# Enhancing Abstract Reasoning in Science Learning through Interactive Multimedia Based on Augmented Reality in Elementary Schools

*by* Ahmad Syawaludin

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ABSTRACT

The ability to reason rationally of elementary school students is terminated on concrete situations so as enhancing abstract reasoning becomes a prompt for students be more critical in solving science problems. The objective of the study was to enhance abstract reasoning in science learning using interactive multimedia based on augmented reality (AR) in the fifth grade students. This study used a Classroom Action Research conducted in two cycles. Each cycle consists of the Plan, Act & Observe, and Reflect stages. Data collection techniques used tests and observations involving 28 students. The credibility of the research data used technical triangulation and source triangulation. The collected data was analyzed descriptively. The results of the study on process aspects showed that the use of interactive multimedia based on augmented reality gave positive changes to the learning process of earth and rock structure material science in the fifth grade of elementary school. The enthusiasm of students in the learning process thus strengthens student-teacher interaction. Student enjoy the learning process and science learning more contextual with students actively, independently and collaboratively involved. The interactive multimedia based on augmented reality facilitates students to reason by exploring more realistic visual object about science material so that it eases student understanding science concept, associating inter-concepts and implementing on information analysis and science problem solving. The success of the product showed that Students' abstract reasoning in science learning enhanced by 24.20% (in the first cycle) and 23.08% (in the second cycle). The results of this study conclude that the use of interactive multimedia based on augmented reality enhances abstract reasoning in science learning in the fifth grade elementary school students.

Keywords: abstract reasoning, augmented reality, elementary school, interactive multimedia, science learning



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## INTRODUCTION

Science is a knowledge that deals with natural phenomena not only a collection of facts and concepts , but also about how to work, how to think, and how to solve problems. Science learning is a medium for students to learn about themselves and their surroundings, and the prospects for further development in applying them in their daily lifes (Djojosoediro, 2010). The earth and the universe is one of the materials for the study of science class for the fifth graders, including earth structure and rock formation . In this study, students are expected to mastery the concepts of earth structure, rock formation, and analyze various types of rocks.

The science study of earth is a form of real objects, but due to their large size and can not be observed inside the earth (earth structure) directly as well as phenomena occurring in it becoming an abstract that the study is not easily understood by students of fifth grade. The majority of children in elementary school are in the operational stage of Jean Piaget's stages of cognitive development (Piaget et al., 1964). At this stage, students are mature enough to use logical or operating thinking, but only for existing physical objects (Ibda, 2015). Students are able to classify, order the construction of the idea of numbers, the fundamental operations of elementary logic of classes and relations, elementary mathematics, and elementary physics (Piaget et al., 1964). Understanding children's ways of thinking and problem solving, educators can elaborate more effective ways to help students acquire and apply their knowledge (Brouse & Chow, 2009).

Learning outcomes of the fifth grade elementary school students according to the 2013 Curriculum content standards in Indonesia at Level 3 or Relational categories (BNSP, 2013). At this level, students address a point, making sense in light of their contribution to the topic as whole (Biggs & Tang, 2007). A deep understanding of the concepts of earth and rock structures is a basic requirement for students to achieve their learning outcomes. Students process basic requirements as a form of abstract reasoning (Markovits et al., 2018). In particular, ages 11-14 years old (grade fifth of elementary school students) as a transition to their cognitive development from a stage to operational to formal operational concrete (Susac et al., 2014). Considering to this problem, the teacher needs to facilitate students to develop logical reasoning and the ability to reason abstractly to achieve learning achievements in learning earth structures and rocks .

Researches on young children's reasoning shows the complex correlations of knowledge, theories, and evidence in their decision-making and problem solving (Kim, 2016). Reasoning is part of an abstract reasoning process. Abstract reasoning refers to the ability of information analysis, detecting patterns and relations, and problem solving on complex levels (Datta & Roy, 2015). Abstract reasoning is an outcome of brain maturation (Piaget, 1952). This ability acts to think clearly, analyze information, solve problems and make rational decisions are important (Psychometric Canada, 2019). Ability to reason abstractly in science learning at elementary school strengthens scientific reasoning in achieving student learning success including science learning that requires data analysis skills , and solving problems by identifying the correlations.

The results of abstract reasoning pretest in earth and rock structures material in the fifth grade students in Public Schools of Surakarta showed unsatisfactory results. The mean of interpretation ability was 51.79, the analytical ability was 46.43, and the problem solving ability was 41.96, so the overall mean aspect of abstract reasoning was 46.73. These results indicated that the students' low ability to reasoning abstractly about the structure of the earth and rock formation were still low. Fifth-grade students are in the transition from concrete thinking to abstract thinking, so efforts to improve abstract reasoning are needed to help students in further processes such as analysis and problem-solving.

The limitations of learning aids and earth structure learning media and the unavailability of science labs at elementary school are classic reasons that are less relevant for the digital era as nowadays. Learning activities in the digital era are conducted inclass or outclass of computer-based technology is a learning component that is easily accessible and can be used to find the source of interactive learning (Smaldino et al., 2019). Utilization of Information and Technology (IT) facilities as smartphone could be an alternative to overcome the limitations of space and the media, and also stimulating abstract reasoning of students in earth structures material. Smartphone has the potential to enhance efficiency and effectiveness in teaching and learning, in addition to enhance learning outcomes and work skills (Morris & Lambe, 2017).

The development of science and technology leads to the world of education developing innovative and effective learning media. Features of smartphone with sophisticated operating systems capable of providing users access to a variety of attractive multimedia content and applications that fulfill daily needs, including its use in interactive media-based Augmented Reality (AR) to study the earth structure in the fifth grade of elementary school. AR Technology is the latest technology for teaching, learning and creative research (Tekedere & Göke, 2016). AR as systems that have three characteristics: (1) Real and virtual combines; (2) Interactive in real time; (3) Registered in 3-D (Information Resources Management Association, 2018). AR technology allows virtual objects to be produced by computers to be placed on physical objects in real time (Ozdemir et al., 2018). Through AR technology, students can study the objects of the earth's structure and phenomena that occur visually to form various types of rocks actively:

AR enhances the perception of the user, helps them to understand better (Iftene & Trandabăt, 2018).

Related researchers have applied AR technology as multimedia in various types of teaching topics and educational levels . The use of AR in middle-level students and universities as an interactive media on human anatomy, geomorphology, and astronomy learning (Jamali et al., 2015; Kurniawan et al., 2018; Turan et al., 2018; Yen et al., 2013). The researchers at elementary school have applied AR media as learning media ecology system, increase motivation and critical thinking skills (Chang & Hwang, 2018; Tarng et al., 2015). If the researchers focused on motivation, mastery of concepts, and the basis of critical thinking skills, this study focused on enhancing the abstract reasoning of the fifth grade elementary school students whose role is important in classifying, identifying relationships, analyzing problems, and eliminating problems. The other novelty is the material learned in this study is on material content, that was structure of the earth.

The material structure of the earth will be easily understood by fifth-grade students if delivered using learning media that are in accordance with the learning characteristics of students. Elementary fifth graders are able to think operationally and logical reasoning replaces intuitive reasoning but is still concrete. By paying attention to student learning characteristics, students need to be actively involved in learning through the use of real media, visual activity, discussion, and cooperation. The use of Augmented Reality media can combine 3-dimensional (3D) objects as a visualization of the earth structure model as if it were in a real environment. Students will actively find a picture of the structure of the earth and rocks through their smartphone camera by scanning markers on teaching materials. Visualization of the concept of earth structure that is still abstract for fifth-grade students can help students to identify traits, understand inter-concept relationships so that they can help in the analysis and problem-solving activities as manifestations of abstract thinking skills. In addition, if viewed in terms of attractive appearance and unique use of media can increase students' interest in learning about the structure of the earth. Therefore, the use of multimedia augmented reality is seen in accordance with the characteristics of fifth-grade elementary school students.

Based on the problems regarding the low ability of fifth grade students in abstract reasoning, this study aims to enhance the ability of abstract reasoning of fifth grade students in learning earth structure material science through the use of AR-based multimedia.

## METHODS

This study uses a qualitative research approach with a type of Classroom Action Research. Many teachers practice personal reflection on teaching, others conduct formal empirical studies on teaching and learning. Classroom Action Research is more systematic than personal reflection (Stringer, 2008). Classroom Action Research used in this study to find out what works best in the classroom to improve student abstract reasoning in earth structure learning.

The study was conducted in the form of cycles. Each cycle has three stages, consisting of a plan, act and observe, and reflect (Eriksson & Kovalainen, 2015). The research identified with "Plan" by compiling learning devices using AR media, planning data collection, students' worksheet compiling, test compiling, observation sheets for learning activities and teacher performance. "Act and Observe" is an implementation of an action plan. Simultaneously, at this stage observation of student learning activities, and the teacher performance determines the quality of the learning process of science in the classroom. Each cycle is evaluated for learning achievement and abstract reasoning using a test. Stage "reflect" focuses on a period of continuous reasoning through discussion activities with teacher about the meaning of all observational data. This stage will determine the new strategy in the preparation of actions in the next cycle or decide to finish the research action. The determination of CAR will stop or continue referred to the performance indicators of action success. The formulation of performance in determining the success of the action is measured by the acquisition of abstract reasoning test scores of earth structure and rock material with a percentage of classical completeness of 75% on minimum completeness criteria of 55.

The subjects were fifth grade students of primary school in Surakarta as much 28 students. Data collection research used tests and observations. Student abstract reasoning in learning earth structure through three aspects consisted of the ability to identify inter-conceptual relationships, information analysis, and problem-solving abilities about the structure of the earth, convection, tectonic phenomena, volcanics, and the formation of various types of rocks. Observation was carried out during the implementation of actions in the classroom, in the learning process using interactive multimedia based on augmented reality.

The technique used to identify the validity of this research data is the triangulation technique. Triangulation is checking data from various sources in various ways and at various times (Sugiyono, 2015). This study used data validity testing techniques in the form of source triangulation and technique triangulation. This study used data validity testing techniques in the form of source triangulation and technique triangulation. The collected data was analyzed descriptively which described the learning of earth structure using interactive multimedia based on augmented reality which led to an improvement in the learning process and an increase in abstract thinking skills of fifth grade students in elementary school. The data analysis phase identifies after the data is collected. All collected

research data were selected and selected (data reduction) on what should be presented and used (data display) (Miles & Huberman, 1994). The data presented becomes valid to be used as a basis for drawing conclusions. Conclusion drawing focuses on enhancing the quality of learning processes, and student abstract reasoning in science learning.

## RESULTS AND DISCUSSION

### The Science Learning Process in Elementary School by Using Interactive Multimedia Based on Augmented Reality

This research was conducted in three stages, consisting of pre-cycle, first cycle, and second cycle. The pre-cycle stage is a preliminary study aimed to identify problems in learning the structure of the earth in the fifth grade of elementary school. Observation of the science learning process in the pre-cycle stage showed that learning was not student-centered (Student Centered Learning). Learning methods only emphasized the concept of memorization. Students had not been trained in problem solving. In addition, students was bored, so some of them played pencil, drawing, or folding paper that had nothing to do with the topic being studied. Observation of student activities was observed in 5 aspects, consisting of students' readiness to learn (aspect 1); enthusiasm of students in learning activities (aspect 2); student activities in discussion activities (aspect 3); student activities in solving problems (aspect 4); student participation in learning closing activities (aspect 5). The results of observations of student activities in the pre cycle are presented in table 1.

**Table 1.** Results of Student Activity Observation

| No | Rated Aspect | Score | Category |
|---|---|---|---|
| 1 | Students' readiness to learn | 2.33 | Fair |
| 2 | Enthusiasm of students in learning activities | 1.33 | Poor |
| 3 | Student activities in discussion activities | 1.67 | Poor |
| 4 | Student activities in solving problems | 1.33 | Poor |
| 5 | Student participation in learning closing activities | 2.00 | Fair |
| | Mean | 1.73 | Poor |

Table 1 is identified that the readiness of students in learning and closing activities is in a fairly good category, while other aspects in the category are not sufficient. Students had not been enthusiastic in learning activities, active in discussion activities and active in solving problems. Obtaining an average score of observation of student activities was 1.73. This score shows that student learning activities in learning the structure of the earth is classified as poor. The teacher used many verbal learning methods and had not used interesting media while being able to present visual objects that aid students' abstract reasoning in studying the material structure of the earth. This condition caused learning of the structure of the earth was not attractive and had an impact on student learning outcomes that were less satisfying.

The action in the first cycle consisted of two meetings with time allotment of 70 minutes each. The first stage of the cycle began with planning everything needed during the action, as: determining learning achievement; compiling learning devices; preparing augmented reality (AR) media; preparing observation sheets for student learning activities, and examination sheets. AR-based interactive multimedia in learning earth structure used a scientific approach to the 2013 curriculum in elementary school. The process aims to acquire a scientific systematic knowledge that gives priority to more active and participatory methods (Baars, 2011; Hernawati et al., 2018; Simonneaux, 2014).

Implementation of actions in the first cycle began with the formation of groups consisting of 4-5 students. Group division was heterogeneous. The teacher had prepared a smartphone that already has AR-based interactive multimedia. The teacher introduced AR media and explained how to use it in learning activities on the structure of the earth. Each group got AR media and alternately students used it for tracing every layer of the earth, the structure of the earth, volcanic processes, tectonics, rock formation, and observing various types of rocks. This led to the role of AR that could be used as a learning resource for students. Related to previous studies reveals the advantages of AR that students can comfortably use technology to access learning resources for independent learning (Garrett et al., 2015). The information obtained by students through multimedia became data for analysis and problem solving that the teacher had prepared through a worksheet. Students seemed enthusiastic in using the media and active in discussion activities.

The activity of observing student activities was carried out during learning activities , including to determine the quality of learning using AR -based multimedia . The results of observations of student activities in learning the structure of the earth in the first cycle are presented in table 2 below.

**Table 2.** Activities of Students in the First Cycle

| No | Rated Aspect | Score | | Mean | Category |
|---|---|---|---|---|---|
| | | Learning 1 | Learning 2 | | |
| 1 | Students' readiness to learn | 2.67 | 3.00 | 3.00 | Good |
| 2 | Enthusiasm of students in learning activities | 2.00 | 2.67 | 2.34 | Fair |
| 3 | Student activities in discussion activities | 1.67 | 2,33 | 2.00 | Fair |
| 4 | Student activities in solving problems | 1.67 | 2.00 | 1.83 | Fair |
| 5 | Student participation in learning closing activities | 2.33 | 2.67 | 2.50 | Good |
| | **Mean** | **2.07** | **2.53** | **2.33** | **Fair** |

The results of the observations in table 2 showed that the activity of students in learning activities in the first cycle has a fairly good category. The enthusiasm of students in learning and student activities in discussions has enhanced than previous learning the structure of the earth using AR-based interactive multimedia. However, aspects of student activity in problem solving still have the lowest score compared to other aspects. Student interest in new AR-based media makes students tell each other what objects they see, discuss 3 interactive learning situations. The results of the observation of the quality of the learning process in the first cycle are presented in Table 3.

**Table 3.** The Quality of Learning Process in the First Cycle

| No | Rated Aspect | Score | | Mean | Category |
|---|---|---|---|---|---|
| | | Learning 1 | Learning 2 | | |
| 1 | The Consistency of Learning Activities with the Curriculum | 4 | 4 | 4.00 | Very good |
| 2 | Implementation by educators | 2 | 3 | 2.50 | Fair |
| 3 | Implementation by students | 2 | 3 | 2.50 | Fair |
| 4 | Student learning motivation | 3 | 4 | 3.50 | Good |
| 5 | Student activeness in learning activities | 3 | 3 | 3.00 | Good |
| 6 | Teacher-student interaction | 2 | 3 | 2.50 | Fair |
| 7 | The ability of educators to teach | 3 | 3 | 3.00 | Good |
| | Mean | 2.71 | 3.29 | 3.00 | Good |
| | Percentage (%) | 67.86 | 82.14 | 75.00 | |

Based on the observation results the quality of the learning process in table 3 showed that the quality of the learning process has enhanced from meeting I to meeting II. Earth structure learning in cycle 1 has fulfilled the Consistency of learning activities with the curriculum aspects. In addition, Student learning motivation, Student activeness in learning activities, and the ability of to teach educators have good categories. Aspects that need to be enhanced include aspects of implementation by educators, aspects of implementation by students, and aspects of interaction between students and teachers. Teachers still have problems in controlling students when they teach science using AR media at the first time. The excessive enthusiasm of the students made the class condition quite noisy because students actively scanned into various AR markers to see visual objects following their curiosity without regard to the instructions on the worksheet.

The stages of implementation of actions in the second cycle have procedures similar to the first cycle. The second cycle identified with activities to prepare an action plan with improvement (the results of reflection activities in the previous cycle). This action was carried out in accordance with the second cycle planning procedure. There are various types of rocks added to interactive multimedia to add to the students' references in getting to know the types of rocks in Indonesia. At the beginning of learning, the teacher explained the procedure for using interactive multimedia AR to support analysis and solve problems that the teacher had prepared through a worksheet. The use of AR media presented more tangible objects so that it could be a source for students to know the concept of earth structure (which cannot be seen directly, and phenomena about earth. Observation activities of student activities were carried out during the second cycle of learning is presented in Table 4.

**Table 4 .** Student Activities in the Second Cycle

| No | Rated Aspect | Score | | Mean | Category |
|---|---|---|---|---|---|
| | | Learning 1 | Learning 2 | | |
| 1 | Students' readiness to learn | 3,33 | 3,67 | 3,50 | Very good |
| 2 | Enthusiasm of students in learning activities | 3,00 | 3,33 | 3,17 | Good |
| 3 | Student activities in discussion activities | 2,50 | 3,33 | 2.92 | Good |
| 4 | Student activities in solving problems | 2.33 | 3,00 | 2.67 | Good |
| 5 | Student participation in learning closing activities | 3,00 | 3.00 | 3,00 | Good |
| | **Mean** | **2.83** | **3.27** | **3.05** | **Good** |

The results of the observations in table 4 show that the activities of students in learning activities in the second cycle has a good category , with an enhancement in scores in meeting 1 to meeting 2. When compared to the previous cycle, in the second cycle there was an enhancement in student activity in all aspects. Learning the structure of the earth by using AR-based interactive multimedia in class V increases students' enthusiasm in the learning process so that it strengthens student-teacher interaction. In addition, students are seen as active in class discussion activities to solve problems collectively.

Meanwhile, observing the quality of the learning process in the second cycle is based on the mean score in the first and second learning. Observation data about the quality of the learning process in the second cycle are presented in table 5. As seen in table 5, there are six aspects of the category very good, and one aspect has a good category. The use of AR-based interactive multimedia in learning earth structure can be implemented by teachers and fifth grade students with the acquisition of implementation scores in very good categories. enhancement almost occur in all aspects, but are not significant in the aspects of student- teacher interaction. It is evidenced that media

AR has interactive characteristics when accessed by users. Students (as users) are enthusiastic in using this new media, which has an impact on increasing student-media interaction. It means that there is no teacher-student interaction, but these results indicate that there has not been a significant increase in this aspect .

**Table 5.** The Quality of Learning Process in the Second Cycle

| No | Rated Aspect | Score | | Mean | Category |
|---|---|---|---|---|---|
| | | Learning 1 | Learning 2 | | |
| 1 | The Consistency of Learning Activities with the Curriculum | 4.00 | 4.00 | 4.00 | Very good |
| 2 | Implementation by educators | 3.00 | 4.00 | 2.50 | Fair |
| 3 | Implementation by students | 3.00 | 4.00 | 2.50 | Fair |
| 4 | Student learning motivation | 4.00 | 4.00 | 3.50 | Good |
| 5 | Student activeness in learning activities | 3.00 | 4.00 | 3.00 | Good |
| 6 | Teacher-student interaction | 3.00 | 3.00 | 2.50 | Fair |
| 7 | The ability of educators to teach | 3.00 | 4.00 | 3.00 | Good |
| Mean | | 3.29 | 3.86 | 3.57 | Good |
| Percentage (%) | | 82.14 | 96.43 | 89.29 | |

The use of interactive multimedia based on augmented reality gave positive changes to the learning process of earth and rock structure material science in the fifth grade of elementary school. Students' interest in AR media made them enjoy the learning process of earth and rocks structures as a fun activity. Most students are interested in continuing to explore other markers by hoping that other 3D objects will appear. Learning earth and rock structures becomes more contextual with students actively, independently and collaboratively involved. Alternately, students scan markers on textbooks of earth and rock structures. In addition, students are seen as active in class discussion activities to solve problems collectively. In accordance with the results of previous studies that visualize objects related to the structure of the earth in 3D help students in the process of concept analysis (Amir, 2017), understand the relationship of their parts (Deshpande & Kim, 2018), enhance student motivation in dimensions of attention dan self-confidence (Cai et al., 2014; Chiang et al., 2014), and enhance student spatial skills (Escudero et al., 2016). The use of AR media in science learning is suitable for the 21st century learning process (Sungkur et al., 2016).

**The Ability of Abstract Reasoning in Science Learning through Interactive Multimedia Based on Augmented Reality in Elementary School**

Measurement of abstract reasoning students is carried out in the pre-cycle, the end of the first cycle and the end of the second cycle. The ability of abstract reasoning of students was measured through tests on aspects of relations identify, analyze information and solve problems. The results of abstract reasoning test in the pre-cycle presented in Figure 1. Figure 1 showed that students' abstract thinking skills are still not good enough. The mean of the pretest on the aspect of relationship identification has the highest score among other aspects. These results indicate that students have the initial ability to interpret data and look for relationships between data, but have not been able to apply it in analyzing and solving problems. In addition, one student obtained a zero score at the information analysis and problem solving stage because he could not provide an answer.

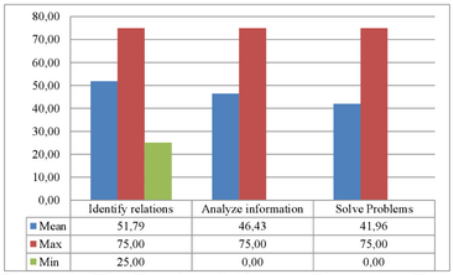


**Figure 1.** The Results of Abstract Reasoning Test in the Pre-Cycle Stage

The percentage of classical completeness in pre-cycle stage is measured at 21.43%. These data indicate that the abstract reasoning of the fifth grade students need to be enhanced to assist them solve scientific problems about the structure of the earth through effective learning and attracting students. Alternatives to enhance the quality of learning using augmented reality media. The use of this medium to engage students actively in the use of learning resources to enhance abstract reasoning on science learning. Implementation of actions is carried out in the form of a cycle. At the end of the first cycle, a test was conducted to determine the ability of students to reason abstractly in learning the structure of the earth after using AR media in science learning. The test results at the stage of first cycle are presented in Figure 2.

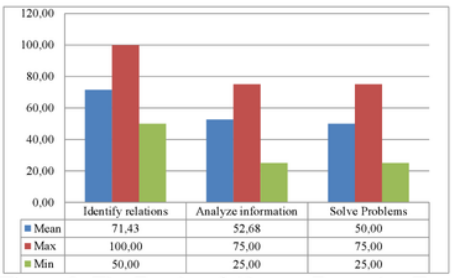


**Figure 2.** The Results of Abstract Reasoning Test in the First Cycle

Figure 2 showed that there is an enhancement in the aspects of students' abstract reasoning after learning the structure of the earth using AR-based interactive multimedia. Compared with the pre-cycle conditions, aspects of relationship identification enhanced by 37.93%, aspects of information analysis enhanced by 13.46%, and aspects of problem solving enhanced by 19.15%. The use of AR-based interactive multimedia has an effective effect on enhancing students' ability to interpret visual objects about the structure of the earth and its ability to connect each structure it observes. This ability helps them in analyzing the information they get to solve problems. Trying new things in learning activities is seen as fun and interesting for students. Directly, students are interested in being active in science learning. This condition is different from the pre-cycle conditions, that students do not have a good interest in studying the structure of the earth.

The reflection phase is conducted to get consideration in planning the implementation of the further action. Seen in the percentage of classical completeness in the first cycle measured at 64.29%. Thus, the action given in this study continues in the second cycle. Based on observations of student activity and the quality of learning during cycle 1, it is identified that deficiencies or constraints faced in the first cycle generally include teachers who have difficulty in controlling students when scanning using AR media; students are too happy to operate AR media outside the worksheet instructions; and students have not focused on problem solving on the worksheet. Efforts to enhance to say the problem in the first cycle include the teacher giving an explanation of the procedure using AR media in a systematic and procedural way. The students in each group were given a division of problem solving tasks. In addition, the 25 cher will limit the time (duration) for each group to solve the problem and explain the results of their group work to 24 given a response by other groups.

At the end of the second cycle, students worked on the abstract thinking ability test in learning the structure of the earth. The test results at the stage of the second cycle are presented in the Figure 3.

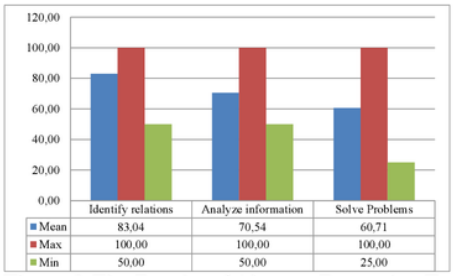


**Figure 3.**The Results of Abstract Reasoning Test in the Second Cycle

Figure 3 is identified that there was an enhancement in all aspects of abstract thinking abilities which were tested after fifth grade students attended the learning of earth structure using AR-based multimedia. Students 'ability to understand concepts and identify correlation between structures in earth structure material again increases in the second cycle. Students' ability in analyzing information relating to phenomena on earth, volcanic events, and rock formation enhances well. The enhanced ability to analyze information about the structure of the earth supports students' ability to solve problems. Enhancing the ability to think abstractly in all aspects was 71.43. The percentage of classical completeness in the second cycle was measured at 82.14%. By considering the results of observations of student activities, the learning process, and the the performance indicators, the action research was already done until the second cycle.

Effective teaching includes the latest strategies that help support alternative ways to understand the world while developing scientific explanations (National Research Council, 1996). Implementation interactive multimedia based on AR as new technology in science learning gives positive impact on enhancing the ability of students to understand the concept with the help of abstract reasoning about the structure of the earth. AR learning media can visualize abstract concepts to be more real so that they can provide an understanding of the structure of a model to be more effective for students (Mustaqim, 2016). In accordance with the AR role, the most promising is to enhance student knowledge and students' understanding of the material (Yuliono et al., 2018).

The comparison of the results of measurement of the ability of abstract reasoning students in learning earth structure inter-cycle structure is presented in the Figure 4.

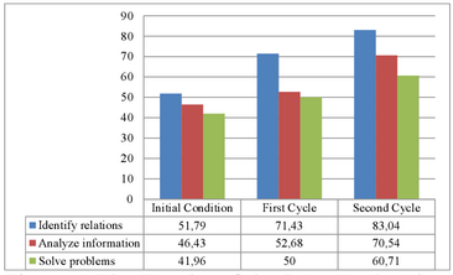


**Figure 4.**The Results of the Inter-Cycle Abstract Reasoning Test

The data in Figure 4 identified that all aspects of abstract reasoning that were tested on students in learning earth structure have increased at each stage of the cycle.The spatial ability of students to understand the structure of the earth makes it easier to understand the correlation between parts that can be applied in the process of further reasoning, as analyzing 23 d solving problems with critical thinking. These results are in accordance with related studies that suggest AR-based tutoring approaches benefit students in increase learning motivation and tendency of 32 nk critically (Chang & Hwang, 2018). Through the use of the AR app for environmental science learning, students are able to achieve a deep understanding of concepts (Georgiou & Kyza, 2018).

The enthusiasm of students towards the learning process of earth structure has enhanced significantly through the use of interactive multimedia AR, but it is not similar to the

enhance in interaction between students and lecturers. Characteristics of fifth grade elementary school students have a high curiosity about new things, including the use of AR-based interactive multimedia. Teachers are advised to provide clear procedures for using teaching materials with AR-based interactive multimedia through problem solving activities in groups.Students interact with other in conversations. In accordance with the research conducted by Kim (2016) revealed that when students participate in discussions, the intellectual realm of students appears to build new ideas, reasoning, and problem solving. Thus, students' motivation in analyzing and problem solving activities can gradually enhance. Through AR-based interactive multimedia, every part of the earth in teaching materials can be a more visual object real to users so that it is more contextual and helped in developing students' abstract reasoning abilities in science learning.

## CONCLUSION

The results of study showed that student activities in learning activities, observation of the quality of the learning process, and learning outcomes gradually enhanced at each stage of the cycle. These results indicate that media interactivity AR, the presentation of objects that are more real, and the ease of using media can enhance interest and help students provide abstractions about natural phenomena that occur within the structure of the earth. Visualization of the structure of the earth, volcanic phenomena, tectonics, and the process of forming various types of rocks makes it easier for students to mastery the material, connect between concepts in understanding other concepts, and apply them in analysis and problem solving so that student learning outcomes in science learning are better. The conclusion of this study is that the use of augmented reality media can enhance the ability of abstract reasoning of the fifth grade students in learning the structure of the earth.

## REFERENCES


Amir, I. (2017). *Pengembangan Buku Ajar dan Augmented Reality Pada Konsep Sistem Pencernaan di Sekolah Menengah Atas* (Doctoral dissertation, Pascasarjana).

Baars, T. (2011). Experiential Science; towards an Integration of Implicit and Reflected Practitioner-Expert Knowledge in the Scientific Development of Organic Farming. *Journal of Agricultural and Environmental Ethics*, *24*(6), 601-628.

Biggs, J., & Tang, C. (2007). *Teaching for Quality Learning at University (Third Edition).* Berkshire: McGraw Hill and Open University Press.

BNSP. (2013). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 64 Tahun 2013 tentang Standar Isi Pendidikan Dasar dan Menengah*. Jakarta: Kemendikbud RI.

Brouse, C. H., & Chow, T. H. (2009). Exploring Pre-Operational and Concrete Operational Children's Thinking on Nutrition: A Case Study. *Health Education Journal*, *68*(3), 219-231.

Cai, S., Wang, X., & Chiang, F. K. (2014). A Case Study of Augmented Reality Simulation System Application in a Chemistry Course. *Computers in Human Behavior, 37*(2014), 31-40.

Chang, S. C., & Hwang, G. J. (2018). Impacts of an Augmented Reality-Based Flipped Learning Guiding Approach on Students' Scientific Project Performance and Perceptions. *Computers and Education, 123*(2018), 226-239.

Chiang, T. H. C., Yang, S. J. H., & Hwang, G. J. (2014). An Augmented Reality-Based Mobile Learning System to Improve Students' Learning Achievements and Motivations in Natural Science Inquiry Activities. *Educational Technology and Society*, *17*(4), 352–365.

Datta, S., & Roy, D. D. (2015). Abstract reasoning and Spatial Visualization in Formal Operational Stage. *International Journal of Scientific and Research Publications*, *5*(10), 1-6.

Deshpande, A., & Kim, I. (2018). The Effects of Augmented Reality on Improving Spatial Problem Solving for Object Assembly. *Advanced Engineering Informatics*, *38*(2018), 760–775.

Djojosoediro, W. (2010). Hakikat IPA dan Pembelajaran IPA SD. Retrieved from https://adoc.tips/unit-1-hakikat-ipa-dan-pembelajaran-ipa-sd-wasih-djojosoedir.html

Eriksson, P., & Kovalainen, A. (2015). *Qualitative Methods in Business Research: a Practical Guide to Social Research*. London: Sage.

Escudero, D. F., Domínguez, E. R., & Valls, F. (2016). Motivation and Academic Improvement Using Augmented Reality for 3D Architectural Visualization. *Education in the Knowledge Society*, *17*(1), 45-64.

Garrett, B. M., Jackson, C., & Wilson, B. (2015). Augmented Reality m-Learning to Enhance Nursing Skills Acquisition in the Clinical Skills Laboratory. *Interactive Technology and Smart Education*, *12*(4), 298–314.

Georgiou, Y., & Kyza, E. A. (2018). Relations between Student Motivation, Immersion and Learning Outcomes in Location-Based Augmented Reality Settings. *Computers in Human Behavior*, *89*(2018), 173–181.

Hernawati, D., Amin, M., Irawati, M. H., Indriwati, S. E., & Omar, N. (2018). The Effectiveness of Scientific Approach Using Encyclopedia as Learning Materials in Improving Students' Science Process Skills in Science. *Jurnal Pendidikan IPA Indonesia*, *7*(3), 266–272.

Ibda, F. (2015). Perkembangan Kognitif: Teori

Jean Piaget. *Jurnal Intelektualita*, *3*(1), 27–38.
Iftene, A., & Trandabăt, D. (2018). Enhancing the Attractiveness of Learning through Augmented Reality. *Procedia Computer Science*, *126*(2018), 166–175.
Information Resources Management Association. (2018). *Virtual and Augmented Reality: Concepts, Methodologies, Tools, and Applications*. Hershey: IGI Global.
Jamali, S. S., Shiratuddin, M. F., Wong, K. W., & Oskam, C. L. (2015). Utilising Mobile-Augmented Reality for Learning Human Anatomy. *Procedia - Social and Behavioral Sciences*, *195*(2015), 659–668.
Kim, M. (2016). Children's Reasoning as Collective Social Action through Problem Solving in Grade 2/3 Science Classrooms. *International Journal of Science Education*, *38*(1), 51-72.
Kurniawan, M. H., Suharjito, Diana, & Witjaksono, G. (2018). Human Anatomy Learning Systems Using Augmented Reality on Mobile Application. *Procedia Computer Science*, *135*(2018), 80–88.
Markovits, H., de Chantal, P. L., & Brisson, J. (2018). Abstract Reasoning and The Interpretation of Basic Conditionals. *Thinking and Reasoning*, *25*(1), 1–13.
Miles, M. B., & Huberman, A. M. (1994). *Qualitative Data Analysis*. London: Sage Publications.
Mustaqim, I. (2016). Pemanfaatan Augmented Reality sebagai Media Pembelajaran. *Jurnal Pendidikan Teknologi dan Kejuruan, 13*(2), 174-184.
Morris, N. P., & Lambe, J. (2017). Multimedia Interactive Ebooks in Laboratory Bioscience Education. *Higher Education Pedagogies*, *2*(1), 28–42.
National Research Council. (1996). *National Science Education Standards*. Washington, DC: The National Academies Press.
Ozdemir, M., Sahin, C., Arcagok, S., & Demir, M. K. (2018). The Effect of Augmented Reality Applications in the Learning Process: A Meta-Analysis Study. *Eurasian Journal of Educational Research*, *74*(2018), 165-186.
Piaget, J. (1952). *The Origins of Intelligence in Children (M. Cook, Trans.)*. New York: W W Norton & Co.
Piaget, J., Inhelder, B., & Lunzer, E. A. (1964). *The Early Growth of Logic in the Child: Classification and Seriation*. Routledge & Kegan Paul.
Psychometric Canada. (2019). Abstract Reasoning Assessment. Retrieved from https://www.psychometrics.com/assessments/acer-test-abstract-reasoning/
Simonneaux, L. (2014). Questions Socialement Vives and Socio-Scientific Issues: New Trends of Research to Meet the Training Needs of Postmodern Society. In *Topics and Trends in Current Science Education* (pp. 37-54). Springer, Dordrecht.
Smaldino, S. E., Lowther, D. L., & Mims, C. (2019). Instructional Technology and Media for Learning 12th Edition. Retrieved from https://www.pearsonhighered.com/assets/preface/0/1/3/4/0134287487.pdf
Stringer, E. T. (2008). *Action Research in Education*. Upper Saddle River, NJ: Pearson Prentice Hall.
Sugiyono. (2015). *Metode Penelitian Kuantitatif, Kualitatif dan R & D*. Bandung: Alfabeta.
Sungkur, R. K., Panchoo, A., & Bhoyroo, N. K. (2016). Augmented Reality, the Future of Contextual Mobile Learning. *Interactive Technology and Smart Education*, *13*(2), 123-146.
Susac, A., Bubic, A., Vrbanc, A., & Planinic, M. (2014). Development of Abstract Mathematical Reasoning: the Case of Algebra. *Frontiers in Human Neuroscience*, *8*(679), 1-10.
Tarng, W., Ou, K. L., Yu, C. S., Liou, F. L., & Liou, H. H. (2015). Development of a Virtual Butterfly Ecological System Based on Augmented Reality and Mobile Learning Technologies. *Virtual Reality*, *19*(3–4), 253–266.
Tekedere, H., & Göke, H. (2016). Examining the Effectiveness of Augmented Reality Applications in Education: A Meta-Analysis. *International Journal of Environmental and Science Education*, *11*(16), 9469-9481.
Turan, Z., Meral, E., & Sahin, I. F. (2018). The Impact of Mobile Augmented Reality in Geography Education: Achievements, Cognitive Loads and Views of University Students. *Journal of Geography in Higher Education*, *42*(3), 427–441.
Yen, J. C., Tsai, C. H., & Wu, M. (2013). Augmented Reality in the Higher Education: Students' Science Concept Learning and Academic Achievement in Astronomy. *Procedia - Social and Behavioral Sciences*, *103*(2013), 165–173.
Yuliono, T., Sarwanto, & Rintayati, P. (2018). The Promising Roles of Augmented Reality in Educational Setting: A Review of the Literature. *International Journal of Educational Methodology*, *4*(3), 125–132.

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