Journal of Physics
Conference Series

The 11th Biennial Conference on Classical and Quantum Relativistic Dynamics of Particles and Fields

1239

Journal of Physics: Conference Series

The open access *Journal of Physics: Conference Series (JPCS)* provides a fast, versatile and cost-effective proceedings publication service.

RSS Sign up for new issue notifications

Latest published conferences

Vol 2442 Go

Conference archive

2023 Go

View forthcoming volumes accepted for publication.

JOURNAL LINKS
Journal home
Journal Scope
Information for organizers
Information for authors
Contact us
Reprint services from Curran Associates

JOURNAL INFORMATION
2004-present
Journal of Physics: Conference Series
doi: 10.1088/issn.1742-6596
Online ISSN: 1742-6596
Print ISSN: 1742-6588

If you would like more detailed information regarding *Journal of Physics: Conference Series* please visit conferenceseries.iop.org, and if you are interested in publishing a proceedings with IOP Conference Series please visit our page for conference organizers.

Conference organizers can use our online form and we will get in touch with a quote and further details.

Most read Open all abstracts

Latest articles OPEN ACCESS

IOPscience Journals Books Publishing Support Login

Journal of Physics: Conference Series

Table of contents

Volume 2392

2022

Previous issue Next issue

Seminar Nasional Fisika Unesa 2022 (SNF Unesa 2022)

Accepted papers received: 21 November 2022
Published online: 13 December 2022

Open all abstracts

Preface

OPEN ACCESS 011001

Preface

OPEN ACCESS 011002

Peer Review Statement

+ Open abstract View article PDF

Keynote Speaker

OPEN ACCESS 012001

Diagnostic Tests as an Important Pillar in Today's Physics Learning: Four-tier Diagnostic Test a Comprehensive Diagnostic Test Solution

E Istiyono

+ Open abstract View article PDF

Papers

OPEN ACCESS 012002

Web Learning Research in Physics Education During the COVID-19 Pandemic

B K Prahani, B Jatmiko, T Amelia, M C Pristianti, S Mahtari and R F R Uulaa

+ Open abstract View article PDF

OPEN ACCESS 012003

Identification of Groundwater Using Geoelectrical Method VES (Vertical Electrical Sounding) in Karimunjawa City, Central Java

M I A T Bahari, S Supriyadi, D G Pryambodo and J Prihantono

OPEN ACCESS 012004

The Influence of Quantum Teaching Model through the TANDUR Strategy on the Students' Learning Outcome of Senior High School Students in Static Fluid Materials

A Y T Allo, I Farida and I L S Sinon

+ Open abstract View article PDF

OPEN ACCESS 012005

Comparison of Histogram Features and Co-occurrence Matrix in Identification of Lung Cancer X-Ray Images with Naive-Bayes Method

M A Bustomi and A M Rusnandar

+ Open abstract View article PDF

OPEN ACCESS 012006

The Influence of Guided Inquiry Learning Model through Experimental Method for Understanding the Concept of Students in Calorie Material

I L S Sinon, K R Sapari and A Y T Allo

+ Open abstract View article PDF

OPEN ACCESS 012007

Development of Physics Learning Instrument using Guided Inquiry Model as Effort to Increase Student Learning Result on Dynamic Fluid Learning Material at Senior High School

M Sumo, B Jatmiko, Z A I Supardi, S Arifin, Nasrullah and A Mukit

+ Open abstract View article PDF

OPEN ACCESS 012008

Fabrication of PVA/SiO2 (Nanofiber) Membranes Prepared Using Electrospinning Method for Lithium Battery Separator

N F Sania and M Munasir

+ Open abstract View article PDF

OPEN ACCESS 012009

Analysis Multi Representation Ability and Learning Outcomes of Optical Materials

T Sunarti and M Z B Amiruddin

+ Open abstract View article PDF

OPEN ACCESS 012010

The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course

N I Zuniari, Z R Ridlo, S Wahyuni, E M Ulfa and M K S Dharmawan

+ Open abstract View article PDF

OPEN ACCESS 012011

Online-Based Assessment of Students' Conceptual Understanding of Energy and Momentum Using Quizizz

A U Yana, S Koes-H, A Taufiq and S Kusairi

+ Open abstract View article PDF

OPEN ACCESS 012012

Development of Digital Module 'Phymology' on Optical Instruments

N S Arnida and F C Wibowo

OPEN ACCESS 012013

Characteristics of The PANI Thin Film Fabricated by The Electrodeposition Method and its Performance as an Alcohol Gas Sensor

N P Putri, A Y Komariyah, T Sunarti, E Suaebah and L Rohmawati

+ Open abstract View article PDF

OPEN ACCESS 012014

Development of Mobile Learning Applications (MLA) Electromagnetic Induction Based on PjBL to Improve Students' Critical Thinking Skills

A Solihin, B H Iswanto and F C Wibowo

+ Open abstract View article PDF

OPEN ACCESS 012015

Enhancement of microstructure characteristic and dielectric constant of $BaMn_{0.05}Ti_{0.95}O_3$ ceramics

B Suherman, F Nurosyid, E Handoko, Khairuddin, D K Sandi, L U Hasanah, F R Agustina, N F S Puspita and Y Iriani

+ Open abstract View article PDF

OPEN ACCESS 012016

E-Book Learning Research in Physics Education During the Last Five Years: A Review and Bibliometric Study

I R Dawana, Dwikoranto, R Setiani and Marsini

+ Open abstract View article PDF

OPEN ACCESS 012017

Characteristics of Optical Emission Spectroscopy Spectrum on Graphite Deposition Process with Sputtering Method

D H Kusumawati, M Nurhuda, D J D H Santjojo and Masruroh

+ Open abstract View article PDF

OPEN ACCESS 012018

Effectiveness of Polyvinyl Alcohol Nanofiber Composites as Anti-Bacterial Materials in Wound Dressing

D H Kusumawati, Munasir, L Rohmawati, P Uzalia, M D Layli, A B Rahanti and I Yuliani

+ Open abstract View article PDF

OPEN ACCESS 012019

Exploring Inquiry Skills During Home Experiments about Science in the Online Instruction

Supeno, Z R Ridlo and A M Setiawan

+ Open abstract View article PDF

OPEN ACCESS 012020

Level of Students' Conceptual Understanding of Static Fluid

Z U Irma, S Kusairi and L Yuliati

+ Open abstract View article PDF

OPEN ACCESS 012021

Controlling Electronic Properties of FeCl2 Monolayer under LDA+U Approach

T B Prayitno, B Nuryasin, E Budi and R Fahdiran

+ Open abstract View article PDF

OPEN ACCESS 012022

Phase Formation, Structural, and Microstructural Characterizations of Ilmenite $FeTiO_3$ Nanopowder Prepared from Liquid-Mixing Method

F U Ermawati

+ Open abstract View article PDF

OPEN ACCESS 012023

Physics Edutainment Learning based on Engklek and Ontang-Anting Games: Creating Fun Physics for Students

E Hariyono, I A Rizki, I A Rizqillah, N F Citra, N Shobah and A Zainuddin

+ Open abstract View article PDF

OPEN ACCESS 012024

Segmentation Effect on Lungs X-Ray Image Classification Using Convolution Neural Network

M Khoiro, R A Firdaus, E Suaebah, M Yantidewi and Dzulkiflih

+ Open abstract View article PDF

OPEN ACCESS 012025

Digital Learning Integrated with Local Wisdom to Improve Students' Physics Problem-Solving Skills and Digital Literacy

J Siswanto, A T J Harjanta, I Suminar and S Suyidno

+ Open abstract View article PDF

OPEN ACCESS 012026

The Liquifaction Modeling to Analysis of Soil Structure Composition

S Astutik and A N Aprilina

+ Open abstract View article PDF

OPEN ACCESS 012027

Autonomy-Based Creative Learning: Equip Creativity and Concern for Prospective Physics Teachers in Wetland Environments

S Suyidno, S Haryandi, S Mahtari, A Azhari and T Sunarti

+ Open abstract View article PDF

OPEN ACCESS 012028

Teaching Physics in Scientific Information Disclosure Era Through Daily Physics Learning

W H Kristiyanto

+ Open abstract View article PDF

OPEN ACCESS 012029

The Physical Properties of Rocks in Blawan-Ijen Sempol District Bondowoso Regency

S Astutik and S L Nisa

+ Open abstract View article PDF

OPEN ACCESS 012030

Pascal or Archimedes: Which Misconception is Higher?

R K Irawati, E W N Sofianto, H Assidiqi and I Rahmawati

+ Open abstract View article PDF

OPEN ACCESS 012031

Modification of Purun Tikus *(Eleocharis dulcis)* Long Fiber with Potential as Composite Reinforcement Material

N H Haryanti, Suryajaya, E Suarso, Khaipanurani and T N Manik

+ Open abstract View article PDF

OPEN ACCESS 012032

The Profile of Misconceptions Using Three Tier Diagnostic Test on Dynamic Fluid

R Aliyah, E Sudibyo, Suyatno and Wasis

+ Open abstract View article PDF

OPEN ACCESS 012033

A Comparative Study of The Crystallinity Value of Polyethylene Glycol-Based Composites Using XRD and WAXS

N A Fauziyah, D S Perwitasari, T A Fadly, S Soontaranon and S Pratapa

+ Open abstract View article PDF

OPEN ACCESS 012034

Microstructure, Chemical Bonds, and Photocatalyst Activity of Neodymium-doped Strontium Titanate ($Sr_{0.97}Nd_{0.03}TiO_3$) with 900°C and 1000°C Sintering Temperature

L U Hasanah, F R Agustina, N F S Puspita, B Suherman, F Nurosyid, D K Sandi and Y Iriani

OPEN ACCESS 012035

Optimization of TPACK-based Project Learning in Micro-teaching Courses in Physics Education Study Programs during the Pandemic

E Y Ekawati and A Prastyo

+ Open abstract View article PDF

OPEN ACCESS 012036

Tunable Magnetic State in AA-Stacked Bilayer Zigzag Graphene Nanoribbon by Increasing Thickness

T B Prayitno, R Fahdiran and E Budi

+ Open abstract View article PDF

OPEN ACCESS 012037

Two Dimensional Simulation of Electromagnetic Waves on Metal Materials Using the FDTD Method

R A Firdaus, M Khoiro, Dzulkiflih, V Rahayu and Mutmainnah

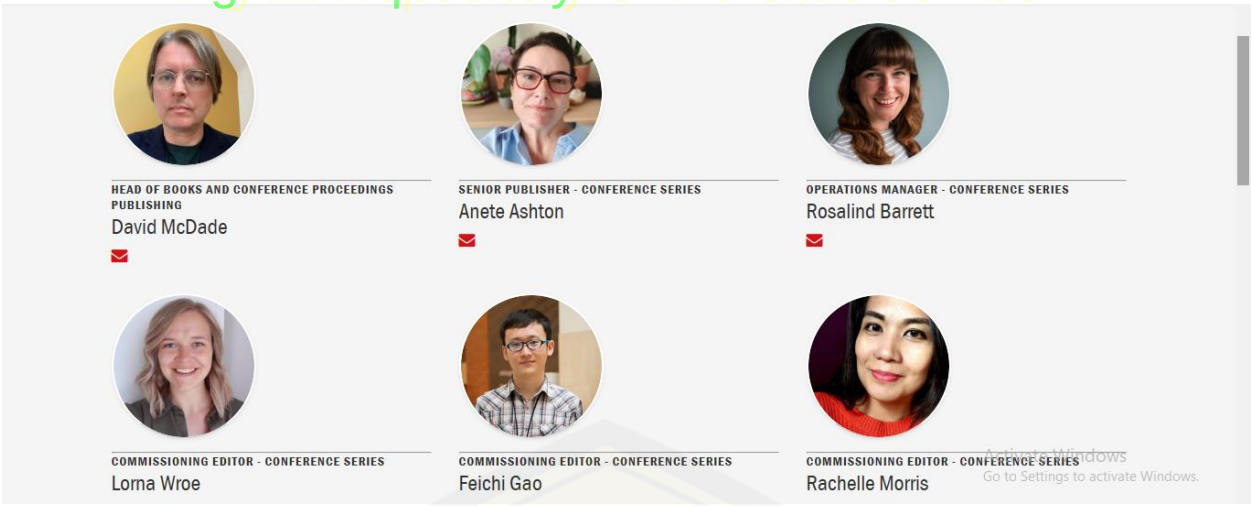
+ Open abstract View article PDF

OPEN ACCESS 012038

Improving Critical Thinking Skills (CTS) of Students Through Wave Energy Learning Project (WELP) on Environmental Physics Lecture

M Satriawan, R Rosmiati, O Saputra and M Habibbulloh

+ Open abstract View article PDF



HEAD OF BOOKS AND CONFERENCE PROCEEDINGS PUBLISHING
David McDade

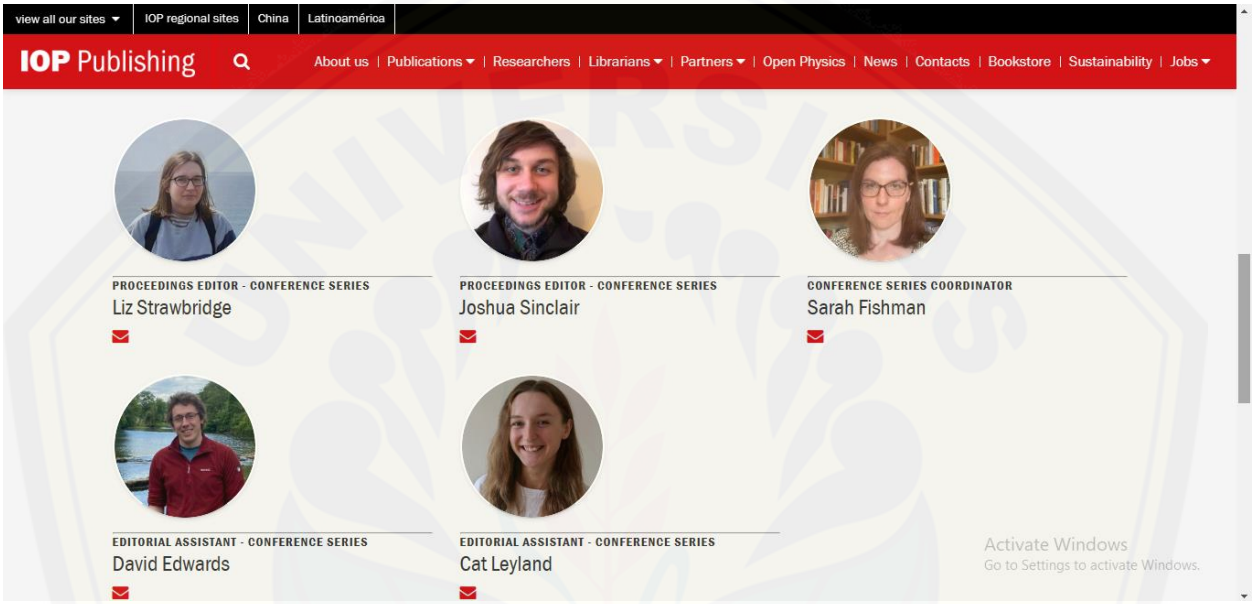
SENIOR PUBLISHER - CONFERENCE SERIES
Anete Ashton

OPERATIONS MANAGER - CONFERENCE SERIES
Rosalind Barrett

COMMISSIONING EDITOR - CONFERENCE SERIES
Lorna Wroe

COMMISSIONING EDITOR - CONFERENCE SERIES
Feichi Gao

COMMISSIONING EDITOR - CONFERENCE SERIES
Rachelle Morris



PROCEEDINGS EDITOR - CONFERENCE SERIES
Liz Strawbridge

PROCEEDINGS EDITOR - CONFERENCE SERIES
Joshua Sinclair

CONFERENCE SERIES COORDINATOR
Sarah Fishman

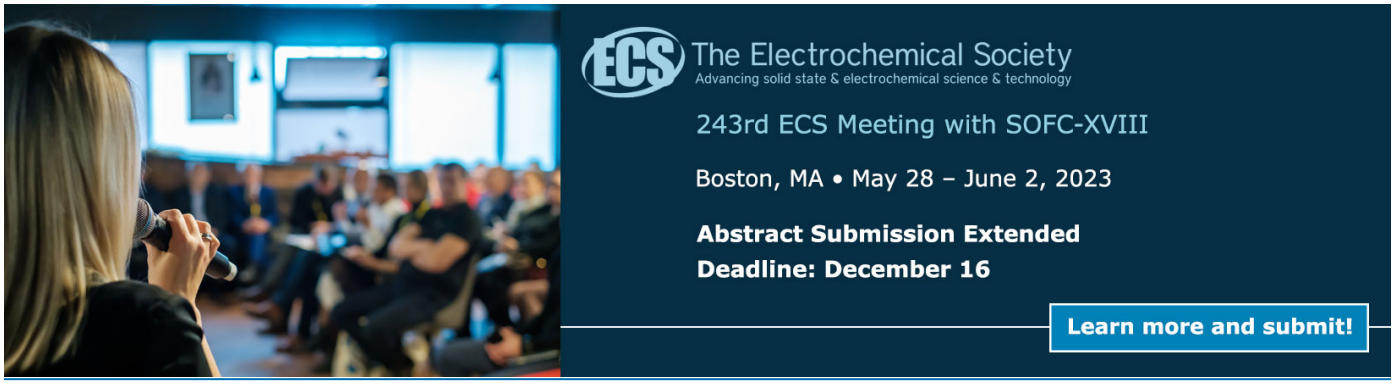
EDITORIAL ASSISTANT - CONFERENCE SERIES
David Edwards

EDITORIAL ASSISTANT - CONFERENCE SERIES
Cat Leyland

PAPER • **OPEN ACCESS**

The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course

To cite this article: N I Zuniari *et al* 2022 *J. Phys.: Conf. Ser.* **2392** 012010



The Effectiveness of Implementation Learning Media Based on Augmented Reality in Elementary School in Improving Critical Thinking Skills in Solar System Course

N I Zuniari, Z R Ridlo*, S Wahyuni, E M Ulfa, and M K S Dharmawan

Department of Science Education, University of Jember, Indonesia

***E-mail**: zainur.fkip@unej.ac.id

Abstract. This research aims to explore students' critical thinking skills in Augmented reality-based learning media implementation on solar system lessons in elementary school. Critical thinking skills at the elementary school level are still relatively low due to the lack of application of learning media that support the improvement of critical thinking skills. Learning media is a very important part of learning. Research design compares modern classes (experimental classes) with control classes. Teaching using augmented reality-based learning media is carried out in experimental classrooms, while teaching is directly carried out in the control class. As a researcher using research and development methods with a qualitative approach to quasi-experimental research methods (pseudo-experiments) with pure experimental design, namely Pre-test Post-test Control Design. It can be known that the value of significance in this study is 39.5% or 0.395 to pre-test. The average pre-test value obtained for the control class was 46.60 with a standard deviation of 12.32 while the average pre-test value for the experimental class was 48.57 with a standard deviation of 11.20. The collection of post-test in the control class was 72.3214 with a standard deviation of 10.45291 while the average value of the experimental class was 90.1429 with a standard deviation of 6.89452. Based on the t-test it can be known that in the pre-test values of the two classes there is no significant or homogeneous difference. After being given the treatment of augmented reality learning media in solar system materials, the post-test values of both classes experienced a significant difference with a Sig.2-Tailed value of 0.000. The results of this study that the learning medium of Augmented Reality has an impact on students' critical thinking skills.

1. Introduction

Natural sciences, which are generally referred to as sciences, have distinct characteristics that distinguish them from social sciences. Science consists of several branches of science. Physics, biology, and chemistry are some examples of branches of science. Each branch of the natural sciences has a character that makes each branch of science different and distinctive from the others [1].

Natural Sciences is a subject in elementary schools [2]. Natural Sciences is one of the important subjects in learning [3]. With the existence of natural science students can find out about living things, non-living things, science about life, and science about the physical world [4]. After knowing these natural phenomena, it can apply them in everyday life. To facilitate the application of Natural Sciences in everyday life, it is necessary to increase students' critical thinking skills by practicing mastery of a concept by students not only in the form of memorizing several concepts they have learned. This makes them able to apply the concept they have to other aspects [5].

The weakness in science learning is due to the techniques or learning media used to put more emphasis on memory factors [6]. Verbalism is a learning process where the teacher is more dominant

and the source of information only comes from the teacher [7] students are difficult to understand because they can only hear and memorize words without seeing the visualization. Real science learning is not the memorization of meaningful words, but rather the result of associations from experiences [8]. In learning, the teacher must have a strategy to create these experiences, namely the visualization strategy. Visualization strategy is a strategy that utilizes images to help strengthen students' understanding of the meaning of words [9].

In the process of teaching and learning, the teacher must know the abilities and characteristics of students on the material provided. One of the materials that students do not understand is the solar system. The solar system itself is a basic science in the field of natural science lessons that can be obtained in elementary school education, where things that are discussed in general are about the sun, planets, and other objects around the sun [10]. The solar system is a system consisting of the Sun, eight planets, dwarf planets, comets, asteroids, and other small celestial bodies [9]. The solar system is divided into several different areas. The first area is the sun, the second area is the terrestrial planets (rocky planets), the third area is the asteroid belt, the area contains space rocks between the orbits of Mars and Jupiter, and the fourth area contains giant planets [11]. In learning, a teacher must have a strategy to create these experiences, namely with visualization strategies. Visualization strategy is a strategy that utilizes images to help strengthen students understanding in interpreting words.

Systems that exist today, generally children know the solar system only from the media of books obtained from the school. Books used in solar system learning activities, of course, only display pictures of objects from members of the solar system, which results in students losing an opportunity to develop skills, observing and can reduce the curiosity of students [10] and have an impact on the achievement of learning goals. One solution to overcome students' lack of understanding of the solar system material is to use interactive learning media. Learning media is one component of learning that has an important role in teaching and learning activities, therefore, teachers need to learn how to determine learning media [12]. Learning media is a media used in learning, which includes teacher aids in teaching and means of carrying messages from learning sources to recipients of learning messages (students) [13]. Like a film, diagrams, computer, television and instructors is a media communication channels. Learning media is a tool used to deliver learning materials that can make students follow the learning process [14]. One of the learning media that can support the need for material on the solar system is ARLOOPA, which is an application that can be operated on devices based on augmented reality.

The use of augmented reality media is still lacking its use in elementary schools, so there is a need for innovation presented in learning in primary school. There needs to be research that discusses the importance of augmented reality learning media to be applied in learning in elementary schools, this aims to ensure the purpose of learning science can be conveyed well through learning media innovations in the world of education [15].

Based on this description, the researchers want to conduct a study to determine the effectiveness of the ARLOOPA application on learning in schools. Thus, data and information will be obtained whether the application can improve students' understanding of information to improve critical thinking skills and the ability to ask elementary students. Several problems will be answered through this research. These problems include: 1) Whether the use of Augmented Reality (AR) learning media is suitable for use in the delivery of materials related to the solar system, 2) Whether there are constraints in the use of Augmented Reality (AR) learning media, 3) How effective is the ARLOOPA application as a media of delivery of solar system materials, 4) How to think critically and the ability to ask students when using ARLOOPA applications. The purpose of this research is to obtain data and information about 1) Whether or not there is suitability for using Augmented Reality (AR) learning media to be used in delivering material related to the solar system, 2) Whether or not there are difficulties in using augmented reality learning media, 3) the effectiveness of the ARLOOPA

application as a media for delivering material on the solar system, 4) the ability to think critically and the ability to ask students when using the ARLOOPA application. This research will be very useful for researchers in developing Augmented Reality (AR) learning media assisted by the ARLOOPA application.

2. Methods

As a researcher using research and development methods with a qualitative approach to quasi-experimental research methods (pseudo-experiments) with pure experimental design, namely Pre-test Post-test Control Design. The qualitative approach is research used to examine natural objects where the researcher is a key of instrument research, data collection techniques are combined, data analysis is inductive, and a result of qualitative research results underline meaning rather than generalization [16]. The media developed in the form of 3-dimensional interactive learning media Augmented Reality (AR), assisted by the ARLOOPA application that will be used by students.

The study was conducted by observing students' understanding of solar system materials and conducting survey activities on respondents (students) who were designated as samples. The population in this study was elementary school students. Sampling is done randomly. Then from the results of randomization, found two classes in one school, namely Semboro State Elementary School 04. In class A, 28 students were selected as respondents to the control class. While in class B also selected 28 students as respondents in the experimental class, with a total of 56 students in the study. The method used is mixed methods.

Table 1. Research design using mixed methods

Group	Pre-test	Treatment	Post-test
Control Class N = 28 students	O_1	-	O_2
Experiment Class N = 28 students	O_3	X	O_4

O_1 & O_3 = both groups of classes were tested with a pre-test to find out there that were expected to be at the same level
O_2 = the post-test results of the control class
O_4 = the post-test results of experiment class [17]

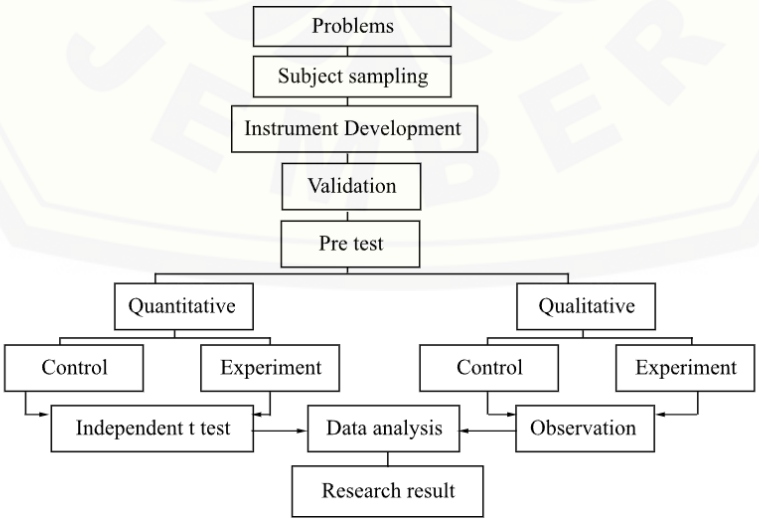


Figure 1. The triangulation model in mixed-method [18]

2.1 Population of Research

The population of this study is third-grader of Semboro State Elementary School 04, Jember Regency. The number of students is 58 students. The control class consisted of 28 students consisting of 14 men and 14 female students. In the experimental class, 28 students consisted of 15 male students and 13 female students. Data were collected from August to December 2021.

2.2 Observation

Observation is the collection of data or information that must be carried out by conducting observation efforts directly to the place to be investigated. Observations are made to identify the problems that exist in a population. Observation activities can be in the form of observations of teacher and student activities during the learning process. Through these observations, it can be known that students of grades IIIA and IIIB are less able to understand the material related to the solar system.

2.3 Test

This test is used to obtain data on the critical thinking skills of grade IIIA students as a control class and class IIIB as an experimental class, either by using ARLOOPA learning media or using lecture methods. These tests are tests, pre-test, and post-test.

2.4 Instrument Data

Provide assignments and observation sheets are used as instruments in this study. The control class and the experimental class were assigned a pre-test, and the post-test consisted of 12 questions. Student computational thought sheets use the Likert scale. Very good (score 5), Good (score 4), Medium (score 3), Fair (score 2), and Less (score 1).

2.5 Task

Humans have been looking at the sky for thousands of years ago. Early observations were recorded related to the change in the position of the planets and the development of ideas related to the solar system. To describe distance in the solar system a convenient to use astronomical units (au), the means distance of the Sun to the Earth Planets. 1 au is $= 1.49597870 \times 10^{11}$ m. Based on observing and trusting. Nowadays, humans also know that objects in the solar system orbit Sun. In addition to the Sun in antiquity, objects moving relative to the stars are Mercury, Venus, Mars, Jupiter, and Saturn. The sun's gravity has an effect on things in the solar system to have movement, as earth's gravity affects the movement of the moon orbiting it. Johannes Kepler was a mathematician in the 1,600s in Germany. He began studying planetary orbits and he was found a planet's orbit is not circular, but Oval or elliptical. Account it further shows that the location of the sun is not at the center of orbit, but a little offset. Kepler also discovered the planet moving at different speeds in their orbits around the sun. To control the motion of the solar system's bodies, that is called gravitationally. With elliptical orbit all of planetary orbits around the Sun.

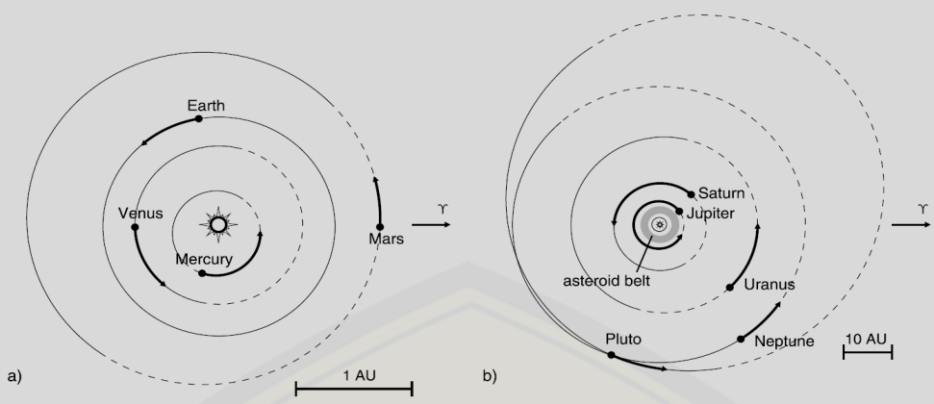


Figure 2. Planetary orbit around the sun

Kepler's Law of planetary motion is a third law to describe the motion of the planets in the solar system. We denote the angle between the radius vector *r* and *e* by *f*. The angle *f* is called the true anomaly. Using the properties of the scalar product, we get:

$$r.e = r\,e\cos f \tag{1}$$

But the product $r \cdot e$ can also be evaluated using the definition of *e*:

$$r.e = \frac{k^2}{\mu} - r \tag{2}$$

Equating the two expressions of $r \cdot e$ we get

$$r = \frac{\frac{k^2}{\mu}}{1+e\,cos\,f} \tag{3}$$

We find that r attains its minimum when $f = 0$, i. *e*. in the direction of the vector *e*. Thus, e indeed points to the direction of the perihelion. Starting with Newton's laws, we have thus managed to prove Kepler's first law: "*The orbit of a planet is an ellipse, one focus of which is in the Sun*". Kepler's First Law of planetary motion describes that all planets move around the sun in elliptical orbits with the sun as one focus of the ellipse. Vector perpendicular to the orbital plane. The magnitude of *k* is

$$k = r^2\,x\,f \tag{4}$$

This is obviously the time derivative of some areas, so let us call it ˙A. In terms of the distance *r* and true anomaly *f*, the surface velocity is

$$A = \frac{1}{2}\,x\,r^2\,x\,f$$

$$A = \tfrac{1}{2}\,x\,k \tag{5}$$

Since *k* is constant, so is the surface. Kepler's Second Law: "*The radius vector of a planet sweeps equal areas in equal amounts of time*". Kepler's Second Law describe that a radius vector joining any planet to the sun sweeps out equal areas in equal lengths of time. Since the Sun until planet distance varies, the orbital velocity must also vary. From Kepler's second law it follows that a planet must move fastest when it is closest to the Sun (near perihelion). Motion is slowest when the planet is farthest from the Sun at aphelion.

$$dA = \frac{1}{2}k\,dr$$

$$\int_{orbital\ ellips} dA = \frac{1}{2}k\int_0^P dt$$

$$\pi ab = \pi a^2\sqrt{1-e^2}$$

$$\pi a^2\sqrt{1-e^2} = \frac{1}{2}kP$$

$$k = \sqrt{G(m_1+m_2)a\,(1-e^2)}$$

$$P^2 = \frac{4\pi^2}{G(m_1+m_2)}\, a^3 \tag{6}$$

Kepler's Third Law is derived from newton's law "*The ratio of the cubes of the semimajor axes of the orbits of two planets is equal to the ratio of the squares of their orbital periods*." Kepler's Third La describe that the squares of the sidereal periods (P) of the planets are directly proportional to the cubes of their means distance (d) from the sun. Equation Kepler's law can be described below, Starting with Newton's laws $F = m.a.$ (F) is a force (m) is a mass, and (a) is a acceleration

$$F_{g=} \frac{GMm}{r^2}$$

$$F = m.a \qquad a = \frac{v^2}{r}$$

$$\frac{GMm}{r^2} = m.\frac{v^2}{r}$$

$$\frac{GM\cancel{m}}{r^2} = \cancel{m}.\frac{v^2}{r} \qquad v = \omega r$$

$$G\frac{M}{r} = v^2$$

$$\omega r^2 = G\frac{M}{r}$$

$$\omega^2 = G\frac{M}{r^3}$$

$$\left(\frac{x\pi}{T}\right)^2 = G\frac{M}{r^3}$$

$$T^2 = \frac{(x\pi)^2}{GM}\, r^3$$

$$T^2 \sim r^3 \tag{7}$$

The solar system is an arrangement. The other things consist of the Sun as a centre of the solar system, planets, comets, meteoroids, and the asteroid around the sun.

Table 2. Average orbital velocity of planets in the solar system

Planet	Average Orbital Speed (km/s)
Mercury	48
Venus	35
Earth	30
Mars	24
Jupiter	13
Saturn	9.7
Uranus	6.8
Neptune	5.4

Table 2 shows that the planet is close to the Sun, moving faster than the planet far from the sun. The field of planetary circulation in the circle of the sun is called the field, and the earth's inner plane circling the Sun is called the ecliptic field. Order the Solar System consists of Sun, Inner Planet, Outer Planets, Comets, Meteoroids, and Asteroids. The sun has a definition as a star in the form of a ball of gas. Heat and luminosity that is the center of the solar system. The energy and heat of the sun make life on Earth because without that would be no life on Earth.

A planet has a definition of a celestial body that cannot emit its own light. His light of a planet only reflects the light receives from the stars. The inner planet is also called the terrestrial planet. Terrestrial planets are a planet close to the Sun, small, has few satellites or not at all, rocky, terrestrial,

partly consisting of fire-resistant minerals, such as silicates that form its crust and mantle, and metals such as iron and nickel form the point. In addition, the inner planet also has an atmosphere large enough to produce weather, craters, and tectonic surface features like valleys of cracks and volcanoes. The inner planets consist of Mercury, Venus, Earth, and Mars.

Figure 3. Inner planets (Mercury, Venus, Earth, and Mars)

The outer planet is also called the planet Jovian. Jovian planet is a planet it is far from the Sun, it has many satellites, and some it's made up of light materials. Like hydrogen, helium, methane, and ammonia. The inner and outer planets are separated by the asteroid belt. The outer planets are made up of Jupiter, Saturn, Uranus, and Neptune [19].

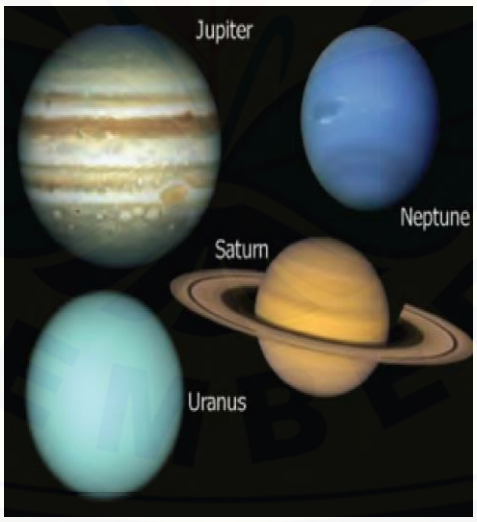


Figure 4. Outer planets

3. Results and Discussion

There are several results found in the research conducted in this elementary school, namely Elementary School Semboro 04. After conducting such research, it is known that the use of Augmented Reality (AR) learning media is suitable for use in the teaching and learning process, especially in the delivery of materials related to the solar system. This is evidenced by the increasing level of understanding of students regarding the material of the solar system. In addition, the use of arloopa-assisted augmented reality (AR) learning media can increase students' curiosity to increase

students' critical thinking skills by being shown their activeness in asking questions in the material. This provides evidence that arloopa applications are effectively used in learning activities.

Students' pre-test and post-test value data in the application of Augmented Reality learning media were analyzed using independent sample t-tests on SPSS. The results of the comparison of pre-test values of control classes and normally distributed experiments show that the class is homogeneous. Homogeneity tests are used to test whether a data model is homogeneous or not. If the data is homogeneous, then the research data can be done at a later stage, while if the data is not homogeneous, it is necessary to make methodological corrections. The next step is to perform the analysis using statistical software (SPSS). In Table 3, it can be seen that the results of students' pre-test scores show significant grades in both control classes and experimental classes.

Table 3. Pre-test and average grades of control classes and experiments

Group Statistic					
Score	**Class**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
	Control	28	46.6071	12.32684	2.32955
	Experiment	28	48.5714	11.20988	2.11847

From the data, it can be known that the value of significance in this study is 39.5% or 0.395. Significant value provides the key information needed to be analyzed and to conclude from the data results. The average pre-test value obtained for the control class was 46.60 with a standard deviation of 12.32 while the average pre-test value for the experimental class was 48.57 with a standard deviation of 11.20. From these data, we can see that there are similar values in the average pre-test value and there is no significance between the control class and the experiment on standard deviation.

Table 4. NS comparison of pre-test results and average grades of control classes and experimental classes

Independent Samples Test										
		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig (2-tailed)**	**Means Difference**	**Std, Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
Score	**Equal variances assumed**	.734	.395	-.624	54	.535	-1.96429	3.14877	-8.27718	4.34861
	Equal variances not assumed			.000	53.520	.535	-1.96429	3.14877	-8.27848	4.34991

From Table 4, it can be found that the results of pre-test in the control class and experiments are analyzed using SPSS software. Based on the results of the t-test shows a significance value (2-tailed) of 1,000 with a significance value criteria of 0.05. Since the criteria for homogeneity, the value of sig (2-tailed) is greater than the significant value, it can be concluded that the data between the control class and the experiment is homogeneous.

The collection of post-test results of both classes was also analyzed using SPSS software. Comparisons of post-test results of control classes and experimental classes can be seen in Table 5. The average value of the control class was 72.3214 with a standard deviation of 10.45291 while the average value of the experimental class was 90.1429 with a standard deviation of 6.89452. Data in Table 6, the t value on Levene's Test score of 0.009 with a p-value of < 0.005 indicates that there is a significant value between the two classes.

Table 5. The table displays post-test results and the average grades of control classes and experimental classes

Group Statistic					
Score	**Class**	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
	Control	28	72.3214	10.45291	1.97541
	Experiment	28	90.1429	6.89451	1.30294

Table 6. Comparison of post-test results and average grades of control classes and experimental classes

Independent Samples Test									
		Levene's Test for Equality of Variances		**t-test for Equality of Means**					
		F	**Sig.**	**t**	**df**	**Sig (2-tailed)**	**Means Difference**	**Std, Error Difference**	**95% Confidence Interval of the Difference**
									Lower / **Upper**
Score	**Equal variances assumed**	7.412	.009	-7.531	54	.000	-17.82143	2.36641	-22.56580 / -13.07705
	Equal variances not assumed			-7.531	46.754	.000	-17.82143	2.36641	-22.58270 / 13.06016

Data in Table 5 and 6 also presents an independent sample t-test result that shows a significant value of 0.000 (p 0.05). From the results of data analysis using SPSS, it can be concluded that the two classes have differences in the results of critical thinking ability tests after the treatment of the application of Augmented Reality learning media in the learning process in solar system materials. Student activity in the experimental class was observed by three observers with a scale of student activity Likert divided into five categories, namely excellent (score 5), good (score 4), moderate (score 3), enough (score 2), and bad (score 1). The results of the student's activity in the control class are described in Figure 3, and the results of the experimental class are shown in Figure 5.

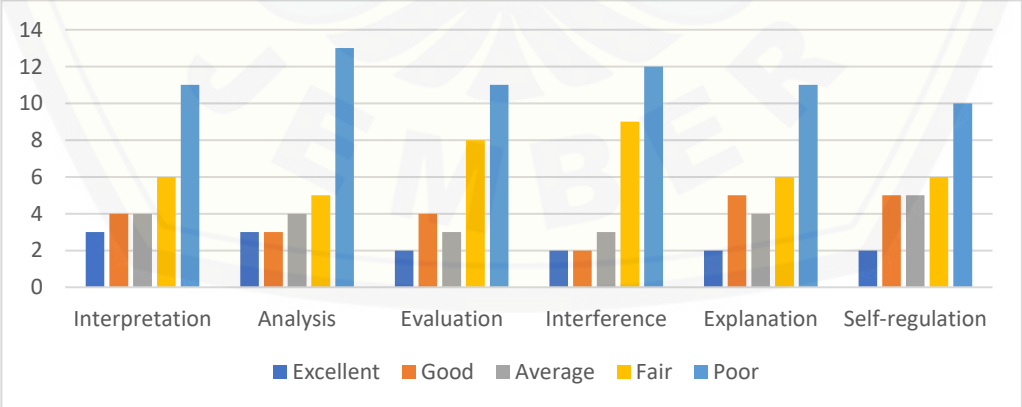


Figure 5. Students' activity results about critical thinking in control classes

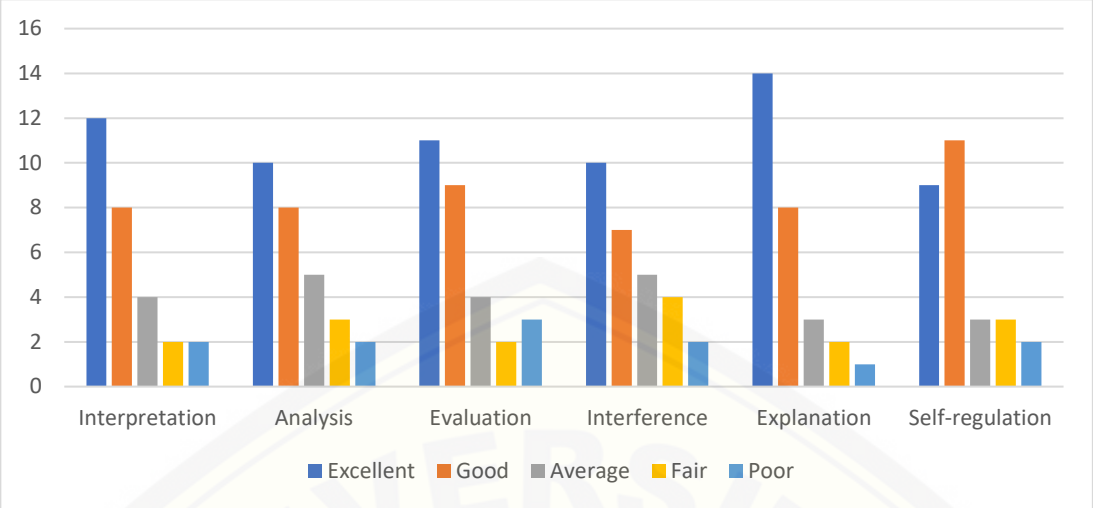


Figure 6. Students' activity results about critical thinking in experimental classes

Based on the data in Figure 5 and Figure 6, using the predefined Likert scale, we can calculate the average score of student activity for each class. We make it per indicator of critical thinking to see which parts students master and which parts are less mastered.

A Technique for students to think critically and creatively in responding to problems using the information provided with HOT. In addition, students should be required to study acting in the learning process. Hot skills that students have can be seen in their learning results. The average grade of student learning outcomes is used to find out the improvement in learning outcomes with using augmented reality learning media [18].

A variation of Virtual Environments (VE), or Virtual Reality, is a definition of Augmented Reality (AR). In industrial technologies, VE completely immerses a user inside a synthetic environment. In this learning media that a user cannot see the real world around him. In Augmented Reality, the user can see the real world from a virtual object, with virtual objects superimposed upon or composited with the real world. Augmented Reality (AR) supplements reality with virtual objects superimposed upon or composited with the real world. Therefore, AR supplements reality rather than completely replacing it. Ideally, it would appear to the user that the virtual and real objects coexisted in the same space [20].

Augmented Reality (AR) is a combination of the virtual world and the real world created by a computer [3]. In general, augmented reality is a combination of virtual objects with real objects to be able to interact in real time in the form of a 3D display [14]. The advantages of augmented reality are as follows: 1) More interactive, 2) Effective in use, 3) Can be widely implemented in various media, 4) Simple object modelling, as it displays only a few objects, 5) Creation that does not cost too much, 6) Easy to operate [21].

Augmented Reality (AR) allows users to see the real world and the virtual world at the same time. One of the current AR development companies is ARLOOPA inc. The company creates an application called ARLOOPA that can be used on both Android and iOS software [22]. This application can make it easier for students to develop skills and make observations and also can increase student curiosity because not only with verbalism but also raised visually so that students can easily understand.

Data collection activities were carried out between the first week to the fourth week of October 2021. The respondents in this study consisted of students spread over a location, namely, Elementary School Semboro 04. The learning media used is Augmented Reality (AR), with applications used in

the form of ARLOOPA, which is an intuitive platform designed to be able to feel augmented reality media easily for the delivery of solar system materials. The following is a display of material for the solar system in the ARLOOPA application.

In the implementation of learning, researchers use quasi-experimental research methods (pseudo-experiments). Quasi-experimental research is a study that uses all subjects in the study group (intact group) to be treated (treatment) instead of using randomly taken subjects [22]. Problems related to the validity of the experiment, both internal and external validity, may arise due to the absence of randomization in determining the subject of the study. To avoid this problem, researchers used a purely experimental design, the Pre-test-Post-test Control Design. The learning steps taken in this study are shown in Table 7.

Table 7. Learning steps used

No	Learning Steps
1.	Students take pre-test tests to find out the student's understanding, both in control classes and experimental classes
2.	After the pre-test, students listen to the teacher's explanation of solar system materials by lecture method using PowerPoint (PPT) media in control classes and use ARLOOPA learning media in experimental classes.
3.	Students make observations using the ARLOOPA learning media in experimental classes.
4.	Students conduct a written post-test to find out students' learning outcomes and students' critical thinking communication skills.

In learning, critical thinking skills are an ability that must be owned and mastered by students because it aims so that every student can do decision-making and problem-solving (conclusions) from various aspects and points of view. In addition, the ability to think critically is also an important intellectual capital owned by students when dealing with problems in everyday life. The study evaluated students' critical thinking skills using the ARLOOPA learning media.

Based on the t-test, it can be known that in the pre-test values of the two classes there is no significant or homogeneous difference. After being given the treatment of augmented reality learning media in solar system materials, the post-test values of both classes experienced a significant difference with a Sig.2-Tailed value of 0.000. This suggests that the ability to think critically of experimental classes is better than that of control classes. Based on six indicators of critical thinking, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation, an assessment is carried out to look at student activities. In the interpretation indicator, 12 children received a maximum score of 5 in an experimental class. From the data, it is seen that students in the experimental class can already choose the required information well. In the analysis indicator, 10 children get a maximum score of 5.

From this, students can say that students in the experimental class have been able to analyze pluto and dwarf planets, although there are still 3 students who experience difficulties and score low. Similar to the inference indicator, the number of winners of a maximum score of 5 experimental class activities is still higher than the control class, which is as many as 10. This value shows that students in the experimental class have been able to connect between the outer and inner planets. In the explanation indicator, 14 children scored a maximum of 5 in experimental classes. Then on the self-regulation indicator, experimental class students tended to have higher scores than control classes with many winners of a maximum score of 5 as many as 9 children in the experimental class. While on the self-regulation indicator, the control class has a maximum value of 5 only as many as 2 children.

A kind of thinking skill oriented to Critical thinking and creative thinking related to Higher order thinking skills is Critical Thinking [23]. Critical thinking skills enable students to process information

logically and prepare for self-study [14]. In addition, Supeno [24] revealed that critical thinking can train students to think logically and it is not easy to receive information directly. Students who have critical thinking skills can determine the information that is important, relevant, and useful. Explains that critical thinking is a purposeful and clear process. That skill used in mental activities such as making decisions, solving problems, analyzing assumptions, persuading, and conducting scientific research [25]. Indicators of critical thinking skills put forward by Facione [26] are interpretation, analysis, evaluation, inference, explanation, and self-regulation.

Table 8. Indicators of Critical Thinking Ability

Critical thinking indicators	Definition	Sub-indicator
Interpretation	Ability to understand and interpret the meaning of a problem	a. Group b. Make meaning c. Clear meaning
Analysis	Ability to investigate or identify links between statements, data facts, and concepts and be able to infer them	a. Testing ideas b. Recognize arguments c. Recognize the reason d. Recognize the question
Evaluation	The ability to assess the credibility of a statement or representation and access relationships of statements, data, facts, concepts, or other forms	a. Assess the quality of questions b. Assess the quality of arguments made with inductive and deductive considerations c. Create and determine the results of considerations
Inference	Ability to obtain and identify concepts or elements in drawing conclusions	a. Stating evidence b. Draw conclusions
Explanation	Ability to provide arguments and establish them logically based on data or facts obtained	a. State the results b. Supports procedures c. Presenting arguments
Self-Regulation	The ability to monitor itself in applying, analyzing, and evaluating the results of previous thinking in solving a problem	a. Self-monitoring b. Self-improvement

4. Conclusion

Based on the four problem formulations that researchers want to answer from this study and the analysis of research data, the following conclusions were found: 1) the use of Augmented Reality (AR) learning media is suitable for use in the teaching and learning process, especially in the delivery of material related to the solar system, 2) some of the obstacles in using augmented reality (AR) learning media, namely the lack of student understanding regarding Augmented Reality (AR), so that students find difficulties in using it, 3) the ARLOOPA application is effectively used as a media for delivering material, especially the solar system, because students can see the material actually, 4) with the ARLOOPA application, it can increase students' curiosity to improve students' critical thinking skills by showing their activeness in asking questions in the material.

Acknowledgment

We would like to thank the Ministry of Education and Culture and Research and Technology for funding our research in the Innovation Talent Program in 2021 and the ESSE (Earth Space and Science Education) Research Group at the Ministry of Science Education, Faculty of Training and Teacher Education, Jember University, Indonesia.

References

[1] Kurniawan D T, Tresnawati N, and Maryanti S 2018 *J. Ilm. Ilmu Pendidik. Dasar* **1** 62.
[2] Siyoto S and Sodik M A 2015 *Dasar Metodologi Penelitian* (Yogyakarta: Media Publishing Literacy).
[3] Panjaitan S 2017 *PRIMARY J. Pendidik. Guru Sekol. Dasar* **6** 251.
[4] Prasanti D 2018 *J. Lontar* **6** 15.
[5] Amarila R S, Habibah N A, and Widiyatmoko A 2014 *Unnes Sci. Educ. J.* **3** 563.
[6] Muakhirin B 2014 *J. Ilm. Guru* **18** 51.
[7] Malawi I and Kadarwati A 2015 *Pembelajaran Tematik (Konsep dan Aplikasi)* (Magetan: CV. AE Media Graphics).
[8] Sari I M, Ahmad S F, and Amsor 2019 *J. Teach. Learn. Phys.* **4** 2.
[9] Rahayu P, Mulyani S, and Miswadi S S 2012 *J. Pendidik. IPA Indones.* **1** 63.
[10] Kusuma S D Y 2018 *J. Inform. Univ. Pamulang* **3** 33.
[11] Muharram R M 2019 *J. Publ. Inform. Eng. Res.* **3** 79.
[12] Asmiatun S, Wakhidah N, and Putri A N 2020 *Penerapan teknologi Augmented reality dan GPS tracking untuk deteksi jalan rusak* (Yogyakarta: Depublish).
[13] Andriyani, Buliali J L, and Pramudya Y 2020 *Pembelajaran Matematika-Sains Bagi Anak Tuna Rungu* (Yogyakarta: CV Bintang Surya Madani).
[14] Magdalene I 2021 *Co-Writing about SD Learning Media* (Sukabumi: CV Trace).
[15] Ningrum K D, Utomo E, Marini A, and Setiawan B 2022 *J. Basicedu* **6** 1297.
[16] Paramitha G P, Sriyanti I, Ariska M, and Marlina L 2021 *J. Inov. Pembelajaran Fis.* **8** 52.
[17] Saputra O 2018 *J. Filsafat Indones.* **1** 71.
[18] Ridlo Z R, Dafik, Prihandini R M, Nugroho C I W, and Alfarisi R 2018 *J. Phys. Conf. Ser.* **1211** 012049.
[19] Widodo W, Rachmadiarti F, and Hidayati S N 2016 *Ilmu Pengetahuan Alam SMP/MTs Kelas VII: buku guru* (Jakarta: Ministry of Education and Culture).
[20] Azuma R T 1997 *Teleoperators Virtual Environ.* **6** 355.
[21] Mustaqim I and Nanang K 2017 *J. Edukasi Elektro* **1** 36.
[22] Sari N E, Oktapia R, Marliana I, and Hardiyanto A 2019 *Pros. SEMNASFIP* (Tangerang: Universitas Muhammadiyah Jakarta).
[23] Ridlo Z R, Dafik, and Nugroho C I W 2019 *J. Phys. Conf. Ser.* **1563** 012034.
[24] Supeno S, Bektiarno S, and Munawaroh A 2018 *Pros. Semin. Nas. Fis.* (Surabaya: Universitas Negeri Surabaya).
[25] Yuni R, Murhayati S, and Murniati A 2021 *Kutubkhanah J. Penelit. Sos. Keagamaan* **21** 65.
[26] Facione P A 2015 *Critical Thinking: What it is and Why it Counts* (California: Insight Assessment).