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Integrating Augmented Reality, Assemblr Edu, and Google Sites in Economics Learning to Improve High School Students' Critical Thinking Skills

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ABSTRACT

The background of the research is the low critical thinking ability of high school students and the ongoing gap in research on the development of digital-based learning media. This research aims to develop high school students' critical thinking skills while integrating the augmented reality platform, assembler edu, and google sites into one three-dimensional learning media. This type of research is research and development which adopts the Borg and Gall approach. The research subject were 200 high school students from two different schools. Data collection techniques used interviews, observations, documentation studies, and tests. The media design was tested through validation tests, small trials, extensive trials, and large-scale trials. The data analysis technique used a multivariate T-test to measure the significance of the treatment and N-Gain scores to measure the effectiveness of the media. The results showed an increase in critical thinking skills in the pretest and posttest scores of 51%. The results of the multivariate T-test showed a significant increase before and after media implementation with a sig value of 0.000 <0.05. The N-Gain test showed a result of 0.84>0.7, meaning that the effectiveness of the learning media was in the High category. The responses of teachers and students to the learning media were 90% and 83% respectively, meaning that teachers and students very well received the media.Based on the analysis, it was concluded that the Auregos learning media can improve high school students' critical thinking skills. The implications of utilizing Auregos learning media can support the sustainable improvement of the quality of economics learning in high schools.

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1. INTRODUCTION

Critical thinking skills in high school students play a strategic role as a foundation for meaningful learning, rational decision-making, and preparedness to face global challenges and modern developments. Strengthening high school students' critical thinking skills is expected to produce a generation that is not only cognitively intelligent but also critical, creative, and responsible toward themselves and their communities. Education has a leading role in preparing students to face various challenges in the 21st century (Fitriati, Rosli, Iksan, & Hidayat, 2023). Education in Indonesia consists of elementary, middle, and high school. High school is one of the secondary education levels. High school students are included in the early adolescent category, which has specific characteristics according to their developmental stage. (R. 'Ainun Hasanah & Latifah, 2021). Teenage students tend to undertake more challenging activities, including in their learning process. (Kintu, Zhu, & Kagambe, 2017). Some of adolescents' challenging behaviors manifest in their attitude toward liking new things to measure their skills in overcoming problems, including learning. (Asanov, Flores, McKenzie, Mensmann, & Schulte, 2021). This high school student likes to explore his abilities and skills to try new things that he likes as a means of understanding complex problems. (Attard & Holmes, 2022). This behavior can be considered the basis for developing interactive learning media that is preferred by high school students. Interactive learning media allows students to enjoy thelearning process with high motivation and curiosity, making it more meaningful. (Daryanes et al., 2023).

Critical thinking is a fundamental skill that high school students need to be able to adapt to the 21st-century generation. 4C skills *(Critical Thinking, Communication, Collaboration, and Creativity)* support students to have the skills to understand and evaluate various choices and their consequences to make wise, fast, and correct decisions (Ye & Xu, 2023). Critical thinking is not a talent, so it requires serious effort to develop through continuous practice. Students must be accustomed to facing problems requiring higher-level thinking to develop critical thinking. Critical thinking skills can generally be categorized into two main dimensions: skills and dispositions. (Asigigan & Samur, 2021). Skills are the abilities, proficiencies, or technical mastery that students possess to solve problems carefully, effectively, and efficiently. Meanwhile, disposition is a person's perspective on economic subjects related to their utility and the benefits of studying them. (Quinn, Hogan, Dwyer, Finn, & Fogarty, 2020). Skills and dispositions are interconnected because when both are combined, they will produce a tendency always to think critically because they know the benefits (Sk & Halder, 2020).

This critical thinking ability is necessary for students to demonstrate their existence and win competitions in various fields. This critical thinking ability needs to be trained from an early age using appropriate learning strategies. (Rati, Arnyana, Dantes, & Dantes, 2023). Learning strategies using problem-solvingis one way to improve critical thinking skills. (Mahanal, Zubaidah, Sumiati, Sari, & Ismirawati, 2019). Problem-solving approaches need to be developed innovatively by teachers to support students' achievement of critical thinking (Persky, Medina, & Castleberry, 2019). This needs to be done so that students can connect their knowledge with contextual problems in their surrounding environment (Li, Zhou, & Lam, 2022). Suppose the integration of critical thinking can be carried out well. In that case, students can demonstrate the quality of thinking to provide responses and process facts into skills to provide practical solutions to every social problem (Eren & Öztuğ, 2020).

The background of this research is the low critical thinking skills of high school students. The results of pre-observations conducted on 200 students divided into two high schools showed that almost all students, when given material and assessments based on High Order Thinking Skills (HOTS), were unable to demonstrate critical and in-depth thinking skills. Students could only answer based on the material read and could not explore knowledge and demonstrate its relevance to phenomena in their environment. High Order Thinking Skills are high-level abilities demonstrated by critical, analytical, logical, reflective, metacognitive, and creative thinking skills in solving complex problems (Ichsan et al., 2019). This inability is obtained due to the memorization process without any effort to understand more deeply about a complex phenomenon or problem (Hayat et al., 2024). As a result, student learning outcomes are low and do not meet the minimum completion criteria. This study focuses on the low level of critical thinking in high school students, particularly in economics. Another

observation finding concerns teachers' skills in utilizing digital technology in learning. Teachers still use simple, time-honored learning media without innovation. In fact, teachers download learning modules from the internet, thus not meeting the needs of differentiated learning. Observations of teachers' lesson plan documents indicate that they only use PowerPoint, projectors, and simple visual media. Teachers' difficulties in developing digital media also hinder the development of students' critical thinking skills.

Research conducted by (Setiana, Purwoko, & Sugiman, 2021) shows that students' skills in Indonesia have not met expectations due to low critical thinking skills. Students in Indonesia are accustomed to being given single rather than open-ended (reasoning) questions, resulting in low critical thinking skills because they believe memorization is easier. This problem impacts on the achievement of educational goals in Indonesia as mandated by Law Number 20 of 2003 concerning the National Education System. Research by (Sari, Sumarmi, Astina, Utomo, & Ridhwan, 2021) stated that there are still many students with low critical thinking skills even though the 2013 curriculum has been implemented.

This research is fundamental because of the massive problems in learning about critical thinking skills that are often complained about by teachers and education observers (Elbyaly & Elfeky, 2023). The problem of critical thinking in students is one of the problems that is often the object of educational research (Wale & Bishaw, 2020). The cause of this critical thinking problem is the inability of students to understand the material comprehensively, deeply, and meaningfully (Saputra, Joyoatmojo, Wardani, & Sangka, 2019). For students, memorization is a primary learning strategy. The impact is that when this memorization is no longer discussed, they will slowly but surely forget because it has no meaning other than getting a grade or learning outcome (Zhang & Reynolds, 2023). Memorizing learning cannot support critical thinking skills, so learning strategies requires students to understand and provide meaning (Hsbollah, H. M., & Hassan, 2022). Meaningful learning will stick firmly in students' memories and remain for a long time (Andrews, van Lieshout, & Kaudal, 2023).

Economics requires a complex understanding because it is related to the breadth of the objects discussed, thus requiring high-level critical thinking skills. Economic material has a a vast and comprehensive scope of problems related to the community economy. The development of critical thinking skills in the subject of economics is included in the objectives of learning economics, including so that students have the ability to: (1) understand several economic concepts to relate economic events or problems in everyday life, (2) display an attitude of curiosity towards economic concepts, (3) form a wise, rational, and responsible attitude by mastering economic knowledge that is beneficial to themselves and society, (4) make quick, accurate, and responsible decisions regarding socio-economic values in a pluralistic society. Critical thinking in economics arises from the use of language and mathematical terms in interpreting economic concepts, which are interpreted as verbal expressions to convey and apply economic ideas and concepts accurately (Utami et al., 2025).

Applying learning media is one strategy in integrating the basic concepts of learning materials more deeply (U. Hasanah, Astra, & Sumantri, 2023). High school students are included in the middle adolescent category who have a high level of skill in developing critical thinking skills if supported by interesting learning media (Kwangmuang, Jarutkamolpong, Sangboonraung, & Daungtod, 2021). The development of high school students' skills is almost perfect, so it is the right momentum to optimize their abilities (Martynets et al., 2020). Using interesting learning media will support students' abilities in developing curiosity about a learning object. (Basri, Purwanto, As'ari, & Sisworo, 2019). This means that high school studentshave higher thinking abilities but need the right learning media to support them (Abdulrahaman et al., 2020). Teacher guidance in implementing learning media isnecessary to ensure that students can utilize the media's objectives optimally (Angraini, Fitria, & Setiawan, 2021).

Augmented Reality (AR) is a new technology that combines digital elements and real-life conditions. (Khan, Johnston, & Ophoff, 2019). The use of Augmented Reality in economics learning allows students to combine the concept of contemporary economic problems with digital technology such as images, videos, illustrations, and animations. (Kamińska et al., 2023). The working pattern of AR integration is to help students visualize abstract cases to develop critical thinking, thereby

providing memorable learning meaning and increasing the efficiency of learning time (Hamzah et al., 2021). Digital technology in augmented reality will support students in developing critical and comprehensive thinking skills in interpreting a problem (Ahmad & Junaini, 2020).

The novelty of this research is the combination of augmented reality (AR), the Assemblr Edu Studio Web educational platform, and the Google Sites platform into a single three-dimensional AR-based digital medium. The augmented reality learning media design uses the Assemblr Edu Studio Web educational platform. Assemblr Edu is an immersive educational platform to help teachers, students, and parents deliver fun and memorable learning using three-dimensional visuals (Paat, Warouw, & Mokalu, 2025). Immersive means involving students to be fully and deeply involved so they feel like they are in a real situation (Kuhail, Elsayary, Farooq, & Alghamdi, 2022). Assemblr edu's innovative media development collaborates with the Google Sites platform, making it more engaging for students thanks to its three-dimensional features. Google Sites is a Google service that helps users create intuitive, easy, and fast websites (Owan, Abang, Idika, Etta, & Bassey, 2023). The menu in Google Sites is very interactive, so it can be designed in an attractive way to develop curiosity and critical thinking skills if integrated into learning (Aulia & Riefani, 2021). Research on digital technology has been widely used as a learning medium to develop critical thinking skills, such as research conducted by (Gonzalez-Mohino, Rodriguez-Domenech, Callejas-Albiñana, & Castillo-Canalejo, 2023) by applying digital tools or research (Walter, 2024) utilizing artificial intelligence in meaningful learning. Both identified gaps, including the lack of innovation in integrating augmented reality, Assemblr Edu, and Google Sites.

The use of technology in learning is a form of adaptation and demands increasing teacher capacity (Islam Sarker, Wu, Cao, Alam, & Li, 2019). Teachers have control over selecting appropriate technology-based learning media for implementation in the classroom. Therefore, teachers must be able to use learning technology (Human-hendricks, 2023). Research conducted by (Mhlongo et al., 2023) revealed that implementing technology in learning supports the transition of a more modern educational paradigm, tailored to learning needs, enabling students to develop an understanding of simple to complex contexts. Integrating learning technology can also personalize students' learning experiences through involvement in knowledge development, improved learning outcomes, and broader improvements in the quality of education (Gligorea et al., 2023).

This study complements previous research on developing critical thinking skills by integrating augmented reality-based digital media. The aim of this research is to develop and test the effectiveness of Augmented Reality-based learning media that integrates Assemblr Edu and Google Sites in improving the critical thinking skills of high school students

2. METHODS

2.1 Design and Types of research

This research is of the Research and Development (R&D) type, a technique for validating and testing products (Prof. Dr. Sugiyono, 2023). Product development in this research involves creating a new product in the form of learning media that integrates augmented reality, Assembler edu, and Google Sites. Product validity is testing a product's validity, effectiveness, and practicality (Prof. Dr. Sugiyono, 2023). The media development adopted the Borg and Gall approach, simplified into four main steps to measure the effectiveness of media in improving high school students' critical thinking skills. The Borg and Gall approach was chosen because it aligns with the need to design and develop systematic and structured learning media products (Rahmatin & Larasati, 2024). The Borg and Gall approach consists of ten stages, simplified into five main ones. These are needs assessment, media design, media validation, trials and revisions, and testing. The other five stages are reduced and integrated with the main stages for effectiveness and efficiency.

2.2 Subject and Location of Research

The research subjects were 200 high school students from two schools in Purworejo Regency. The sampling technique used was saturated sampling, so that all members of the population were included in the study as field trial subjects. The research object is a digital-based learning medium that integrating augmented reality, assembler edu, and Google Sites. The goal of using the media is to improve critical thinking skills. The research location was two high schools in Purworejo Regency, Central Java.

2.3 Development Procedure

The media was developed through five main stages, namely (1) needs analysis, aimed at collecting initial information and understanding more deeply the research problems, (2) design development, by designing learning media, (3) media validation, carried out to assess the feasibility and validity of the product, (4) revision, aimed at perfecting the product by considering input, suggestions and improvements from experts at the validation stage, and (5) trials, carried out in three stages, namely small trials, large trials and large scale trials.

The design stage is the initial part in developing learning media. In the design stage, three steps will be carried out, namely (1) compiling materials, layout designs, and videos, (2) developing storyboards, and (3) creating the initial media framework. (1) Preparation of Materials, the material was compiled based on an analysis of Core Competencies (KI) and Basic Competencies (KD). Layouts and images to support media presentations were created using Photoshop and Canva software. Videos were created using CapCut. (2) Storyboard Development, a storyboard is a display, menu, or story displayed on digital learning media. The steps for creating this learning media design are outlined in the storyboard development stage. (3) Initial Media Framework, the initial media framework is a draft media design that the validator will test for feasibility before it is used in learning.

This stage is the final part of the overall product development based on augmented reality, assembler edu, and Google Sites (Auregos). Media creation begins with (1) making interactive PowerPoints with the help of the canva platform, (2) making learning videos with the help of the CapCut platform, (3) quizzes using the Quizizz platform, (4) assessments using the Google Form platform, and (5) integrating components into Assembler edu and Google Sites. The main components of the media are (1) Introduction containing the opening, core competencies, basic competencies, learning objectives, and learning strategies. (2) Curriculum, (3) Teaching Materials, and (4) Assessment.

2.4 Instrument and Validation

The instruments used in the research were (1) interview guidelines to uncover learning needs and problems, (2) observation sheets on student attitudes in learning, (3) documentation study sheets to check learning documents and the availability of learning facilities and infrastructure, (4) validation sheets, (5) media validation sheets, (6) practitioner validation sheets, (7) pre-test and post-test questions, and (8) questionnaires to find out students' and teachers' responses to the learning media developed. The instrument used to measure student responses to the Auregos learning media was a questionnaire completed by respondents in a large feasibility test of 200 students. Product validation was conducted to assess the product's feasibility and validity. The selected validators consisted of three elements: media expert validators, material expert validators, and expert practitioner validators.

2.5 *Data Analysis*

The research data consists of two types, namely qualitative and quantitative. Qualitative data comes from interviews, media validation, material validation, and expert practitioner validation. Qualitative data obtained in the form of suggestions, input, criticism, and comments. Measurement of the level of product validity uses the validity criteria levels in table 1.

Table 1. Validity Criteria Level

Criteria	Criteria
0%-20%	Invalid
21%-40%	Less Valid
41%-60%	Quite Valid
61%-80%	Valid
81%-100%	Very Valid

Measurement of the level of teacher and student responses regarding Auregos media using a questionnaire instrument with reliability criteria $r_{11} > 0.70$ is categorized as high. Quantitative data comes from the pretest, posttest, and questionnaire results. Quantitative data were analyzed using the Multivariate T-Test to determine whether there are differences in students' critical thinking abilities before and after being given treatment. Selection of a multivariate t-test formula to compare two sample groups that have more than one dependent variable simultaneously. Decision making if Sig. (2-tailed) ≤ 0.05, then there are differences in the critical thinking abilities of high school students before and after applying Auregos learning media.

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

The effectiveness measurement uses the N-Gain Test formula, which aims to determine whether the application of Auregos learning media is effective in improving the critical thinking skills of high school students. N Gain is an analysis method used to measure learning effectiveness by comparing the increase in scores between the pretest and posttest.

$$\text{N-Gain} = \frac{\text{Posttest Score-Pretest Score}}{\text{Ideal Score-Pretest Score}}$$

The results of the N-Gain test are consulted with the effectiveness determination table for decision-making based on Table 1 of the N-Gain Score division categories.

Table 2. Interpretation of N-Gain Score

N-Gain Score	Category
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Average
$g < 0.3$	Low

3. FINDINGS AND DISCUSSION

3.1 Result

Product Validation

Media validation aims to obtain suggestions or criticism regarding the media concept that has been prepared (Fleary, 2022). The validation process involved six validators who met the criteria (1) Academic criteria, a lecturer, S3 (doctoral) education, minimum functional position as senior lecturer, and have relevant expertise in their field (2) Practitioner criteria, senior teacher (minimum rank III.d), with economic expertise, minimum five years of economics teaching experience. The scoring technique provided by the validator uses a Likert scale: 4 = very appropriate, 3 = appropriate, 2 = not appropriate, 1 = very not appropriate. Media validation consists of three aspects:material expert validation, media expert validation, and expert practitioner validation. Material expert validation aims to obtain input, suggestions, or improvements related to the suitability of the material with core competencies, basic competencies, and relevance to critical thinking. Material experts assess the material's content, feasibility, and accuracy. Media expert validation aims to obtain suggestions or input related to effectiveness, ease of use, including menus, displays, or media visualizations. Media validation is helpful for obtaining media concepts ready for use in the field. The purpose of expert practitioner validation was to obtain suggestions or improvements from the perspective of media users, based on practical conditions in the field. The validation results indicated that the developed learning media were highly valid and ready for use with minor improvements. The validation results can be seen in table 3.

Table 3. Summary of Validation Results

Validator	Percentage	Criteria	Conclusion
Materials Expert	97	Very Valid	Valid for use with corrections
Media Expert	94	Very Valid	Valid for use with corrections
Expert Practitioner	93	Very Valid	Valid for use with corrections
Average	95	Very Valid	Valid for use with corrections

Based on Table 2, the average for each aspect is 95%, meaning that the media is categorized as very valid. The discussion of each validated aspect is as follows.

Material Validation

The material validation used four indicators to measure its validity. These indicators include material suitability, accuracy, feasibility, and critical thinking. The validation results showed that the learning material obtained the final criteria of very valid material with a score assessment of validator 1 of 97% and validator 2 of 97%, resulting in an average of 97% which meets the criteria of very valid. These results indicate that the material presented is very valid and can support the development of critical thinking skills.

Material plays a crucial role in developing students' critical thinking skills. Problem-based material requires students to explore their thinking skills more broadly to find solutions to their problems. Research conducted (Eren & Öztuğ, 2020). This demonstrates that the material plays a role in developing students' thinking skills. Therefore, teachers must get used to presenting complex problems in each lesson so that students become accustomed to analyzing, assuming, using perspectives, and collaborating. Although declared very valid, the material still needs to be refined. According to the

validator, the material is in line with core competencies and basic competencies. However, the discussion needs to be deepened to provide a more comprehensive understanding of phenomena in society. This refinement of the material is in accordance with research from (Bouw, Zitter, & de Bruijn, 2021), which states that real cases in the students' environment need to be included in the discussion of the material so that students can think more critically in responding to it.

Media Validation

Media validation uses five indicators: substance, operation, text and illustrations, visualization, and quality. Media expert validation aims to obtain suggestions or input regarding effectiveness and ease of use, including menus, appearance, and media visualization. Media validation is helpful for obtaining a media concept ready for use in the field. The media assessment by the validators above indicates that the media is highly valid for use, with an average score of 94%. Each aspect meets the very valid criteria based on the assessment by the two media expert validators.

The media makes a significant contribution to improving the quality of learning. It makes the teacher's role more effective, overcomes the challenges of verbalism, and standardizes students' dynamic learning experiences (Kang & Kim, 2021). The contribution of media in learning includes increasing motivation, developing thinking skills, developing learning experiences, increasing interaction, and increasing the effectiveness and efficiency of learning (Alzubaidi et al., 2023). Although the media was declared highly valid, both validators suggested improvements. These included avoiding text colors that are similar to the background color and adding a video menu.

Practitioner Validator

Validation by practitioners was conducted on two economics teachers who met the criteria. Both teachers came from two different schools. The goal was to obtain suggestions or improvements from the perspective of media users, according to practical conditions in the field. The practitioner validators' assessment indicated that the media was highly valid for use, with an average score of 93%. Each aspect achieved the highly valid criteria based on assessing the two expert validators from the practitioner element. However, both validators provided suggestions for improving the developed media. The suggestion was to integrate local wisdom into the learning media so that students can appreciate their culture. Integrating local culture in learning aims to help students understand the cultural potential of their surroundings, thereby demonstrating concern. (Kim, 2020).

Product Development

The product development process began after researchers gathered various information to support the research. Product development began with creating a flyer using the Canva platform, followed by creating an educational video using the Capcut platform. The educational video addressed economic inequality in Indonesia. After completing the video, it was integrated into the Assemblr Edu platform. The product development process can be seen in Figure 1.

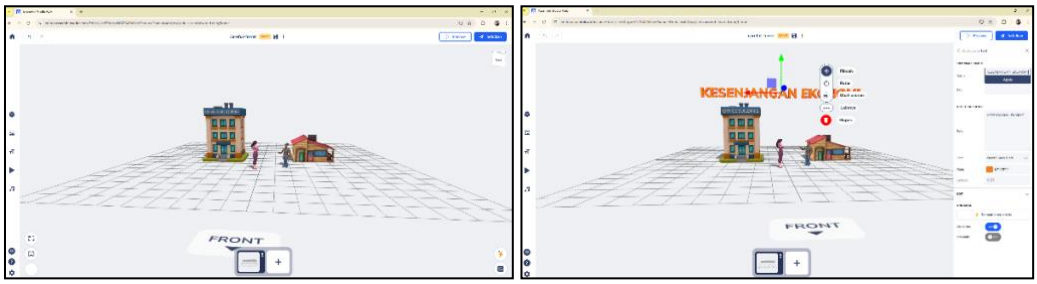
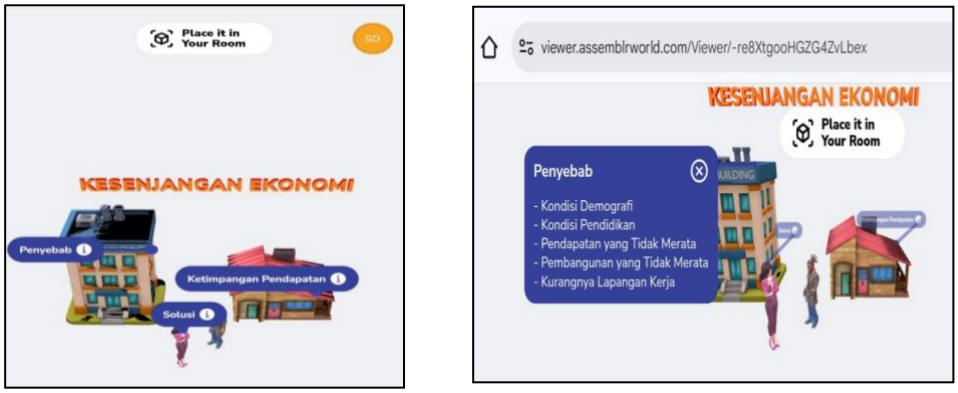


Figure 1. Display of the arrangement of elements and titles of learning materials

Figure 1 illustrates the initial steps in developing learning media. It begins with opening the Assemblr Edu platform and selecting an appropriate template. The template is tailored to the characteristics of the material to be taught through the media. Figure 3 shows the cover page, which contains the title of the material and the class. Animations and annotations will be added to the cover page to pique students' curiosity. Assemblr Edu is capable of displaying three-dimensional illustrations, creating a cartoon-like appearance.



Figures 2 and 3. Display of the arrangement of elements and titles of learning materials

Figure 4 displays the initial menu of the learning media. It displays a three-dimensional illustration and animation of a building and two people interacting. Above it is a selectable menu. To read the material, students can select the available menu. Figure 5 shows an illustration of material on the causes of economic inequality. Demographic conditions, educational conditions, unequal income and development, and a lack of employment opportunities cause economic inequality. Two people are presented in conversation using a three-dimensional animation to make this section more engaging.

Figures 4 and 5. Learning Material Display

Figures 4 and 5 show the learning materials students can access. Income inequality can occur due to unequal income distribution within a region or country. Inequality in income distribution can be measured using the Gini coefficient and the Lorenz curve. Solutions to economic disparities can be addressed through education, infrastructure, and government subsidies. New annotations can be added to the screen as needed.

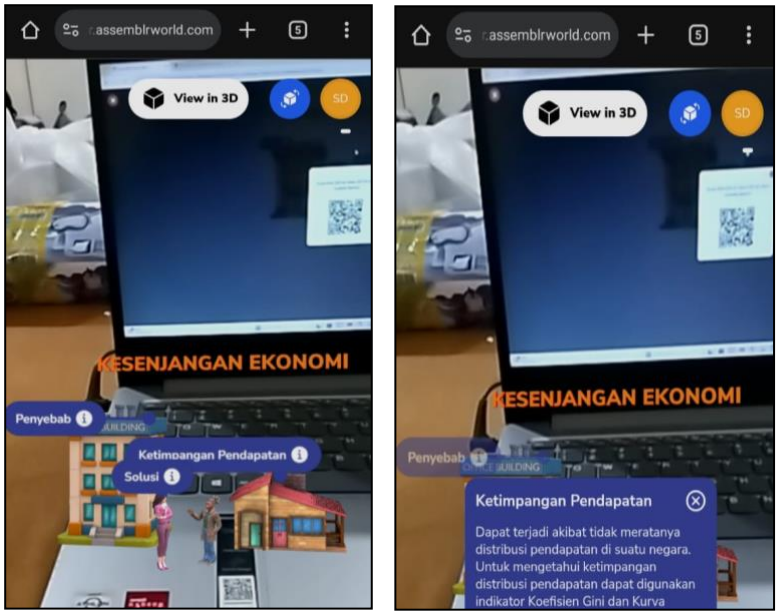


Figure 6 and 7. Media Storage Stage and QR Code

In Figures 6 and 7, media objects can be displayed in a location preferred by students, such as a wall, ceiling, whiteboard, or other flat surface. To do this, select "Place It Your Room," then point the camera at the flat surface to display a three-dimensional object, as shown in the image above.

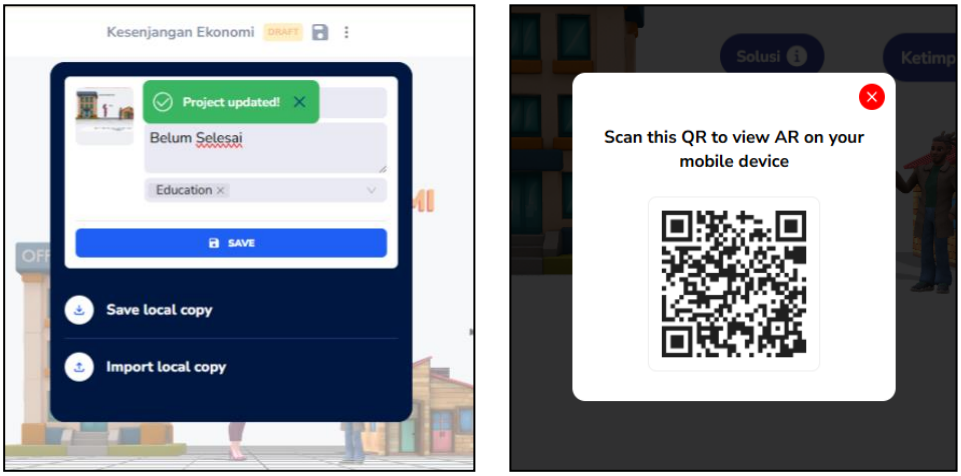


Figure 8 and 9. Media Storage Stage and QR Code

Figure 8 represents the final stage of media creation. The completed media will be saved as a file document. After the product is saved, a QR code will be generated, as shown in Figure 9. The QR code is used to access the media and its contents. The QR code will be distributed to students so they can access it viamobile phones or laptops. Once the media concept is developed, the validator willconduct a media validation test.

Product Revision

Various suggestions from the validators during the previous validation stage were used as guidelines for product refinement to ensure it was more ready for use in learning. The results of the product revisions are shown in table 4.

Table 4. Revision Product

Before Revision	After Revision	Information
		Integration of culture or local wisdom into the material. Researchers added a discussion of local wisdom-based economic disparities to the imbalance in wealth and income distribution that occurs despite the potential of local wisdom that has not been optimally utilized, along with solutions.
		Addition of learning videos in the media. The researcher added a video depicting economic inequality in a country.
		The addition of material on social problems in the surrounding environment includes fundamental problems such as scarcity of resources which causes unemployment and poverty, as well as more complex problems.

Test Product Effectiveness

The learning media product design, which has undergone validation and subsequent revision, will be used as the final learning media product. The final product, an Augmented Reality-based learning

media integrating the Assemblr Edu Platform and Google Sites, was subsequently named Auregos by the researchers. In its implementation, other platforms may also be used to support learning.

The Auregos learning media is designed for use in a single learning session. However, if the media will be used again for another session, teachers only need to enter the learning material content and accessories. The Auregos media contains core competencies, basic competencies, learning objectives, learning objective completion criteria (KKTP), learning materials, inspirational videos, reflections, and assessments in a single learning session. A form is also included at the end of the media for students to fill out with suggestions or criticisms.

The large-scale media testing phase was conducted after being declared feasible and valid in the small and large trials. Respondents for the large-scale media testing were 200 students from two high schools. The instruments used were test questions, including pretests and posttests. A summary of the results of the implementation of the learning media to improve students' critical thinking skills is presented in table 5.

Table 5. Large-Scale Testing Results

Interval	Pretes		Posttes		Criteria
	Frequency	Percentage	Frequency	Percentage	
86-100	26	13,0	144	72,0	Very High
76-85	45	22,5	35	17,5	High
56-75	74	37,0	14	7,0	Average
10-55	55	27,5	7	3,5	Low

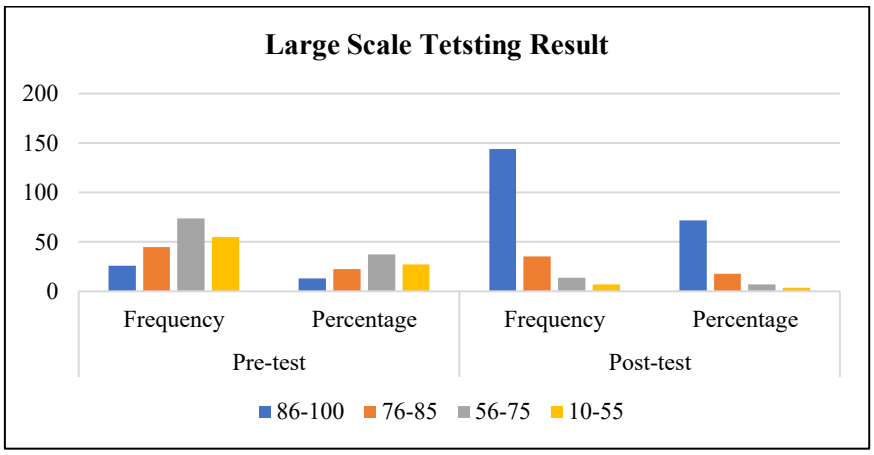


Figure 10. Bar Chart of Large-Scale Testing Results. Source : Table 5

Based on Table 5, the learning outcomes of students from both high schools during the pre-test were dominated by scores between 56 and 75, with 74 students (37%). Meanwhile, 26 students (13%) achieved the very high criteria. The implementation of learning media successfully improved the critical thinking skills of high school students by 72%, or 144 students achieving the very high predicate. The number of students with scores below 55 decreased from 55 during the pre-test to 7 after the post-test. The results of the large-scale feasibility test indicate that the Auregos learning model significantly improved critical thinking skills in high school students.

Media Effectiveness

The pretest and posttest results on students' critical thinking skills were summarized to facilitate measuring improvement after using Auregos media. The data are processed in table 6 below.

Table 6. Comparison of Pretest and Posttest

Stage	N	Minimum	Maximum	Mean	KKTP Achievement	
					Frequency	Percentage
Pretest	200	50	89	68.84	78	39
Postest	200	45	100	85.62	180	90

Based on Table 5, it is known that the achievement of the KKTP (Competency Standards) for critical thinking skills increased after using learning media. In the pretest, 78 students (39%) successfully achieved the KKTP. After using learning media, the achievement frequency was 180 students (90%). The increase in KKTP achievement in the pretest and posttest was 51%. This means that the Auregos learning media can improve critical thinking skills.

A difference test was conducted to determine whether there was a difference in critical thinking skills between before and after using learning media. The difference test used the Multivariate T-test formula. The SPSS output results showed that the sig. (2-tailed) value was 0.000 <0.05. The results of the T-test showed a significant increase (sig. 0.000 < 0.05), indicating the high effectiveness of Auregos media in developing critical thinking skills. It was concluded that there was a significant (absolute) difference between the critical thinking skills of high school students before and after applying Auregos learning media.

The N-Gain test aims to determine whether the application of Auregos learning media effectively improves the critical thinking skills of high school students. The following are the results of the N-Gain test using SPSS 20. The SPSS output results of the N-Gain test show that the mean value of the N-Gain score is 0.84>0.7, meaning that the effectiveness of the Auregos learning media is in the High category. While the mean value of the N-Gain percent is 84%>76, meaning that the Auregos learning media effectively improves the critical thinking skills of high school students.

Teacher and Student Responses

The instrument used to measure teacher and student responses to the Auregos learning media was a questionnaire completed by respondents in a large-scale test of four teachers and 200 students. The media response questionnaire by teachers and students used four indicators: editorial, visualization, implementation, and materials. The questionnaire results explained that the Auregos learning media received a positive response from teachers of 90%. This means that the media able to help students and teachers in the learning process in the classroom. Meanwhile, the student questionnaire showed that the Auregos learning media was very well received by students with an average score of 83%. The highest aspect was the media's ability to increase learning motivation by 90%.

3.2 *Discussion*

The development of a digital-based learning model by integrating the Augmented Reality platform, Assemblr Edu, and Google Sites aims to develop the critical thinking skills of high school students. The development of this learning model is included in the development research (R&D)

adopting a simplified Borg and Gall approach without reducing the essence of each stage of product development. The research subjects were students from two high schools in Purworejo district. The background of this research is the still low critical thinking skills of high school students based on the results of field observations. The low critical thinking skills are indicated by their inability to solve problems based on High Order Thinking Skills (HOTS).

Students need to possess critical thinking skills to face the characteristics of 21st-century skills, namely the 4Cs (Critical Thinking, Communication, Collaboration, and Creativity). The 4C enable students to understand and evaluate various choices and their consequences, enabling them to make wise, quick, and accurate decisions (Supena, Darmuki, & Hariyadi, 2021). Critical thinking skills are not talents, but rather skills that need to be developed to face the dynamics of problems, especially economic ones. Ennis defines it as a reflective way of thinking that focuses on informed decision-making (Lau, 2024). This theory explains that critical thinking is not a talent, but rather a skill that can be developed through analysis, evaluation, and reflection. The subject of Economics requires students to have these skills because the characteristics of the material are broad and directly related to social society so that students are expected to have the ability to understand a number of economic concepts to relate economic events or problems in everyday life, display an attitude of curiosity towards economic concepts, form a wise, rational, and responsible attitude by mastering economic knowledge that is beneficial to themselves and society, make quick, accurate, and responsible decisions regarding socio-economic values in a pluralistic society (Dumitru, Minciu, Mihaila, Livinti, & Paduraru, 2023).

The development of digital learning media by combining augmented reality (AR), the Assemblr Edu Studio Web educational platform, and the Google Sites platform into a single three-dimensional AR-based digital media called Auregos. Auregos has been proven to improve the critical thinking skills of high school students. The results of the study, which has passed all stages of testing, show that the Auregos media is able to develop the critical thinking skills of high school students. The menus in Auregos are highly interactive, thus developing curiosity and critical thinking skills when integrated into learning. Curiosity arises because the interest in learning is correlated with critical thinking skills (Fajari & Chumdari, 2021). Students with a high interest in something will show curiosity about new things, thereby stimulating their ability to think more critically (Arisoy & Aybek, 2021). The benefits students will gain from developing critical thinking skills include the ability to analyze problems from multiple perspectives and maintain an objective attitude. Furthermore, critical thinking will guide students to be wise and rational in their decision-making.

The results of the Auregos media development research support extensive research conducted to measure the effectiveness of digital technology use in learning (Avila-Garzon, Bacca-Acosta, Kinshuk, Duarte, & Betancourt, 2021) proves that Augmented Reality can enrich the educational context, develop motivation, and provide learning autonomy to students. Other research by (AlGerafi, Zhou, Oubibi, & Wijaya, 2023) shows that technological media can increase students' intrinsic motivation and interest in learning if used appropriately. Meanwhile, research related to Assemblr Edu was conducted by (Damayanti & Putra, 2024) which resulted in the conclusion that learning outcomes improved after receiving treatment. The effectiveness of Assemblr Edu was also measured through research by (Triana & Hariyastuti, 2024) which resulted in the conclusion that it can develop the ability to work together and think quickly and critically among students. However, several previous studies still found gaps, namely the lack of innovation for the integration of augmented reality, assembler edu, and Google sites. Integration of digital technology is one form of learning development to be more adaptive to current developments. Therefore, this research has advantages because it combines three digital platforms at once into one innovative digital learning media. The use of digital technology requires teachers to be

adaptive in their ability to use information technology. Teachers must continuously develop their own capacity in order to move towards more modern learning that is able to meet learning needs and personalize students' learning experiences. This research provides a theoretical contribution to the development of digital learning media that can be designed to be more effective, efficient, and optimize the use of visual and auditory elements in learning videos or digital presentations.

Research Limitations

This study still has limitations, namely the number of respondents, as it was limited to high school students from two schools. Furthermore, collecting data on teacher and student responses using questionnaires is highly dependent on the subjectivity and perspectives of respondents. Resource limitations can also affect the depth of data analysis. These limitations are expected to serve as a reference for developing more in-depth and representative findings in future research.

4. CONCLUSION

The use of Auregos media in learning has been proven to significantly improve thinking skills based on the results of the Multivariate T-test, which obtained a value of 0.000 <0.05. The effectiveness test using N-Gain obtained a score of 0.84> 0.7, thus it is concluded that the learning media is effective in improving the critical thinking skills of high school students. Teacher and student responses were 90% and 83%, respectively, considering that teachers and students received the learning media very well. Auregos media can be an innovative alternative for teachers to deliver economics material effectively so as to improve students' critical thinking skills. The impact of the use of this digital-based learning media can support the improvement of the quality of economics learning in high schools on an ongoing basis. Future research is expected to be conducted on a larger scale involving schools of various levels so that the results are more comprehensive and can be generalized to a wider subject. In addition, researchers should review the effectiveness of this media periodically and continuously.

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