0.000	20.664	1.982	16.720	24.609

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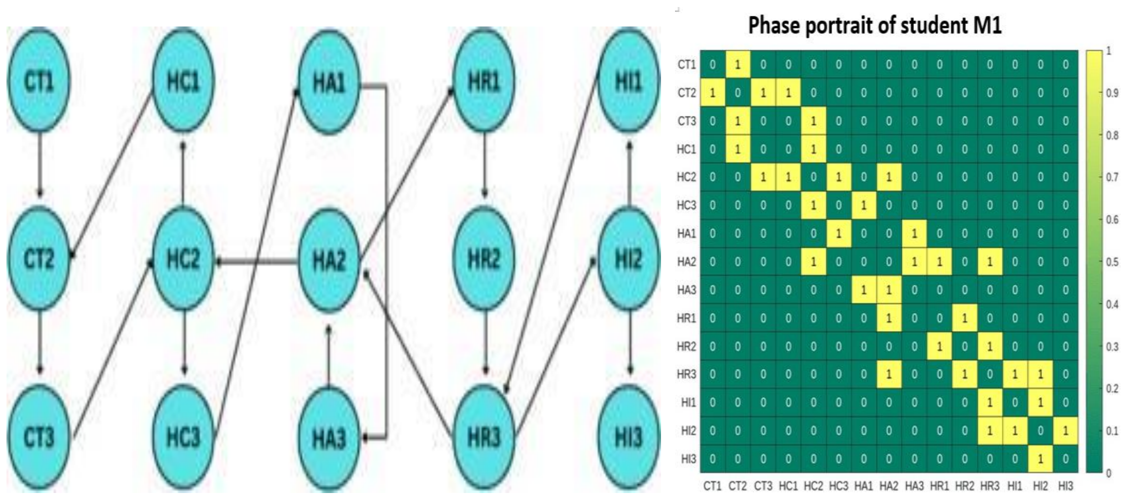
Table 8 shows that the significance Sig value is 0.015, which is less than 0.05. This suggests that after implementing the RBL- STEAM approach combined with the Pictorial Riddle technique and supported by Assemblr-Edu media, there is a statistically significant difference in the average historical thinking skills test scores between the experimental and control class students.

4.4. Phase Portrait

A phase portrait represents an individual's thought process in an illustrated or diagrammatic form. The phase portrait of the students in this research is constructed from their historical thinking patterns using RBL-STEAM-based learning combined with the Pictorial Riddle Technique facilitated by Assemblr-Edu Media. Student 1's response indicates the first post-test result, M1, which shows a high category of historical thinking. Figure 5 (a) visually depicts the historical thinking patterns of students who fall into high categories. Figure 5 (b) shows the adjacency matrix of distance one from the graphical representation.



(a) (b)

Figure 5.
(a) Graph representation of M1, (b) Adjacency matrix of distance 1 of M1.

Next, we will evaluate the total depth (TD), mean depth (MD), relative asymmetry (RA), and real relative asymmetry (RRA) of M1's train of thought. The advantage of conducting this analysis lies in assessing students' historical thinking skills through the lens of flow configuration. Total Depth (TD) refers to the sum of the path lengths for the observed sub-indicators, $Mean\ Depth\ (MD) = \frac{TD}{n-1}, RA = \frac{2(MD-1)}{n-2}, GL = 2\ \frac{L(L)^{\frac{1}{2}}-2\ L+1}{(L-1)(L-2)}\ \ and\ RRA = \frac{RA}{GL}$. Using this formula, the values presented in Table 9 are derived.

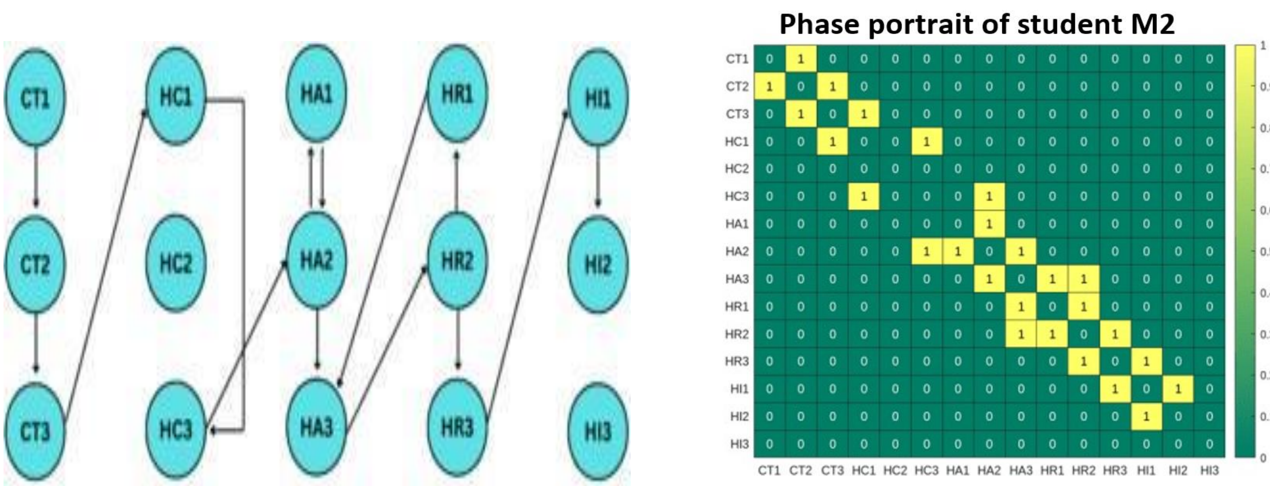
Table 9.
TD, MD, RA, and RRA values of M1 phase portrait.

No	Sub-indicators	TD	MD	RA	RRA	No	Sub-indicators	TD	MD	RA	RRA
1.	CT1	129	9.21	1.26	3.95	9.	HA3	50	3.57	0.40	1.24
2.	CT2	103	7.36	0.98	3.05	10.	HR1	60	4.29	0.51	1.58
3.	CT3	45	3.21	0.34	1.06	11.	HR2	101	7.21	0.96	2.99
4.	HC1	45	3.21	0.34	1.06	12.	HR3	44	3.14	0.33	1.03

5.	HC2	38	2.71	0.26	0.82	13.	HI1	58	4.14	0.48	1.51
6.	HC3	51	3.64	0.41	1.27	14.	HI2	57	4.7	0.47	1.48
7.	HA1	57	4.07	0.47	1.48	15.	HI3	73	0.65	0.65	2.03
8.	HA2	37	2.64	0.25	0.79						

In Table 9, it is evident that sub-indicator HA2 possesses an RRA score of 0.79. The RA score associated with this particular sub-indicator is deemed optimal since lower RRA values, provided they are not negative, signify greater integrity and can be classified as favorable. Within this sub-indicator, student M1 experienced notable advantages in problem-solving.

Next, we will discuss the phase portrait of student M2. M2 is a student with moderate historical thinking ability. Figure 6 (a) shows the graphical representation of Student M2's thought flow, while Figure 6 (b) shows the adjacency matrix of distance one from the graphical representation.



(a) (b)

Figure 6.
(a) Graph representation of M2, (b) Adjacency matrix of distance one from M2.

Next, we will evaluate the total depth (TD), mean depth (MD), relative asymmetry (RA), and real relative asymmetry (RRA) of M2's thought train. The advantage of conducting this analysis lies in assessing students' historical thinking skills through the lens of flow configuration. Total Depth (TD) is the total number of path lengths of the observed sub-indicators, $Mean\ Depth\ (MD) = \frac{TD}{n-1}, RA = \frac{2(MD-1)}{n-2}, GL = 2\ \frac{L(L)^{\frac{1}{2}}-2\ L+1}{(L-1)(L-2)}\ and\ RRA = \frac{RA}{GL}$. Using this formula, the values presented in Table 10 are derived.

Table 10.
TD, MD, RA, and RRA values of M2 phase portrait.

No	Sub-indicators	TD	MD	RA	RRA	No	Sub-indicators	TD	MD	RA	RRA
1.	CT1	68	5.67	0.85	2.56	8.	HA3	34	2.83	0.33	1.01
2.	CT2	57	4.75	0.68	2.06	9.	HR1	41	3.42	0.44	1.33
3.	CT3	48	4	0.55	1.65	10.	HR2	38	3.17	0.39	1.19
4.	HC1	41	3.42	0.44	1.33	11.	HR3	45	3.75	0.5	1.51
5.	HC3	36	3	0.36	1.09	12.	HI1	54	4.5	0.64	1.92

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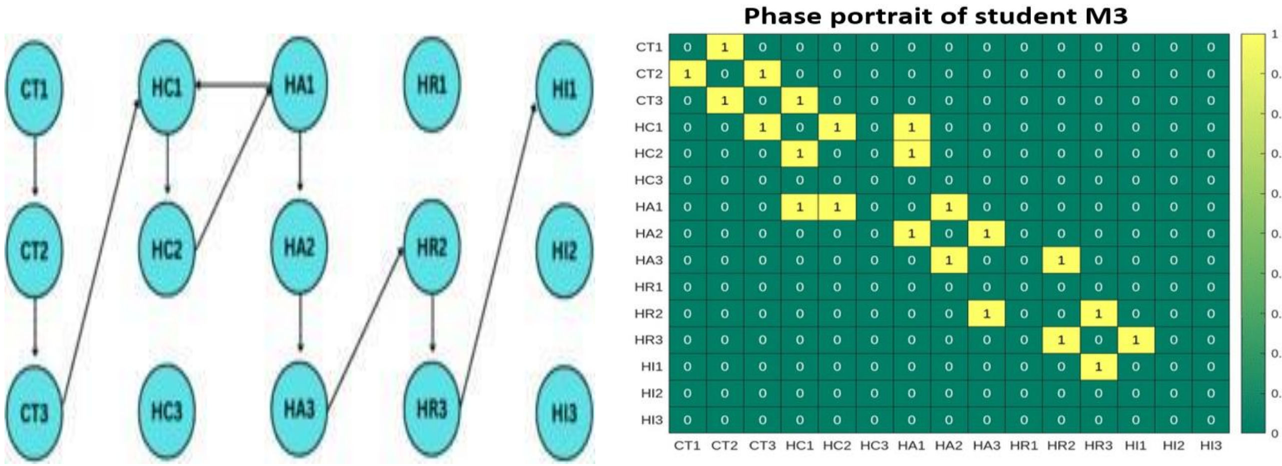
6.	HA1	44	3.67	0.49	1.46	13.	HI2	65	5.42	0.80	2.42
7.	HA2	33	2.75	0.32	0.96						

In Table 10, it is evident that sub-indicator HA2 possesses an RRA score of 0.96. The RA score associated with this particular sub-indicator is deemed optimal since lower RRA values, provided they are not negative, signify greater integrity and can be classified as favorable. Within this sub-indicator, student M2 experienced notable advantages in problem-solving.

Next, we will discuss the phase portrait of student M3. M3 is a student with low historical thinking skills. Figure 7 (a) shows the graph representation of student M3's thinking flow, while Figure 7 (b) shows the adjacency matrix of distance one from M3's graph representation.



(a) (b)

Figure 7.
(a) Graph representation of M3, (b) Adjacency matrix of distance 1 of M3.

Next, we will analyze the total depth (TD), mean depth (MD), relative asymmetry (RA), and real relative asymmetry (RRA) of the M3 train of thought. The advantage of conducting this analysis lies in assessing students' historical thinking skills through the lens of flow configuration. Total Depth (TD) is the total number of path lengths of the observed sub-indicators, $Mean\ Depth\ (MD) = \frac{TD}{n-1}, RA = \frac{2(MD-1)}{n-2}, GL = 2\ \frac{L(L)^{\frac{1}{2}}-2\,L+1}{(L-1)(L-2)}$ $and\ RRA = \frac{RA}{GL}$. From this formula, the distribution of values in Table 11 is obtained.

Table 11.
TD, MD, RA, and RRA values of M3 phase portrait.

No	Sub-indicators	TD	MD	RA	RRA	No	Sub-indicators	TD	MD	RA	RRA
1.	CT1	49	4.9	0.87	2.52	7.	HA2	27	2.7	0.38	1.09
2.	CT2	40	4	0.67	1.94	8.	HA3	30	3	0.44	1.29
3.	CT3	33	3.3	0.51	1.49	9.	HR2	35	3.5	0.56	1.61
4.	HC1	28	2.8	0.4	1.16	10.	HR3	42	4.2	0.71	2.06
5.	HC2	31	3.1	0.47	1.36	11.	HI1	51	5.1	0.91	2.65
6.	HA1	26	2.6	0.36	1.03						

In Table 11, it is evident that sub-indicator HA1 possesses an RRA score of 1.03. The RA score associated with this particular sub-indicator is deemed optimal since lower RRA values, provided they are not negative, signify greater integrity and can be classified as favorable. Within this sub-indicator, student

M3 experienced notable advantages in problem-solving. Based on the RRA values of M1, M2, and M3, it can be seen that the smallest RRA value is the RRA value of M1.

4.5. NVivo Analysis

Using NVivo software, the third analysis is a qualitative examination of variations in students' historical thinking skills. Word Frequency Query is one of NVivo's tools that allows text to be displayed visually. Researchers can use this feature to see how frequently intriguing words appear in the transcripts of their in-depth interviews with students. From the search results using this feature, sets of terms that occur often in the data were compiled. This analysis resulted in a compilation of commonly occurring terms in the interview data, as illustrated in Figure 8.

Figure 8.
Word cloud of historical thinking skills.

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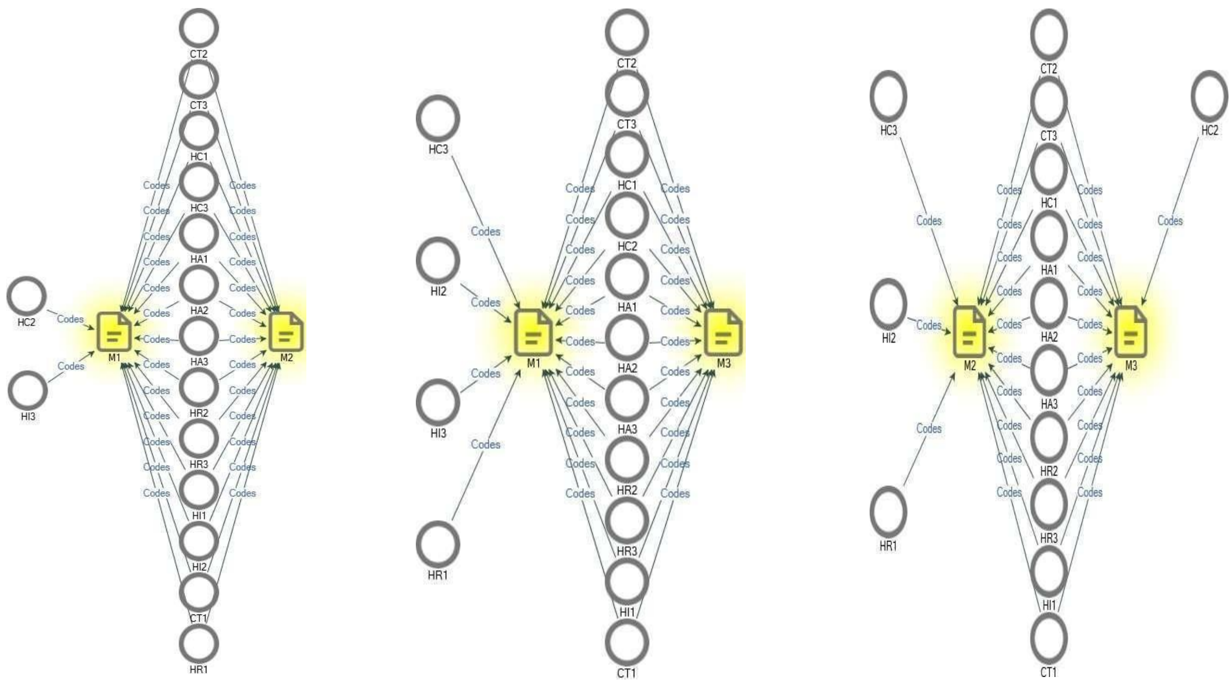

(a) (b) (c)

Figure 9.

(a) Comparison of M1 and M2, (b) Comparison of M1 and M3, and (c) Comparison of M2 and M3.

Next, we will examine the comparative information provided by the three interviews. Comparative information is a valuable feature of NVivo. In this section, the historical thinking skills are divided into several sub-indicators. The first indicator is chronological thinking, which has three sub-indicators, namely sequence (CT1), periodization (CT2), and temporal context (CT3). The second indicator is historical comprehension, which has three sub-indicators, namely contextualization (HC1), historical perspective (HC2), and causation (HC3). The third indicator is historical analysis, which has three sub-indicators, namely source analysis (HA1), interpretation (HA2), and corroboration (HA3). The fourth indicator is historical research, which has three sub- indicators, namely research design (HR1), primary source research (HR2), and secondary source analysis (HR3). Last, the historical issues indicator also has three sub-indicators, namely historical empathy (HI1), synthesis (HI2), and communication (HI3).

From Figure 9 (a), we can see the difference in sub-indicators that M1 and M2 can pass. There is a difference between sub- indicators M1 and M2, where HC2 and HI3 can only be passed by M1. Figure 9 (b) shows the difference in sub-indicators that M1 and M3 can pass. There is a difference between sub-indicators M1 and M3, where sub-indicators HC3, HI2, HI3, and HR1 can only be passed by M1. Figure 9 (c) shows the difference in sub-indicators that M2 and M3 can pass. There is a difference between the sub-indicators of M2 and M3, where sub-indicators HC3, HI2, and HR1 can only be passed by M2, and only sub-indicator HC2 can be passed by M3.

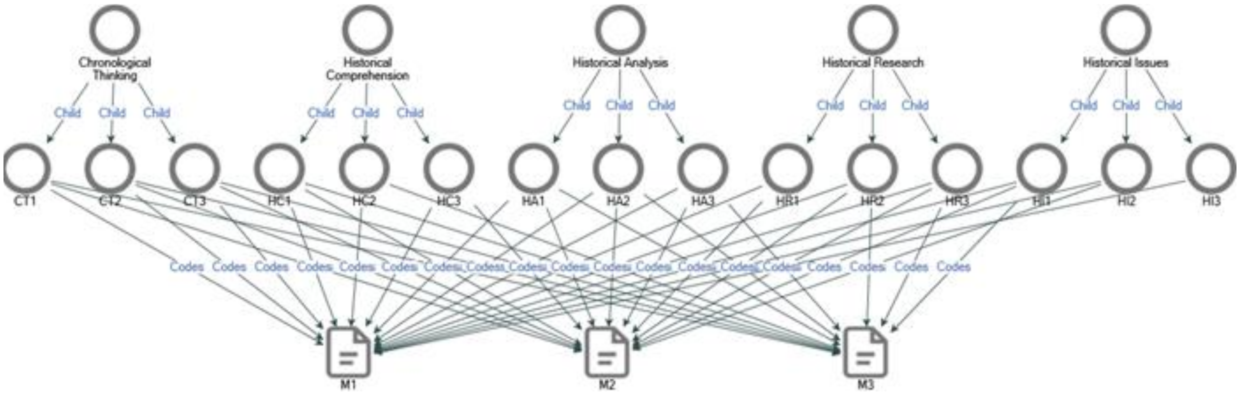

Figure 10.
Project map of historical thinking skills on M1, M2, and M3.

Next, we will compare the students' total data and how it relates to the pre-established categorization. We'll also show the classification results from the interviews. Figure 10 shows NVivo's project map feature. It can be seen that this project map is consistent with the previous analysis, where M1 fulfills all sub-indicators, while M2 and M3 do not meet some sub-indicators.

4.6. Smart-PLS Analysis

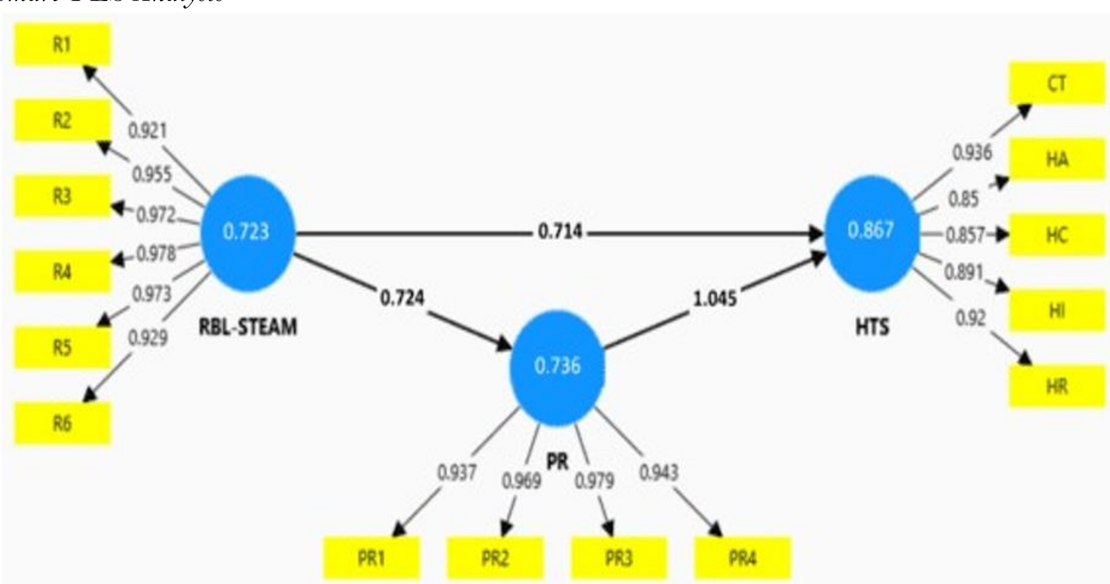

Figure 11.
Smart-PLS algorithm.

The concluding analysis indicates that Smart-PLS will be utilized. The initial step in Smart-PLS involves employing the SEM- PLS algorithm to assess the model's viability and its indicators and sub-indicators for this research. Referring to Figure 11, we will evaluate the standard algorithm by considering the current elements, which include the loading factor value, reliability, and the average variance extracted (AVE). The purpose of the loading factor value is to ascertain each sub-indicator's convergent validity. A sub-indicator is considered to have convergent solid validity if its value exceeds 0.7. Specifically, the loading factor values are 0.723 for the RBL-STEAM indicator, 0.736 for the Pictorial Riddle (PR) indicator, and 0.867 for the Historical Thinking Skills (HTS) indicator. Details on the loading factor value, Cronbach's alpha reliability, composite reliability, and average variance extracted are presented in Table 12.

Table 12.
Loading factor value, reliability Cronbach's alpha, composite reliability, average variance extracted.

Indicator	Sub-indicator	Loading factor	Reliability cronbach's alpha	Composite reliability	AVE
RBL-STEAM	R1	0.921	0.798	0.891	0.858
	R2	0.955			
	R3	0.972			
	R4	0.978			
	R5	0.973			
	R6	0.929			
Pictorial riddle (PR)	PR1	0.937	0.845	0.874	0.815
	PR2	0.969			
	PR3	0.979			
	PR4	0.943			
Historical thinking skills (HTS)	CT	0.936	0.871	0.849	0.861
	HA	0.85			
	HC	0.857			
	HI	0.891			
	HR	0.92			

Table 12 reveals that all sub-indicators within the model have a loading factor value exceeding 0.7, indicating strong convergent validity. This suggests that each sub-indicator effectively measures the intended indicators. Additionally, the model's assessment includes examining metrics such as Cronbach's alpha reliability, composite reliability, and the average variance extracted (AVE).

The reliability of an indicator is assessed using Cronbach's alpha and composite reliability values, with satisfactory reliability indicated by values surpassing 0.7. According to Table 12, all indicators meet this reliability criterion, ensuring their effectiveness in the SEM model evaluation. The AVE is another crucial metric for determining convergent validity; an AVE value above 0.5 signifies strong convergent validity, a standard that all indicators in Table 12 meet.

Furthermore, the cross-loading factor value plays a pivotal role in the discriminant validity test, which ascertains that the values of each latent model are distinct from those of other indicators. Analysis based on the cross-loading factor values confirms that each latent model's values are uniquely distinguishable from those of different indicators.

The subsequent analysis involved bootstrapping, as illustrated in Figure 12. This examination tested three hypotheses, concluding that each demonstrated a significant impact. Specifically, Hypothesis 1 (H1) showed that RBL-STEAM significantly relates to Historical Thinking Skills (HTS) with a p-value of 0.000 (less than 0.05) and a t-value of 32.147 (greater than 1.96), suggesting a strong association between RBL-STEAM and Historical Thinking Skills. Hypothesis 2 (H2) revealed a significant relationship between RBL-STEAM and Pictorial Riddle (PR), with a p-value of 0.000 and a t-value of 34.563, indicating a significant correlation. Hypothesis 3 (H3) found that Pictorial Riddle PR) is significantly associated with Historical Thinking Skills (HTS), evidenced by a p-value of 0.000 and a t-value of 33.749.

Further analysis was conducted on the direct and indirect effects' path coefficients. The path from RBL-STEAM to HTS has a p-value of 0.0304; from RBL-STEAM to PR, the p-value is 0.0143; from PR to HTS, the p-value is 0.0314; and for the indirect path from RBL-STEAM through PR to HTS, the p-value is 0.0092. These findings significantly affect the indirect path coefficient, demonstrating that the synergy between RBL-STEAM and PR significantly affects historical thinking skills.

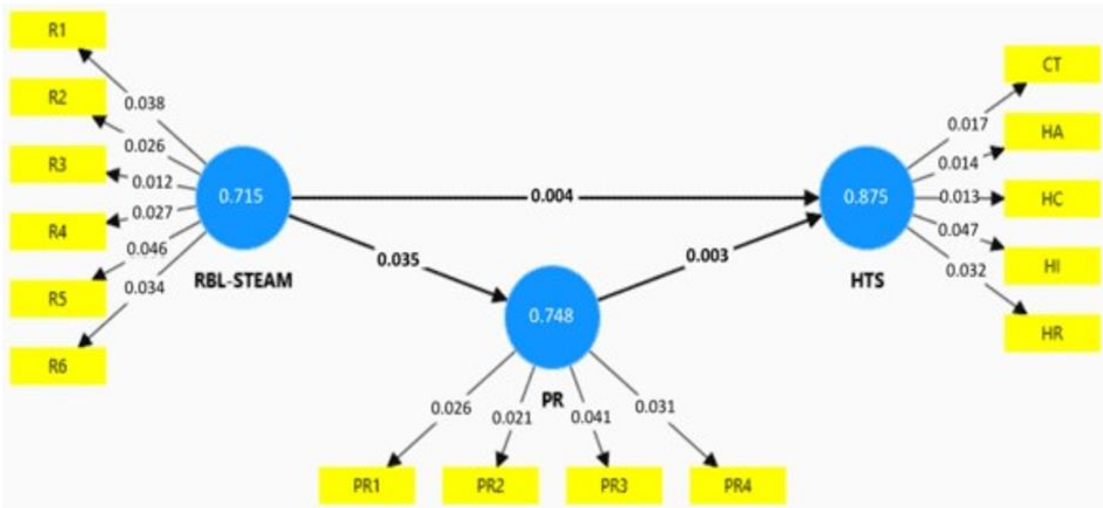

Figure 12.
Smart-PLS bootstrapping result.

5. Discussion

This research explores the impact of integrating RBL-STEAM with the Pictorial Riddle technique, facilitated by Assemblr-Edu Media, on students' historical thinking skills in history courses. The study utilized two classes: an experimental class that employed the RBL-STEAM model with the Pictorial Riddle technique assisted by Assemblr-Edu Media, and a control class that used only the RBL-STEAM model. Hypothesis testing was conducted using the two independent samples t-test via SPSS. Data from the post-test were analyzed with SPSS inferential statistical software, using the independent samples t-test. The significant Sig value of $0.015 < 0.05$ suggests a notable difference in the average historical thinking skills test scores between the experimental and control classes, indicating that the experimental class, which utilized the RBL-STEAM model with the Pictorial Riddle method supported by Assemblr-Edu, significantly improved historical thinking skills more effectively than the control group. Furthermore, this study investigated the students' experiences with this approach using NVivo software and used Smart-PLS to examine the relationships between RBL-STEAM variables and students' historical thinking skills.

The Pictorial Riddle technique, supported by Assemblr-Edu media, is an innovative learning method that positively influences students' thinking skills in history subjects. However, what is superior in learning the Pictorial Riddle method lies in its stages, namely, presenting problems in the form of pictures supported by Assemblr-Edu media so that it can enhance understanding and further analysis of the concept of historical events, collecting and verifying data in groups, and then students make observations that contain problems. After that, students hold discussions to formulate hypotheses and conduct analysis to conduct questions and answers [36]. Educators only act as facilitators so that students in the learning process seek and critically analyze the problems given by the educators [37, 38]. In this way, students become familiar with improving their historical thinking skills.

Students who engage in the investigative process of learning history impact historical thinking skills because they are asked to analyze their thinking as they search for answers to the questions posed [39, 40]. The Pictorial Riddle method emphasizes that students are actively involved in solving problems through images by using technology as a learning medium, one of which is Assemblr-Edu [41]. The results of this research are strengthened by a previous study conducted by Agustin and Farisi [42] who stated that the Pictorial Riddle method became more effective in student learning in history subjects, as evidenced by students being more active in asking questions and holding discussions for further analysis.

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And they make presentations to the class. The findings of the research indicated that the implementation of the Pictorial Riddle method in history subjects was categorized as good.

An effective way to build students' historical thinking skills is to use appropriate models/methods, especially to teach students how to reason, analyze, and think critically [43, 44]. Utilizing the Pictorial Riddle Method can enhance learning effectiveness, resolve issues, and cultivate students' cognitive abilities. The Pictorial Method integrated with technology can make learning history more meaningful [45, 46]. The Pictorial Riddle Method, supported by augmented reality-based media, emphasizes students' learning activities in searching and finding information, where students act not only as recipients but also as discoverers in finding the core of the material so that they can cultivate an attitude of self-confidence [47-49]. Thus, students are trained to think critically about historical information by improving their historical thinking skills to make history learning more optimal.

6. Conclusions

This study finds that the RBL-STEAM approach, when combined with the Pictorial Riddle technique and supported by Assemblr- Edu learning media based on Augmented Reality, significantly enhances students' historical thinking skills in history classes. This assertion is supported by the results from two independent samples t-test, which revealed significant differences, with a Sig value of 0.015, less than 0.05. This indicates that the experimental class, which used the RBL-STEAM model integrated with the Pictorial Riddle method and Assemblr-Edu media, significantly outperformed the control group, which only used the RBL-STEAM model, in terms of enhancing historical thinking skills. Additionally, the study explored how students experienced the learning process using NVivo software. Furthermore, Smart-PLS was utilized to analyze the questionnaire results to explore the relationship between RBL-STEAM variables and students' historical thinking skills.

This is because the Pictorial Riddle method supported by Assemblr-Edu media helps students become more active and less tiresome in the learning process and encourages students to improve their historical thinking skills to solve problems. Art aspects on STEAM approach also have significant impact for improving student historical thinking skills, understanding arts aspect on learning historical building making student understand the Golden ratio on historical building. This research recommends that educators apply the Pictorial Riddle method assisted by Assemblr-Edu media in the history learning process so that students become more active, broaden their insight, and become an interesting additional reference for learning history.

7. Recommendations

Some recommendations for further research include comparing this method with other pedagogical approaches to highlight its unique effectiveness. Cross-cultural studies could demonstrate how cultural contexts influence learning outcomes. Investigating the impact of teacher training on implementation could enhance understanding of its broader applicability. Broadening the content focus beyond history could reveal its potential in other disciplines. Additionally, exploring the integration of emerging technologies could further enrich the learning experience. Finally, examining student perspectives could provide invaluable insights for refining and tailoring this approach to meet different educational needs. These avenues of future research promise to advance both theory and practice in history education and beyond.

8. Limitations

Several limitations emerge from this research, warranting careful consideration. One pivotal constraint lies in the study's contextual specificity, as the unique integration of RBL-STEAM with pictorial riddle techniques, coupled with the use of Assemblr-Edu media, may not always translate across varied educational settings or disciplines, potentially limiting the broader applicability of the findings. Furthermore, the sample size and demographic characteristics raise questions about the generalizability of the results, as a sample that lacks diversity or representativeness could skew the study's outcomes and their relevance to different student populations. Methodological considerations also come to the fore, with potential limitations in research design and data analysis methods impacting the study's validity and reliability. Additionally, the research's dependence on technology, specifically Assemblr-Edu media, introduces a variable that could significantly affect the efficacy of the educational intervention, influenced by factors such as accessibility and user familiarity with the technology. Lastly, the temporal scope of the study may not adequately capture long-term impacts or the evolution of students' historical thinking skills, posing a challenge to understanding the sustained effectiveness of the educational strategies employed. These limitations underscore the necessity for a nuanced interpretation of the study's findings and further research to validate and expand upon the initial insights garnered.

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Institutional Review Board Statement:

The Ethical Committee of the University of Jember, Jember, Indonesia has granted approval for this study on 3 December 2023 (Ref. No. 8752/UN25.5.1/LL/2023).

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

Competing Interests:

The authors declare that they have no competing interests.

Authors' Contributions:

All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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