RESEARCH ARTICLE

Development of practicum-based mobile augmented reality through the group investigation model to improve students' creative thinking

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Abstract: Students' creative thinking skills need to be developed, one of which is through learning. This research was aimed to produce Augmented Reality (AR) media based on Group Investigation (GI) practice models on various living things to improve students' creative thinking skills. This research and development using the 4-D model. However, it only reached the Develop stage. The population of this study was students of SMA Muhammadiyah 10 Surabaya in the Science class, with 37 students in each class. This study collected data through validation tests, pre-tests, post-tests, observation sheets for creative thinking skills, questionnaires, and student responses. The data analysis technique used is qualitative and quantitative descriptive. The results of development research carried out by researchers related to Mobile AR media with display aspects with 17 indicators obtaining good category. Whereas in the programming aspect, seven indicators are good category. So, the Mobile AR media validation results are good category. Biological material in the application with AR with content aspects with eight indicators are very good category. Whereas in the learning aspect, which consists of 16 indicators, in the good/valid category. The material in this category is worthy of being tested in the field. Based on descriptive statistics, the pre-test and post-test proved to be higher. We discuss these results and its implications.

Keywords: Augmented reality; biology practicum; creative thinking skills; group investigation model

Introduction

The role of education in life on an ongoing basis cannot be denied (Guan, 2021; Herbert et al., 2021). Education is a vessel for transforming or transferring knowledge, which is carried out in various ways or strategies through teaching (Chytas et al., 2020; Soltani & Morice, 2020). Before the internet happened as it is now, the education system was carried out conventionally with a behavioristic approach (Bhushan et al., 2018; Li et al., 2021; J. Zhang et al., 2021). In an era as sophisticated as today, the development of science and technology is a serious concern in making education through better learning (Cheng, 2020; K. B. Park et al., 2020). Previously, conventional teaching was no longer used in this regard and adapted to the development of science, which emphasized creative and innovative ways (Sahin & Yilmaz, 2020). The learning schools are currently trying to achieve must improve various student skills, especially 21st-century skills (Radianti et al., 2020; Sahin & Yilmaz, 2020).
In fact, in the 21st-century, the education system must apply the skills needed in the world of education today. One of the demands of the 21st century focuses on communication skills (Conley et al., 2020; López-Faican & Jaen, 2020). According to the US-based Partnership for 21st Century Skills in identifying skills needed in the 21st century, namely "The 4Cs" - collaboration, communication, creativity, and critical thinking (Kou et al., 2021; Sajid et al., 2021). These competencies are important to be taught to students in the context of core study areas. The intended communication skills are effectively conveying information and criticism and using various media and technology reflectively and interactively (Lichters

et al., 2021; C. Wang et al., 2021; Ye et al., 2021). Effective communication emphasizes interpersonal skills, collaboration, personal responsibility, social responsibility and thinking about the public interest, and two-way communication (Do et al., 2020; Kwangmuang et al., 2021; Williams et al., 2020).

Over time, technological advances have had a significant impact on current communication patterns. Communication is no longer seen as an interactive activity identical to the direct presence of the recipient and sender (Che Dalim et al., 2020; Yalcin & Bilge, 2021). It distances communication with those closest to them, so it also happens to students who use social media more often than face-to-face discussions and playing gadgets during learning (Ibrahim & Money, 2019; López-Labrador et al., 2021). Such behaviour causes students to become less sensitive and unresponsive, not care about their surroundings, and the higher their attitude toward individuality. This causes students' communication skills and creative thinking to be low (Dastmard et al., 2021; C. Liu et al., 2021; Redifer et al., 2021). Low communication skills will trigger new problems that are quite complex or cause miscommunication. This miscommunication can have an impact on conceptual errors and unable to improve creative thinking skills (Collins-Jones et al., 2021; Villaseñor Rodríguez, 2014).

Lack of creative skills can occur among students at home and school for different reasons (Krause et al., 2021; Nakamura et al., 2019). According to the philosophy of constructivism, knowledge can be constructed or constructed by students from themselves (Jakubina et al., 2020; K. H. Park et al., 2011). The construction process is obtained through interaction with the environment according to the student's level of understanding (Harun et al., 2020; Tuli & Mantri, 2020). When students interact, such as playing games on cell phones, students construct knowledge based on something that is only heard at a glance (Arulanand et al., 2020). When students interact with their learning environment, students construct knowledge based on their experiences (Orciuoli et al., 2020; Uriel et al., 2020). Therefore, errors in constructing knowledge can occur because students are naturally not used to correctly constructing their knowledge (Mourtzis et al., 2020). Moreover, if it is not supported by more accurate and representative sources of information, it will become a serious problem for developing students' knowledge (Alalwan et al., 2020; Pan et al., 2021).

Overcoming the problems in developing students' knowledge by preparing a curriculum requires students to apply 21st-century skills (P. Z. Chen et al., 2020; Ibán et al., 2020; H. Zhang et al., 2020). These skills include 1) learning and innovation skills, 2) life and career skills), and 3) information technology and media skills. One of them is in information technology and media skills, and there is a media literacy component in which students are expected to be able to choose and develop media to use as a source of information and communication in current conditions, especially in the world of education (Akpur, 2020; Sun et al., 2020). Because of that, the emergence of the digital literacy movement in the world of education in Indonesia is part of the imperative that must continue to be used in implementing the learning process in schools. The digitization that is happening right now cannot be separated in the world of education, and schools must have various consequences with it (Huang et al., 2020; Said-Metwaly et al., 2021). Learning media such as mobile augmented Reality is necessary to provide innovative and effective value in learning, especially in biology subjects (Alalwan et al., 2020; Groyecka-Bernard et al., 2021).

Digitalization in education through learning is very important for students as part of the millennial generation (Kaplan Sayi & Akgul, 2021; Yildiz & Guler Yildiz, 2021). Although digitization at the elementary and junior high school levels still focuses on reading sources in print media such as newspapers, books, magazines, and so on (Çakır et al., 2021). However, it can be seen that communication skills and creative thinking can also be developed in students' current abilities as provisions for the next level of education (Navarro Ramón & Chacón-López, 2021; Yang & Zhao, 2021). Skills in accessing the internet as an effective communication tool are not bound by space and time (Albar & Southcott, 2021). Communication skills sought in the learning process are the most important part of providing provisions for the next level of life (Ayyildiz & Yilmaz, 2021). The millennial generation is part of a technology-native community or native technology users who have interacted with and been introduced to the technological era since birth (S. Wang et al., 2020; Zhou et al., 2020). Meanwhile, most teachers are still newcomers to the world of information technology, so they are sometimes less competent than their students in knowing and using internet media (Xiao et al., 2020).

These conditions make the learning model used to achieve 21st-century skills by improving communication skills while increasing students' creative thinking skills, namely by applying the Group Investigation (GI) learning model (Jugembayeva & Murzagaliyeva, 2021; Zhao & Yang, 2021)**.** The GI model is a cooperative learning model that can encourage students to play an active role and help each other in mastering lessons to achieve maximum achievement (Berestova et al., 2021; Dou et al., 2021). Then involve, small groups working using collaborative inquiry, planning, projects and group discussions and presenting student findings in class (Jugembayeva & Murzagaliyeva, 2021). Several students in learning biology, especially at the high school level, found that there were students who were unable to communicate or express opinions well and were not skilled in developing their creative thinking (Guan, 2021; Zhao & Yang, 2021). one of the creative and innovative learning media that can facilitate students to develop communication skills and creative thinking skills is by using Mobile Augmented Reality which is a technology that combines two-dimensional and or three-dimensional virtual objects into a real environment (Berestova et al., 2021; Jugembayeva & Murzagaliyeva, 2021).

Several previous studies have discussed the Group Investigation model, which needs to be integrated with current technological developments (Bakker et al., 2020; Ibáñez et al., 2020). Mobile augmented reality is one of the technologies that must be used in current developments. This study aims to determine the development of practicum-based Mobile Augmented Reality through the Group Investigation model to Improve Students' Creative Thinking. Then related to the need for more research regarding the combination of learning models with technology in biology subjects, this can be a severe concern in the world of education in improving learning systems to be more constructive and fun (Ameri et al., 2019; Nezhad et al., 2020). In addition, what needs to be considered is the teacher's ability to become a facilitator who guides students in carrying out the learning process according to the curriculum used. On the other hand, related to the learning model used today, especially in biology subjects, it must be more focused and student-centered with various skills (H. Zhang et al., 2020; Zhu et al., 2020). Because biology lessons are synonymous with practicum, teachers must be able to operate technology as part of the learning media used skillfully (Ibrahim & Money, 2019; C. Liu et al., 2021; Ye et al., 2021). In line with that, the learning model used in the future is no longer teacher-centered but instead focuses on how students can be facilitated by the teacher's role in the learning process. This research aims to produce Augmented Reality media development products based on Group Investigation (GI) practice models on various living things to improve students' creative thinking skills.

Method

Research design

This type of research is research and development. This research develops Mobile Augmented Reality in biology subjects using the GI learning model to improve students' communication skills and creative thinking. This research and development refer to the 4-D development model (Four D Models) proposed by Thiagarajan et al. This research is only limited to the development stage (develop). The target of this research is Mobile Augmented Reality. For trials of Mobile Augmented Reality in learning as test research subjects, students of class XI IPA 1 at SMA Muhammadiyah 1 Surabaya, totaling 37 students. The research design used in this research is the research design of the 4-D model development (Four-D Models), according to Thiagarajan, which consists of 4 stages defining, designing, developing and disseminating.

Defining stage

The defining stage is useful for determining and defining needs in the learning process and gathering various information related to the product to be developed. This stage is divided into several steps.

Front-end Analysis

A preliminary analysis was carried out to discover the basic problems in the development of Macromedia Flash. At this stage, facts and alternative solutions are presented to make it easier to determine the first step in developing Macromedia Flash, which is suitable for development.

Task Analysis

Task analysis aims to identify the main tasks students carry out. Task analysis consists of Core Competencies (*Kompetensi Inti*/KI) and Basic Competencies (*Kompetensi Dasar*/KD) related to the material to be developed through Macromedia Flash.

Learner Analysis

Student analysis is very important to do at the beginning of planning. Student analysis is done by observing the characteristics of students. This analysis was carried out by considering students' characteristics, abilities, and experiences as a group and individually. Analysis of students includes the characteristics of academic abilities and motivation towards subjects.

Concept Analysis

Concept analysis aims to determine the material's content in the developed Macromedia Flash. Concept analysis is made in learning concept maps, which will later be used to achieve certain competencies by identifying and systematically compiling the main parts of learning materials.

Specifying Instructional Objectives

Learning objectives are analyzed to determine learning achievement indicators based on material and curriculum analysis. By writing down the learning objectives, the researcher can find out what studies will be displayed in Macromedia Flash, determine the question grid, and determine how much the learning objectives have been achieved (Table 1).

Table 1. Analysis of learning objectives

Core Competency (KI)	Basic competencies	Indicators of Competence Achievement
KI 3 Understanding, applying, analyzing factual, conceptual, procedural, and metacognitive knowledge based on curiosity about science, technology, arts, culture, and humanities with insights into humanity, nationality, statehood and civilization regarding the causes of phenomena and events, and applying procedural knowledge to a specific field of study according to talents and interests to solve problems.	3.9 Analyzing the relationship between the structure of the organ-composing tissue in the excretory system concerning bioprocesses and functional disturbances that can occur in the human excretory system.	Students can: 3.9.1 Identify the organs of human excretion and the types of waste products produced. 3.9.2 Identify the structure and function of the kidney organs. 3.9.3 Describe the process of urine formation. 3.9.4 Identify the structure and function of the skin organs. 3.9.5 Identify the structure and function of the lungs. 3.9.6 Identify the structure and function of the liver. 3.9.7 Relating organ-composing tissue structures in the human excretory system with bioprocesses. 3.9.8 Analyzing the relationship between the structure of the organ-composing tissue in the excretory system and linking it to the excretory process to explain the mechanisms and functional disturbances that can occur in the human excretory system through literature studies.
KI 4 Processing, reasoning, and presenting in the concrete and abstract realms related to self-development that he learns at school independently, act effectively and creatively, and can use methods according to scientific principles.	4.9 Presenting the results of an analysis of the influence of lifestyle on abnormalities in the structure and function of organs that cause disorders of the excretory system and their relation to technology.	Students can: 4.9.1 Compile a report on the results of an analysis of the influence of lifestyle on abnormalities in the structure and function of organs that cause disturbances in the excretory system and its relation to technology in writing. 4.9.2 Presenting data from the analysis of the influence of lifestyle on abnormalities in the structure and function of organs that cause disorders of the excretory system and its relation to technology.

Design stage

The design stage is carried out after getting the problem from the definition stage. This stage aims to design a Macromedia flash that can be used in Biology learning. This design stage includes:

Criterion-test construction

The preparation of instrument tests is based on the preparation of learning objectives which are a benchmark for students' abilities in the form of products, processes, and psychomotor during and after learning activities.

Media selection

Media selection is carried out to identify learning media relevant to the material's characteristics and according to the needs of students. The media was chosen to suit student analysis, concept analysis and task analysis, target user characteristics, and deployment plans. It is useful to assist students in achieving the expected core competencies and basic competencies.

Format selection

Format selection is done in the first step. Format selection is made so that the selected format follows the learning material. The choice of presentation form is adjusted to the learning media used. Format selection in development is intended by designing learning content, choosing approaches and learning resources, organizing and designing macromedia flash content, and making macromedia flash designs which include layout designs, images and writing.

Initial design

The initial design, namely the Macromedia flash design that the researcher has made, is then given input by the supervisor. The input from the supervisor will be used to improve the Macromedia flash before production. Then make revisions after getting suggestions for improving Macromedia Flash from the supervisor, and later this design will be carried out at the validation stage. This design is in the form of Draft I from Macromedia Flash.

Development stage

This development stage aims to produce macromedia flash, revised based on expert input and student testing. There are two steps in this stage, namely as follows:

Expert appraisal

This expert validation serves to validate the contents of the excretory system material in Macromedia Flash prior to testing, and the validation results will be used to revise the initial product. The Macromedia flash that has been prepared will then be assessed by the material expert validator and expert media lecturer so that it can be seen whether the Macromedia flash is feasible or not. The results of this validation are used as improvement material for the perfection of the developed Macromedia Flash. After the first draft was validated and revised, draft II was produced. Draft II will then be tested on students in the

Development testing

After expert validation, a limited field trial was conducted to determine the results of applying Macromedia Flash in classroom learning, including measuring students' communication skills and mastery of concepts with Macromedia Flash. The results obtained from this stage are macromedia flash which has been revised.

Stage of dissemination

This dissemination stage is the dissemination stage that researchers do not carry out. In this case, development divides the disseminate stage into three activities: validation testing, packaging, diffusion and adoption. In the validation testing stage, the product revised at the development stage is then implemented on the real target. At the time of implementation, the achievement of goals was measured. This measurement is carried out to determine the effectiveness of the product being developed. After the product is implemented, the developer needs to see the results of achieving the goals. Goals that have not been achieved need to be explained the solution so that the same mistakes are not repeated after the product is disseminated.

Trial design

This limited trial design uses a Quasi Experiment research type with a research design using a Nonequivalent control group design. In this study, two class groups were not randomly selected. The procedure for implementing the Limited Tryout was based on the Learning Implementation Plan that had been prepared: 1) In the initial activity, the teacher checked student attendance, provided motivation to encourage learning interest and conveyed learning objectives. 2) The teacher presents the scope of the material classically by using verbal or text presentations. The presentation focused on the concepts of the material discussed. 3) The teacher divides the class into several heterogeneous groups. 4) The teacher explains the purpose of learning and group assignments that must be done. 5) The teacher invites group leaders to describe the task material cooperatively. 6) Each group discusses the task material cooperatively in their group. 7) After completion, each group, represented by the group leader or one of its members, conveys the discussion results. 8) Other groups can respond to the results of the discussion. 9) The teacher gives a brief explanation (clarification) if there is a concept error and gives a conclusion. 10) The teacher evaluates learning. Researchers conduct evaluations to determine the learning outcomes obtained during the learning process. Observations were made during the research activities. Observers observed observation sheets for creative thinking skills. Providing student response questionnaires observed by students after learning activities are completed. Giving tests to students in the form of multiple choice questions totalling 20 questions.

Research variables

The variables used in this study are 1) Independent Variables, namely the Jigsaw learning model assisted by Macromedia Flash and conventional learning models. The dependent variable in this study is communication skills and creative thinking. The control variable in this study is the material of the excretory system. While the Variable Operational Definition, namely the GI learning model, is a model with a constructivist paradigm, it is intended that students are directed to be able to make learning experiences as knowledge for themselves. The important aspects in the Group Investigation learning model involve 3 aspects: physical, intellectual, and mental; being active because students will be invited to plan learning. The steps for applying the Group investigation learning model are 6 stages: forming groups, determining the themes to be discussed, conducting investigations, making written reports, group presentations, and evaluating or assessing. The learning model is carried out with the help of AR. AR is used with mobile phones in the form of android animation, with the topic of biology. In this study, the interactiveness of AR was obtained from the choice of material menus that could be studied according to the student's wishes and the feedback when students had finished working on something.

Communication skills and creative thinking

The communication skills referred to in this study are verbal and non-verbal. Verbal communication skills, namely writing and presentation activities. The aspects measured in writing activities are organization, development, control techniques, language style and insight. Verbal communication skills in writing activities are measured using a product assessment sheet. At the same time, the aspects measured in presentation activities are arrangement, information content, appearance, acting, delivery, and responding to questions. Non-verbal communication is shown in presentation activities, namely in acting and delivery. Verbal communication skills in presentation activities are measured using an observation sheet. The observer observes communication skills during the learning process. Communication skills are measured using observation sheets. The observation sheet is used while the creative thinking skills referred to in this study are the individual's ability to find ways, strategies, ideas, or new ideas about how to obtain a solution to a problem as seen from the achievement of indicators of learning outcomes in excretion system material as measured through multiple choice tests in the form of pre-test and post-test. Minimum Completeness Criteria Students at SMA Muhammadiyah 1 Surabaya ≥ 70. Calculation of concept mastery by looking at the average value of N-Gain <0.3 is in a low category, while >0.7 is in the high category. Pretest and posttest used.

Validation techniques

Validation techniques are used to measure the feasibility of Augmented Reality learning media. The feasibility of Augmented Reality learning media needs to be measured using a questionnaire to validate it first. Three questionnaires are used: the due diligence/Augmented Reality validation questionnaire by media experts, the Augmented Reality test/validation questionnaire by material experts and the Augmented Reality test questionnaire by user experts. Guidelines for scoring in each questionnaire are in Table 2.

Table 2. Scoring guidelines

Information	Skor
Very good	5
Good	4
Enough	3
Not enough	2
Very less	1

Observation techniques

Observation techniques measure students' oral communication skills using an observation sheet as a Rating Scale or Advanced Scale. The Rating Scale is almost the same as the Check List; it is just that the rating scale uses a rating. The rating scale used in this study is a Numerical Rating Scale type. The Numerical Rating Scale describes a certain characteristic or quality that will be measured using numbers 1-3. This observation is carried out when the process of presentation activities takes place by the observer.

Product appraisal techniques

The product assessment technique measures students' written communication skills using a product assessment sheet in the form of a Rating Scale or Advanced Scale. The Rating Scale is almost the same as the Check List; it is just that the rating scale uses a rating. The rating scale used in this study is a Numerical Rating Scale type. The Numerical Rating Scale describes a certain characteristic or quality that will be measured using numbers 1-3. This observation was carried out while evaluating the article by the observer.

Test technique

The test technique is used to measure students' mastery of concept abilities. Concept mastery ability is measured by comparing the pre and post-test results. The test is in the form of 20 multiple-choice questions during the pre and post-test. In addition, the test is also an individual quiz whose function is to find out students' understanding after studying the excretory system material with the GI (Group Investigation) learning model assisted by Augmented Reality.

Validation sheet

To determine the feasibility of Macromedia Flash media, it can first use a media and material expert validation test/validation questionnaire and a user test questionnaire. In the media expert validation test questionnaire sheet, 2 aspects are assessed: appearance and programming. The display aspect has 7 components which are broken down into 17 indicators. The seven components are layout design, text/typography, image, animation, audio, video, and packaging. At the same time, the programming aspect has 2 components which are broken down into 7 indicators. The two components are usage and navigation and interactive links. In the material expert validation test questionnaire, 2 aspects are assessed, namely content and learning. The content aspect has 2 components, namely, curriculum and users. While learning has 3 components, namely opening, core, and closing.

Observation sheet

Communication skills observation sheet: The instrument used to measure students' communication skills in biology learning with the jigsaw model uses the Numeral Rating Scale observation guideline to describe a particular characteristic or quality to be measured using 3 score options. Measure it by filling in 1 to 3 scores according to the aspects of the communication skills assessment. Aspects of the skills assessed are presentation activities. Observation sheet used.

Product rating sheet

Communication skills product assessment sheet: The instrument used to measure students' communication skills in biology learning with the jigsaw model is to use the product assessment guideline rubric. The Numeral Rating Scale describes a certain characteristic or quality to be measured using 3 score options. Measure it by filling in 1 to 3 scores according to the aspects of the assessment of communication skills. The aspect of skills assessed is the activity of writing articles. Product assessment sheet used.

Learning outcomes test sheet

Tests collect data from student learning outcomes to measure students' ability to master concepts. The test instrument used in collecting data on learning outcomes is a multiple-choice test. This test was obtained from the evaluation data given at the pre-test and post-test. The test sheet used can be explained in the Table 3 and Table 4.

From the Mobile AR feasibility test/validation instrument by media experts through display and programming aspects with 9 components with 24 indicators, it becomes 24 items. The Mobile AR feasibility test aims to see the feasibility of the educative aspects of learning media by experts in the field of learning materials being developed. The media expert feasibility test results are used as input in learning media. The media expert feasibility test instrument aims to see aspects of the feasibility of media in learning media and is used as input in learning media.

The Mobile AR feasibility test/validation instrument by material experts through content and learning aspects consist of 5 components with 24 indicators so that there are 24 items. The Mobile AR feasibility test aims to see the feasibility of educational materials in learning materials by experts in the field of learning materials being developed. Then the material expert feasibility test results are used to input the learning material. The material expert feasibility test instrument aims to see aspects of the feasibility of the material as input to the learning material that will be used in the learning process.

Table 3. Feasibility test/validation instruments for mobile augmented reality by media experts

No.	Aspect	component	Indicator	No of point	∑
1.	Appearance	Layout Design	1) The accuracy of choosing the background with the material	1.	1
			2) Precision proportion layout	2.	1
		a. Text /Typography	3) The correct selection of fonts for easy reading	3.	1
			4) Accurate font size for easy reading	4.	1
			5) Accurate text colour for easy reading	5.	1
		b. Image	6) Image composition	6.	1
			7) Image size	7.	1
			8) Image display quality	8.	1
		c. Animation	9) Suitability of animation with the material	9.	1
			10) Interesting animation	10.	1
		d. Audio	11) The accuracy of choosing the backsound with the material	11.	1
			12) Precise sound effects with animations	12.	1
		e. Video	13) The accuracy of the video selection with the material	13.	1
			14) Video quality	14.	1
		f. Packaging	15) The attractiveness of the front cover	15.	1
			16) Appropriate display with content	16.	1
			17) Media durability	17.	1
2.	Programming	g. Use	18) Compatibility with the user	18.	1
			19) Flexibility (can be used independently and guided)	19.	1
			20) Complete instructions for use	20.	1
			21) Display instructions for use	21.	1
			22) Presenting benchmarks of learning success	22.	1
		h. Navigation and Interactive link	23) Accurate use of navigation buttons	23.	1
			24) Interactive link performance precision	24.	1
Total					**24**

Table 4. Feasibility test/validation instruments for Macromedia Flash by material experts

No.	Aspect	component	Indicator	No. Point	∑
1.	Content	a. Curriculum	1. Conformity of SK/KD biology K13	1.	1
			2. Conformity of indicators with SK/KD	2.	1
			3. Suitability of the material with the scope of biology	3.	1
		b. User	4. The suitability of the media with the characteristics of students	4.	1
			5. The suitability of the method of delivery of material with student development	5.	1
			6. Provide opportunities for self-study	6.	1
			7. Demand student activity	7.	1
			8. Pay attention to individual differences	8.	1
2.	Learning	Opening	9. The attractiveness of the title	9.	1
			10. Appropriateness of apperception with objectives and learning materials	10.	1
		a. Core	11. Confused presentation of the material	11.	1
			12. Material truth	12.	1
			13. Clarity of material	13.	1
			14. Depth of the material	14.	1
			15. Breadth of material	15.	1
			16. The attractiveness of the presentation of the material	16.	1
			17. Appropriate presentation of examples	17.	1
			18. Completeness of presentation of examples	18.	1
			19. Language compatibility with EYD	19.	1
			20. Language suitability for the target user	20.	1
		b. Closing	21. Compatibility of practice questions with indicators	21.	1
			22. Systematic practice questions	22.	1
			23. The proportion of practice questions	23.	1
			24. Quality feedback	24.	1
Total					**24**

Results and Discussion

In the following, research data is presented (Table 5), which includes validation data from experts in the field of AR mobile media, experts in the field of material and student activities, data on student communication skills, students' creative thinking skills with pre-test results before learning and post-test results after learning and responses students after learning to use the GI learning model assisted by mobile AR on animal biology subject matter. Media expert validation results in data can be seen from the validation sheet obtained at the end of the mobile AR media revision. After the revision was carried out according to the suggestions of the validator, the researcher validated it again according to certain criteria. This validation function determines the feasibility and suitability of the product developed by researchers in the form of mobile AR adapted to the GI model.

Table 5. Data from media expert validation results

Aspect	Indicator	Score	Percentage	category
Appearance	The accuracy of selecting the background with the material	4	0.20	Good
	The accuracy of the layout proportions	5	0.25	Very good
	Correct selection of fonts for easy reading	4	0.20	Good
	Correct font size for easy reading	4	0.20	Good
	Correct text colour for easy reading	5	0.25	Very good
	Image composition	4	0.20	Good
	Image size	4	0.20	Good
	Image display quality	3	0.15	Enough
	Suitability of animation with the material	4	0.20	Good
	Animation fun	4	0.20	Good
	The accuracy of choosing the backsound with the material	4	0.20	Good
	Sound effect accuracy with animation	3	0.15	Enough
	The accuracy of the video selection with the material	4	0.20	Good
	Video quality	4	0.20	Good
	The beauty of the front cover	4	0.20	Good
	Appropriate display with content	4	0.20	Good
	Media durability	5	0.25	Very good
	Average Amount	**4,05**	**0.20**	Good
Programming	Compatibility with users	4	0.20	Good
	Flexibility (can be used independently and guided)	5	0.25	Very good
	Complete instructions for use	4	0.20	Good
	Display instructions for use	4	0.20	Good
	Presenting benchmarks of learning success	4	0.20	Good
	Accurate use of navigation buttons	4	0.20	Good
	Interactive link performance precision	4	0.20	Good
	Average Amount	**4,14**	**0.20**	Good

Based on Table 5, related to the Mobile Augmented Reality (AR) media developed by researchers with a display aspect with 17 indicators obtaining an average score of 4.05 getting a percentage of 0.20 in the "good" category. Whereas in the programming aspect, 7 indicators obtained an overall average score of 4.14 getting a percentage of 0.20 in the "good" category. So thus, from these results, the augmented reality car media validation results are in the "good" category. The validation results of the Augmented Reality mobile media follow the expected criteria, then the results of the material validation are also explained as listed in Table 6.

Based on table 6 regarding the biological material contained in the application with Mobile AR which was developed by researchers with content aspects with 8 indicators obtaining an average score of 4.37 getting a percentage of 0.21 in the "very good" category. At the same time, the learning aspect consists of 16 indicators with an average score of 4.12 getting a percentage of 0.20 in the "good" category or the "Valid" category. Materials in this category deserve to be tested in the field. Then according to the research data conducted through the experimental and control classes, a normality test was carried out with the final value of the experimental and control classes. Pretest-Posttest Test of Experimental Class Students with the pre-test normality test first based on the output Q-Q Plot of experimental class pre-test value data as described in Figure 1.

Table 6. Material Expert Validation Result Data

Aspect	Indicator	Score	Percentage	category
Content	SK/KD suitability of biology K13	5	0.25	Very good
	Compatibility of indicators with SK/KD	5	0.25	Very good
	The suitability of the material with the scope of biology	4	0.20	Good
	Media suitability with student characteristics	4	0.20	Good
	The suitability of the delivery method with the development	4	0.20	Good
	Provide opportunities for self-study	5	0.25	Very good
	Demand student activity	4	0.20	Good
	Pay attention to individual differences	4	0.20	Good
	Average Amount	**4.37**	0.21	Very good
Learning	Interesting title	3	0.15	Enough
	Appropriateness of apperception with goals and materials	5	0.25	Very good
	Confused presentation of the material	4	0.20	Good
	Material truth	4	0.20	Good
	Material clarity	4	0.20	Good
	Material depth	4	0.20	Good
	Material breadth	4	0.20	Good
	The attractiveness of the presentation of the material	5	0.25	Very good
	Appropriate presentation of examples	5	0.25	Very good
	Completeness of presentation of examples	5	0.25	Very good
	Language compatibility with EYD	4	0.20	Good
	Language suitability for the target user	4	0.20	Good
	Compatibility of practice questions with indicators	4	0.20	Good
	Systematics of practice questions	3	0.15	Enough
	The proportion of practice questions	4	0.20	Good
	Quality feedback	4	0.20	Good
	Average Amount	**4.12**	**0.20**	Good

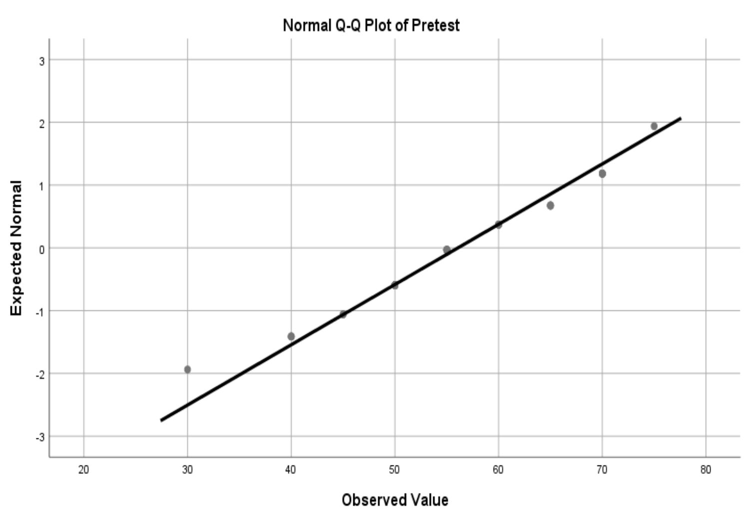

Figure 1. Pre-test data normality test based on experimental class Q-Q plots

Based on the Q-Q Plot output, the experimental class's pre-test value data shows normal data because the plot points follow the normal line. Based on the Q-Q Plot, the variables are normally distributed from the pre-test normality test, and the plots appear to follow the fit line. Because if the data distribution is not normally distributed, then the distribution of the plots is away from the model (straight line). The graph above's diagonal line illustrates the ideal data state that follows a normal distribution. Then the dots around the line describe the state of the data that can be tested. It can see a straight line from the bottom left to the top right from the Q-Q Plot. The level of spread of points on a line shows the normality of the data. If a data distribution is normal, the data will be spread around the line. The data is spread out in a straight line from the graph above. So, it can be concluded that the pre-test score data for experimental and control class students or both samples come from normally distributed populations. Then from, the analysis of the pre-test data output, it is continued with the post-test normality test for the experimental class based on the Q-Q plot as in Figure 2.

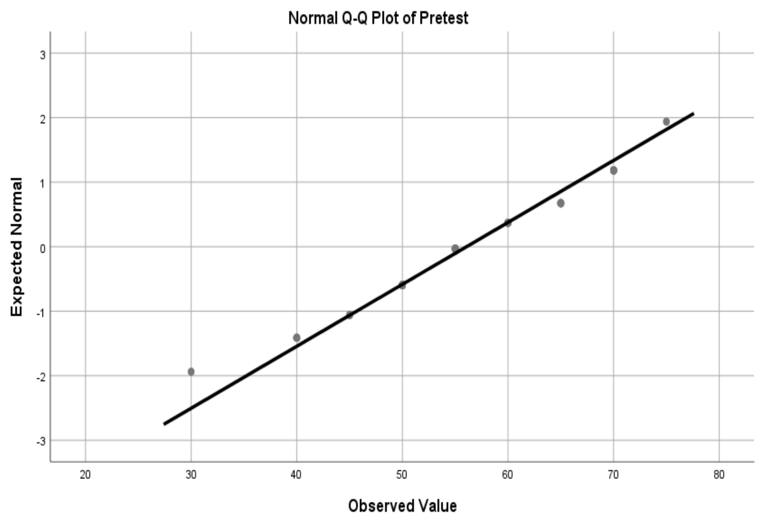

Figure 2. Post-test data normality test based on experimental class Q-Q plots

Based on the Q-Q Plot Output data, post-test values for the experimental class show normal data because the plot points follow the normal line. Based on the Q-Q Plot from the post-test normality test, the visible plots appear to be fit lines, and the data is normally distributed. The data is normal because the points follow the normal line. Theoretically, a pre-test data set is said to have a normal distribution if the data is spread around the line. Based on the graph above, the interpretation of the output test of normality with post-test scores is based on a straight line that crosses from the lower left corner to the upper right so that it forms a complete diagonal direction and can be referred to as the normality reference line. If the data is not spread along the diagonal line, then the data is not normally distributed. The data above shows that the post-test experimental class data on the graph spread along the diagonal line so that the data can be said to be normally distributed. Then according to the hypothesis indicator criteria, H0: There is no difference in the pre-test and post-test scores of the experimental class students and H1: there are differences in the pre-test and post-test scores of the experimental class students. The test statistic must reject H0. If the Sig value < the results can be seen in the paired samples test that has been obtained, explain as in Table 7.

Table 7. Paired samples test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pretest - Posttest	-19.973	14.358	2.360	-24.760	-15.186	-8.462	36	.000

Based on the Paired Samples T-Test Table, the value of Sig. Equal to 0.000 < alpha 0.05, it is concluded that H0 is rejected, meaning that there is a difference in the average results of the pre-test and post-test scores of the experimental class students. This Paired Samples Test table is the main output table showing the tests' results. It can be seen from the significance value (2-tailed) in the table. The significance value (2-tailed) of this case example is 0.000 (p <0.05). So, the pre-test and post-test results experienced significant (meaningful) changes. Based on descriptive statistics, the pre-test and post-test proved to be higher. So, from the results of the data analysis, it can be concluded that using mobile AR technology based on biology labs through the GI learning method can improve students' creative thinking skills. The Paired Sample T Test results are determined by their significance value. This value then determines the decisions taken in this study from the results of the hypothesis analysis, which assumes that it can be decided that the Sig <0.05 means rejecting H0 and accepting H1 so that this study can be concluded that there is a difference in the pre-test and post-test averages. Then the results of the experimental class data analysis that has been carried out through the normality test and the T Paired samples test will be compared with the control class research data, which was not given treatment using augmented reality media, as seen in the control class pre-test normality test via the Q-Q Plot (Figure 3).

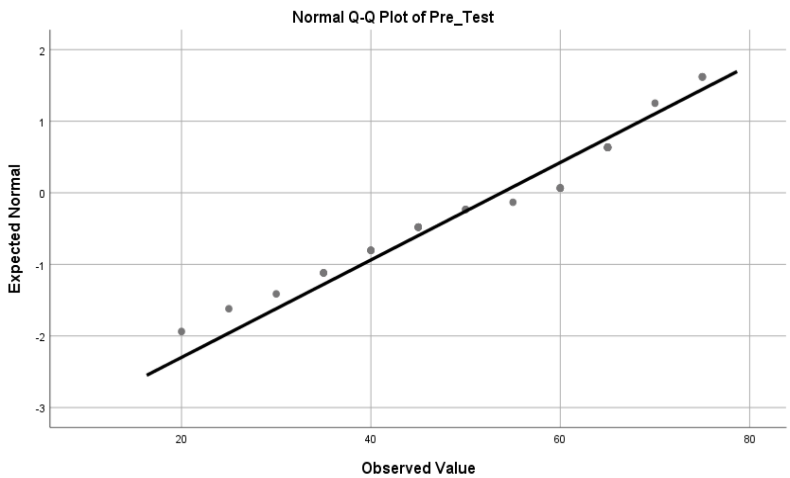

Figure 3. Post-test data normality test based on control class Q-Q plots

Based on the Output Q-Q Plot data, pre-test values. The control class shows normal data because the plot points follow the normal line. From the pre-test normality test based on the Q-Q Plot that the plots that appear to follow the fit line, it is said that the variables are normally distributed. If the distribution of data is not normally distributed, then the distribution of the plots is away from the straight-line model. When seen, the diagonal line in the graph above illustrates the ideal state of the data that follows a normal distribution. Then the dots around the line describe the state of the data that can be tested. According to the Q-Q Plot can see a straight line from the bottom left to the top right. The level of spread of points on a line shows the normality of the data. If a data distribution is normal, the data will be spread around the line. The data is spread out in a straight line from the graph above. Thus, it can be concluded that the pre-test score data for the sample control class students came from a normally distributed population. Then from the analysis of the pre-test data output, it is continued with the post-test normality test of the control class based on the Q-Q plot as in Figure 4.

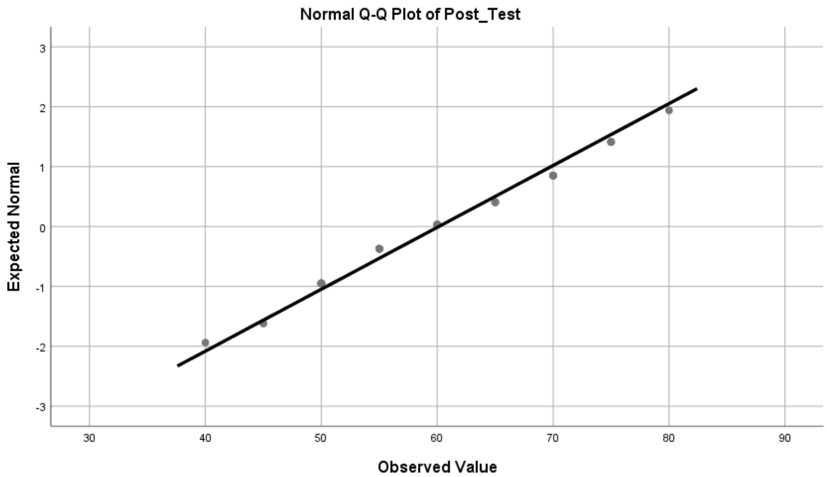

Figure 4. Post-test data normality test based on control class Q-Q plots

Based on the Q-Q Plot output data, the control class post-test values show normal data because the plot points follow the normal line. Based on the Q-Q Plot, the variables are normally distributed from the pre-test normality test, and the plots appear to follow the fit line. Because the distribution of the post-test data is not normally distributed, the distribution of the plots is far from the model (straight line). The graph above's diagonal line illustrates the ideal data state that follows a normal distribution. Then the dots around the line describe the state of the data that can be tested. It can see a straight line from the bottom left to the top right from the Q-Q Plot. The level of spread of points on a line shows the normality of the data. If a data distribution is normal, the data will be spread around the line. Then from the graph above, the data is spread around it straight. So, it can be concluded that the post-test score data for control class students or both samples come from normally distributed populations. After the normality test is carried out using the Q-Q Plot output, it is continued with the hypothesis indicator H0: There is no difference in the pre-test and post-test scores of the Control class students, and H1: there are differences in the pre-test and post-test scores of the Control class students with Test Statistics: Reject H0 If the Sig value <0.05 thus producing as listed in Table 8.

Table 8. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper			
Pair 1	Pretest - Posttest	-6.351	14.320	2.354	-11.126	-1.577	-2.698	36	.011

Based on the Paired Samples T-Test Table, a significance value of 0.0011 <0.05 is obtained, so it can be concluded that H0 is rejected, meaning that there is a difference in the average results of the pre-test and post-test scores of students in science class 2 (Control Class). This Paired Samples Test table is the main output table showing the tests' results. It can be seen from the significance value (2-tailed) in the table. The significance value (2-tailed) of this case example is 0.000 (p <0.05). So, the pre-test and post-test results experienced significant (meaningful) changes. Based on descriptive statistics, the pre-test and post-test proved to be higher. So, from the results of the data analysis, it can be concluded that using mobile AR technology based on biology labs through the GI learning method can improve students' creative thinking skills. Then the Paired Sample T Test results are determined by their significance value. Thus, from the results of the data analysis, it is continued with the normality assumption test of the final value of the experimental and control classes, which can be seen in Figure 5.

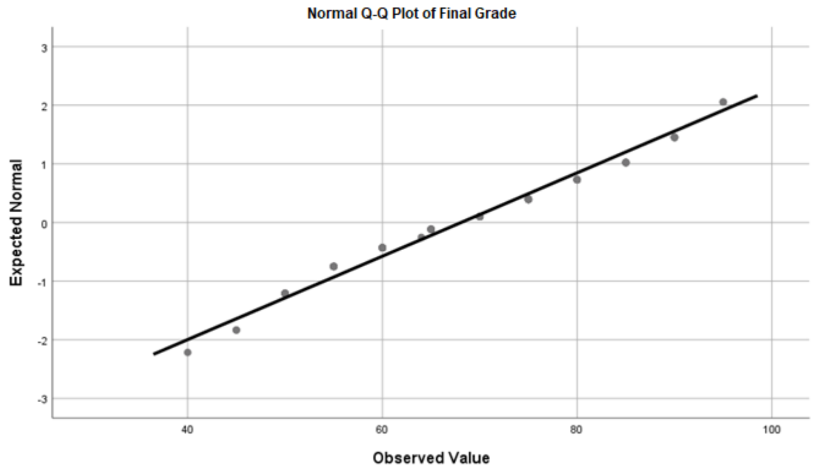

Figure 5. Assumption test of normality of final grades for experimental class and control class

Based on the Q-Q Output, the plot shows normal data because the plot points follow the normal line. The plots that follow the fit line show that the variables are normally distributed from the pre-test and post-test normality tests based on the Q-Q Plot. If the distribution of pre-test and post-test data is not normally distributed, the distribution of the plots is far from the straight-line model. Then the diagonal line in the graph above illustrates the ideal state of the data that follows a normal distribution. The dots around the line have described the data's state that can be tested. It can see a straight line from the bottom left to the top right from the Q-Q Plot above. The spread of these points in a line shows the normality of the research data. If a data distribution is normal, the data will be spread around a straight line. Then from the graph above, the data is spread around it straight. So, it can be concluded that the post-test score data for control class students or both samples come from normally distributed populations. From the normality assumption test of the experimental class and the control class, it is continued with the T-test, the final value adjusted for the hypothesis indicator consists of Hypothesis H0: There is no difference in the average final score of students in the Experiment class and Control class and H1: There is a difference in the average final score of students the Experiment class and the Control class so that the Test Statistics can be explained if: reject H0 If the Significance Value is less than 0.05 with the results as in Table 9.

Table 9. Group statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Final Score	Experiment	37	76.05	13.312	2.189
	Control	37	60.14	9.681	1.592

Based on the group statistics table above shows that the two groups have 37 samples each between the experimental class and the control class. The final test scores for the experimental group were higher than the control group, averaging 76.05 and 60.14. Then the results of the std deviation are the final experimental score of 13.312, and the value of the control class is 9.681, so the experimental class is higher than the experimental class. Meanwhile, the mean std error in the final experimental value was 2.189, and the final control value was 1.592, concluding that the experimental class was higher than the control class. Thus, descriptive statistics can be concluded that there is an average difference between the experimental class and the control class. Furthermore, in proving whether there is a difference between the experimental and control classes, it is continued with the independent samples test, which can be seen in Table 10.

Table 10. Independent samples test

		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
Final Score	Equal variances assumed	2.623	.110	5.883	72	.000	15.919	2.706	10.524	21.313
	Equal variances not assumed			5.883	65.757	.000	15.919	2.706	10.516	21.322

Based on the table above, it is obtained that the Levene'S Test Equality of Variances P-Value is 0.110 > 0.05, so it means that the variance of the data between the final scores of the experimental and control classes can be said to be homogeneous or the same. The interpretation of the Independent Sample Test output table above is guided by the values contained in the Equal variances assumed table. It is known that the significance value (2-tailed) is 0.000 <0.05, so as the basis for making decisions in the independent sample T-test, it can be concluded that Ho is rejected and Ha is accepted. Thus, it can be concluded that there is a significant difference between the experimental and control classes of critical thinking. Furthermore, from the table, it is known that the mean difference assumed value is 15.919. This value indicates a difference between students' average creative thinking skills in the experimental and control classes.

Based on the results of the research data using the normality test and followed by the Paired Sample T Test, giving the pre-test to the post-test results increases students' creative thinking skills because the significance value is 0.00 <alpha 0.05. This Paired Samples Test table is the main output table showing the results of the tests after the normality test. This analysis can be seen from the significance value (2-tailed) in the table, shown from the has. The significance value (2-tailed) of this case example is 0.000 (p <0.05), indicating that the pre-test and post-test results experienced significant (meaning) changes. Based on the descriptive statistics of the pre-test and post-test, it is proven that the post-test is higher than the pre-test results. Thus, before carrying out the learning process using augmented reality technology based on biology practicum, a pre-test is given first, after which it is continued with the learning process during the allotted time and finally, a post-test (Dou et al., 2021; Gajda & Gralewski, 2021). Student success in improving creative thinking skills depends on the learning facilities provided by the teacher to students (Heidari Soreshjani & Jahangirian, 2021; Kustov & Kustov, 2021).

Data analysis was carried out by identifying the development of learning media by validating with validators related to the feasibility and practicality test of learning media in the form of mobile augmented Reality based on biology practicum. Then, from the results obtained through the normality and homogeneity tests, proceed with the T-test to determine the average difference between the experimental and control classes. Learning through an augmented reality mobile learning media with the GI learning method goes through its stages (Ivanov et al., 2021; Taylor et al., 2022). The GI learning mode assisted by augmented Reality in biology practicum helps students learn more effectively and efficiently (Luo et al., 2021). The application of mobile AR based on biology practicum through GI has an impact on students' creative thinking skills (R. Chen et al., 2021; T. Liu et al., 2021). The GI model is generally more implemented according to its stages, but following the development of science and technology, the learning model can be integrated with mobile AR (R. Liu et al., 2021). The application of the GI model assisted by augmented Reality is used as a medium for biology practicum in improving students' creative thinking skills (Buentello-Montoya et al., 2021; Nagaoka et al., 2021).

AR is an interactive technology that provides visuals by focusing on virtual objects and delivering a real reality (Dumas et al., 2021; Yin et al., 2021). Augmented Reality can unite virtual objects, namely two-dimensional virtual objects or three-dimensional virtual objects, into a three-dimensional real environment. A real three-dimensional environment will bring virtual objects into the real form or like real Reality (Mao et al., 2021; Stone et al., 2021). Thus, users are made it difficult to distinguish between the real world and virtual augmentation by systems created in AR (Philippe et al., 2020). Augmented Realty learning media designed through the GI learning model in biology labs provide a fun learning atmosphere (Xiao et al., 2020; Zhou et al., 2020). Learning biology practicum is an effective medium in helping the learning process, which is usually carried out in the laboratory in virtual media but is like Reality (S. Wang et al., 2020). Because learning biology cannot be separated from the tools and materials that must be prepared by the teacher, so by using augmented Reality, it is as if the practicum is direct, and it does not have to prepare tools and materials as usual (Albar & Southcott, 2021; Ayyildiz & Yilmaz, 2021).

Biology practicums that are often carried out, in general, are always automatically not associated with technological developments, especially in high schools where schools are still underdeveloped, sometimes it is difficult to prepare tools and materials according to learning objectives (Navarro Ramón & Chacón-López, 2021; Yang & Zhao, 2021). So using AR can provide solutions to the problems of learning biology practicum in the classroom (Çakır et al., 2021) because using AR media with the GI model in practice will have an impact on a more interactive, efficient and effective learning process (Kaplan Sayi & Akgul, 2021). Then through AR learning media, it is easier to become a solution during the adaptation period to new habits and become one of the interactive technologies used in biology learning in the practicum process (Groyecka-Bernard et al., 2021; Yildiz & Guler Yildiz, 2021). Augmented Reality adds virtual objects to real objects at the same time, and AR can be a solution to biology practicum problems, especially for displaying learning objects in the classroom to make it more interactive and effective (Huang et al., 2020; Said-Metwaly et al., 2021). The application uses biology practicum learning with Augmented Reality media to make it easier for students to carry out practicums correctly (H. Zhang et al., 2020).

This research aims to discover the role of AR technology as a learning media solution for biology practicum (P. Z. Chen et al., 2020; Ibán et al., 2020). AR, which is widely implemented in various media, is easy to operate and does not cost too much to manufacture, making AR a learning media solution during the adaptation period to new habits (Huang et al., 2020; Said-Metwaly et al., 2021). AR combines the virtual and real worlds to produce information from data taken from a system on designated real objects so that the boundaries between the two become increasingly thin (Soltani & Morice, 2020). AR can create interactions between the real world and the virtual world, and all information can be added so that the information is displayed in real-time as if the information is interactive and real, especially in biology labs (Bhushan et al., 2018; K. B. Park et al., 2020). In general, biology labs usually use practicum objects directly, but with current developments in science and technology, breakthroughs are needed, and it has to be cooperative with these developments in the learning process (López-Faican & Jaen, 2020; Radianti et al., 2020).

AR media through the GI learning model can improve students' creative thinking skills (Arulanand et al., 2020; Harun et al., 2020; Tuli & Mantri, 2020). Creative thinking skills are an individual's ability to find ways, strategies, ideas, or new ideas about how to get a solution to a problem. Creative thinking skills assist in problem-solving (Ibán et al., 2020; Sun et al., 2020). Creative thinking skills can stimulate students to develop advanced thinking skills (Ibán et al., 2020; Mourtzis et al., 2020). creative thinking becomes a habit of the mind trained by paying attention to intuition, turning on the imagination, and expressing new possibilities (Harun et al., 2020; Jakubina et al., 2020). Creative thinking skills are very important for students because creative thinking skills are one of the learning competencies in the 21st century (Berestova et al., 2021; Çakır et al., 2021; Dumas et al., 2021). Creative thinking skills in science learning can positively contribute to the personal, social, technological and economic development they will do as adults in the 21st century (Yang & Zhao, 2021; Yildiz & Guler Yildiz, 2021).

The 21st-century skills are the most important part that must be pursued in the Education Institute through interesting and fun learning (Kaplan Sayi & Akgul, 2021). Thinking more creatively will not come suddenly without qualified abilities, high curiosity, and followed by skills in reading (Ibán et al., 2020). when wanting to improve students' creative thinking skills, of course, it is not just teaching with the dropping of obligations, but more on how the learning process can improve students' 21st-century taste, one of which is students' creative thinking skills (Akpur, 2020; Kaplan Sayi & Akgul, 2021). Following the indicators of creative thinking, namely (1) fluent, which is the ability to generate many ideas; 2) flexible, namely the ability to produce varied ideas; 3) original, which is the ability to generate new ideas or ideas that did not exist before, and 4) detailing, is the ability to develop or add ideas so that detailed or detailed ideas are produce (Çakır et al., 2021). Creative thinking has several indicators for generating new ideas to solve problems (Dumas et al., 2021). Because actually, creative thinking is a process that develops unusual ideas and generates new thoughts that have a broad scope (T. Liu et al., 2021; Nagaoka et al., 2021).

Conclusion

From the results of the development research that has been carried out by researchers based on table 5 related to Mobile Augmented Reality (AR) media developed by researchers with display aspects with 17 indicators obtaining an average score of 4.05 getting a percentage of 0.20 in the "good" category. Whereas in the programming aspect, 7 indicators obtained an overall average score of 4.14 getting a percentage of 0.20 in the "good" category. So thus, from these results, the validation results of mobile augmented reality media are in the "good" category. Then based on Table 6, related to the biological material in the application with Mobile AR developed by researchers with content aspects with 8 indicators by obtaining an average score of 4.37 getting a percentage of 0.21 in the "very good" category. Whereas in the learning aspect consisting of 16 indicators with an average score of 4.12, a percentage of 0.20 is in the "good" category or the "Valid" category. Materials in this category deserve to be tested in the field. According to the Paired Samples T Test Table, the value of Sig. of 0.000 < alpha 0.05, it was decided that H0 was rejected, meaning that there was a difference in the average results of the pre-test and post-test scores of the experimental class students. This Paired Samples Test table is the main output table showing the tests' results. It Can be seen from the significance value (2-tailed) in the table. The significance value (2-tailed) of this case example is 0.000 (p <0.05). So, the pre-test and post-test results experienced significant (meaningful) changes. Based on the pre-test and post-test descriptive statistics, it is proven that the post-test is higher. So, from the results of the data analysis, it can be interpreted that using mobile AR technology based on biology labs through the GI learning method can improve students' creative thinking skills. The interpretation of the Independent Sample Test output table above is guided by the values contained in the Equal variances table; it is assumed that it is known that the significance value (2-tailed) is 0.000 <0.05, so as the basis for the decision to take the independent sample T test it can be titled that Ho is rejected and Ha is accepted. Thus, it can be interpreted that there is a significant difference between the experimental and control classes of critical thinking. Furthermore, from the table, it is known that the assumed mean difference value is 15.919. This value indicates a difference between students' average creative thinking skills in the experimental and control classes.

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Conflicts of Interest

There was no potential conflict of interest reported by the authors in this study, so that pure research from the results of development research was piloted into the learning process.

Author Contributions

W. Wikanta: Methodology; data analysis; write article manuscripts; review and editing. **P. Suharti:** Manuscript writing; review; searching for references and edit. **A. Asy'ari:** Writing articles, review; and editing.

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