ASPIRE model (analysis, scaffolding, project, investigation, reaction, and evaluation) for mathematical creative thinking ability

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Abstract. ASPIRE model is an innovation in mathematics learning that is expected to develop mathematical creative thinking ability. The aspects of the ASPIRE model consists of analysis, scaffolding, project, investigation, reaction and evaluation. The research aims to describe the steps of the ASPIRE model. analysis is the stage where students are analyzed their abilities through filling out questionnaires or online tests so the teacher understands the ability of students and gives them treatment according to their abilities. Scaffolding stage is the provision of assistance, motivation, and direction to students in conducting learning activities. Project stage is implementing learning material in a project assignment. Investigation stage is the process of investigating the results of project tasks and communicating them so that they can be compared with the acquisition of others. Reaction stage is applying of problems related to the material in project task. Evaluation is the stage of testing the ability of students individually. The ASPIRE model is a combination of project-based learning models, problem-based learning, and investigative learning that all three learning models are considered capable of developing mathematical creative thinking ability.

1. Introduction

Mathematics is one of the subjects taught in schools from elementary to upper levels. Mathematic is given at all levels of education in order to equip students with the ability to think logically, analytically, systematically, critically, innovative, creative, and the ability to cooperate. This is in line with [1-2] which states that the purpose of education at the school level is to encourage students to think creatively and logically. The ability to think creatively is also one of the goals of national education. One of the goals of national education is to develop creative abilities. Therefore, in the learning of mathematics developed creative thinking skills known as mathematical creative thinking abilities. The ability to think creatively mathematically according to [3] was an ability that must be possessed by students.

Mathematical creative thinking is creative thinking in learning mathematics. Creative in the context of mathematics according to [4] is the result of creative work may not always have useful implications in terms of application in the real world, enough to find unusual solutions in solving mathematical problems through standard algorithms. The aspects measured in the ability to think creatively according to [5] consist of fluency, flexibility, elaboration, and originality. Based on the description,

the ability to think mathematically creative is the ability to solve mathematical problems based on aspects of fluency, flexibility, elaboration, and originality.

Mathematical creative thinking ability according to [6] as one of the higher-level thinking skills. Therefore we need special treatment for students to develop it. Project based learning based on [7] stated that is able to develop mathematical creative thinking abilities. Problem based learning according to [8] is also one of the learning models that can develop mathematical creative thinking abilities. ASPIRE model as one of the innovative learning models is expected to improve mathematical creative thinking abilities. ASPIRE model consists of analysis, scaffolding, project, investigation, reaction, and evaluation. Each component consists of several learning steps. Therefore purpose of study is to describe learning step of the ASPIRE learning model that it can improve mathematical creative thinking ability.

2. Methods

The research method used is the study of literature. Researchers conducted a search of various written sources, both in the form of books, articles and documents relevant to the problem under study. Information obtained from this literature study is used as a reference to strengthen the argument. This research analyzes based on the theory of how the ASPIRE learning model plays a role in developing mathematical creative thinking abilities.

3. Research Results and Discussion

ASPIRE model is designed as a learning innovation that can develop mathematical creative thinking abilities. The components in ASPIRE model consist of analysis, scaffolding, project, investigation, reaction, and evaluation. Each component in the ASPIRE model consists of several stages. The stages in each component are integrated so that the syntax of ASPIRE model is formed. Based on literature studies that have been carried out using various sources, a description of each component of the ASPIRE model is obtained as follows.

The ability of students in a class is heterogeneous, which means there are some students who easily understand the material taught in class, there are also some students who have difficulty understanding the material taught in class. Such conditions are a challenge for teachers to be able to give fair treatment to the two groups. Therefore, the teacher should conduct an analysis of students' abilities so that they can group students in hetergon. Analysis as the first component of the ASPIRE model aims to identify students' abilities. Students with high abilities can be tutors for students with medium and low abilities. As the statement of [9] that their peers are potential helpers in the academic environment. Peer tutoring [10] is one way students can assist each other during learning activities. Research has shown that peer tutoring has a positive effect on the academic performance of both the tutors and tutees [11].

The second component in the ASPIRE model is scaffolding. Scaffolding is based on Vygotsky's theory which, according to [12] is learning that occurs when a child works or learns to handle tasks that have not been studied but those tasks are in the Zone of Proximal Development (ZPD). ZDP according to [13] is defined as an area between what students themselves can do at the actual developmental level (current level of development) and what students can achieve to the potential developmental level if assisted by adults or experts. Scaffolding plays an important role in achieving this level of potential development. Scaffolding is a learning where students are given a number of assistance during the initial stages of learning and then reduce the assistance and provide opportunities for students to take over greater responsibilities after being able to do it themselves.

Scaffolding according to [14] to support student learning activities, namely feeding back, giving of instruction, explaining, modeling, and questioning. Feeding back provides information about student performance. The giving of hints, namely giving instructions or suggestions by the teacher to help students. Instructing involves the teacher to tell students what to do or to explain of how and why something should be done. Explaining refers to the provision of more detailed information by the teacher. Modeling, the process of offering behavior to emulate. Questioning, namely asking questions

to students who need active linguistic and cognitive answers. While [15] stated that scaffolding in mathematics learning consists of three levels. Level 1 environmental provisions where teachers pay attention to the surrounding environment related to seating arrangements, class organizations, and equipment in the classroom. Level 2 explaining, reviewing, and restructuring is a direct interaction between teacher and student. Level 3 explicitly discuss the development of conceptual thinking by creating opportunities to express understanding to students and teachers simultaneously.

Based on this description, scaffolding is the provision of assistance to student during the initial learning then students take responsibility after they can do it. Scaffolding is given by conditioning the environment that supports learning activities, for example by providing structured worksheets, learning media, and using language that is easy for students to understand. Therefore, the scaffolding stage in the ASPIRE model consists of: explaining, instructing, and restructuring. Explaining is a teacher providing an explanation of the material being studied. Instructing, namely the teacher gives instructions to students using the help of teaching aids and other learning media. Restructuring is a way for teachers to encourage experience to focus student attention on aspects related to learning.

The third component in the ASPIRE model is project. Project as part of project-based learning that focuses on organizing independent learning in empirical projects. Project-based learning according to [16] is student-centered learning that contributes to improving academic performance. Project-based learning is an approach through practical activities, interactive discussions, independent operations and teamwork so students can achieve planned targets and build their own knowledge. Students through project-based learning according to [17] go through a lengthy process of finding designs, solutions to problems. Therefore according to [18] project-based learning can improve long-term thinking skills. Project-based learning according to [19] contributes to bring individuals closer to the profession through the acquisition of knowledge while solving practical and real cases that are closed to the professional world. In fact, project-based learning according [20] works to integrate and apply knowledge as follows: structured new knowledge, knowledge learned in other courses, knowledge based on previous life experiences, and self-taught knowledge.

The stages in project-based learning according to [21] include the organizational stage, the goal setting stage, the preparatory stage, the practical phase, the presentation stage, and the final stage. The main stages of project-based learning according to [22] especially in mathematics learning are teamwork when students work together to solve problems. This makes it possible to see that mathematics not only has practical value, but also gives students the opportunity to appreciate work relationships with peers. Students through project completion are expected to be able to develop creativity.

The characteristics of project-based learning according to [23] are developing creativity and encouraging them to work cooperatively. Project-based learning according to [7] also stated that could observe the student's creativity through various projects of school mathematics learning media. The project stage in the ASPIRE model is the assignment of project assignments. The project given is adjusted to the material that has been explained by the teacher. Project work is done in groups. Each group is required to complete the project and prepare reports according to the results obtained.

Each group has a high possibility to get different results in completing the project. Therefore a group investigation is needed on investigation of the project. Investigation according to [24] is a cooperative group investigation that emphasizes data collection by students, interpretation of information through group discussions, and synthesis of individual contributions into group projects. Investigation is considered appropriate to be applied in the learning process because according to [25] can improve students' scientific work skills. The investigation process according to [26] involves examining empirical data or specific cases, formulating and confirming allegations, and generalizing. Investigative group learning according to [27] consists of six steps, namely class identifies sub-topics and organizes research groups, groups plans their work, groups implement their research work, groups their plans research work, group present their research work, teacher and students assess presentation.

Investigation, especially in mathematical learning according to [28] is learning real life or open life. Investigation provides an opportunity for students to use several channels to investigate problems.

Investigation allows students to explore several mathematical pathways that lead to various mathematical ideas and solutions. This is in line with [29] which stated the purpose of mathematical investigations is to encourage students to discover and experience themselves through the mathematical process. Investigation in the ASPIRE model is a process of inquiry into the project's results. Students study in depth the project reports that are being presented in order to obtain conclusions. Investigations combine a variety of skills and concepts, perhaps linking some concepts that were previously taught as peak activities or as a continuous teaching tool over a period of time that gradually establishes student understanding. The stages of the investigative component in the ASPIRE model are to examine in depth the project reports presented and to compile questions based on the results of the project reports.

After students obtain conclusions through further investigation activities students react to the conclusions from the results of the investigation. Reactions to the training evaluation model according to [30] are designed to measure participants' reactions to learning products, and can include reactions to their relevance, training methods, qualifications, and assessment methods. Reaction criteria according to [31] which is related to students' perceptions, impressions, and feelings that are operationalized using self-report measures. Students react to learning experiences that have been obtained previously. The reaction is implemented by students through problem solving given by the teacher. Therefore, students' mathematical creative thinking abilities are tested at this stage.

Mathematical creative thinking ability according to [4] is the ability to produce unique and varied mathematical problem solving solutions, including components of fluency, flexibility, elaboration and originality). On other hand [32] stated that creative learning in mathematics at the school level is the result of work that does not always have useful implications on real-world application, simply offering new insights in solving mathematical problems. Therefore, the reaction component of the ASPIRE model in supporting the ability to think creatively mathematically consists of understanding the problem, formulating problem solving strategies, carrying out problem solving, and checking solutions with different problem solving strategies.

The last component in the ASPIRE model is Evaluation. Evaluation is about conducting self-assessments. Self-assessment is the process of comparing the results of the performance that has been done with the learning objectives. Ratings according to [33] can improve individual performance. Teachers according to [34] are encouraged to use information collected from evaluation guides to improve the clarity of mathematical programs used to teach students. Evaluation aims to measure the ability of students so that teachers can make decisions to treat these students. The results of this evaluation can be used to return to the initial components of the ASPIRE model, namely the analysis then goes to the next stage. Therefore the syntax of the ASPIRE model is stated in Figure 1.

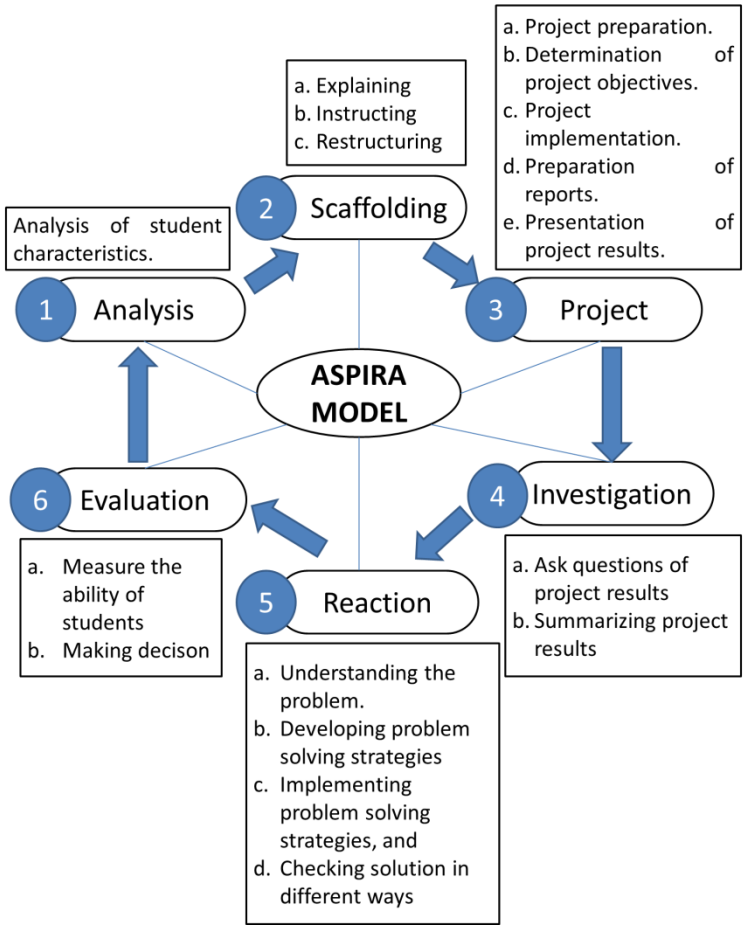

Figure 1. Sintax of ASPIRA Model

4. Conclusion

The ASPIRE model consists of analysis, scaffolding, project, investigation, reaction and assessment components. Each component of the ASPIRE model consists of several stages. Analysis consists of analysis student characteristics, and learning environment. The scaffolding consists of explaining, instructing, and restructuring. The learning phases in the project consist of preparation, goal setting, implementation, report preparation, presentation. The stages of the investigative are to examine in depth the project reports presented, compile questions based on the results of the project report, and draw conclusions from the project results. the reaction component of the ASPIRE model in supporting the ability to think creatively mathematically consists of understanding the problem, formulating problem solving strategies, carrying out problem solving, and checking solutions with different problem solving strategies. Evaluation is measuring students ability. ASPIRE model presents various components where the syntax of the ASPIRE model looks quite complex so that the implementation of the ASPIRE model requires quite a long time. Students who are deemed unable to reach the completeness limit then students must repeat from the beginning of the learning phase.

References

[1] Švecová V, Rumanova L & Pavlovičová G 2014 *Procedia-Soc. Behav. Sci.* **116** 1715
[2] Bart W M, Hokanson B, Sahin I & Abdelsamea M A 2015 *Think. Ski. Creat.* **17** 17
[3] Lince R 2016 *J. Educ. Pract.* **7** (6) 206
[4] Sriraman B 2009 *ZDM* **41** (1-2) 13
[5] Silver E A 1997 *ZDM* **29** (3) 75

[6] Tyagi T K 2016 *Int. J. Math. Educ. Sci. Technol.* **47**(3) 388
[7] Ummah S K, In'am A & Azmi R. D. 2019 *J. Math. Educ.* **10** (1) 93
[8] Rosnawati R 2018 *J. Phys.: Conf. Ser.* **1097** (1) 012111
[9] Newman R S & Schwager M T 2017 *Univ. Chic. Press J.* **94** (1) 3
[10] Alegre F, Moliner L, Maroto A & Lorenzo-Valentin G 2019 *Heliyon* **5** (9) e02491
[11] Shenderovich Y, Thurston A & Miller S 2016 *Int. J. Educ. Res.* **76** 190
[12] Clay M M & Cazden C B 1999 *Lev Vygotsky: Crit. assess.* **3** 354
[13] Van Der Stuyf R R 2002 *Adolesc. learn. dev.* **52** (3) 5
[14] Van de Pol J, Volman M, & Beishuizen J 2010 *Educ. psychol. rev.* **22** (3) 271
[15] Anghileri J 2006 *J. Math. Teach. Educ.* **9** (1) 33
[16] Wekesa N W & Ongunya R O 2016 *J. Educ. Pract.* **7** (16) 25
[17] Chua K J. Yang W M & Leo H L 2014 *Int. J. Technol. Des. Educ.* **24** (4) 437
[18] Edström K & Kolmos A 2014 *Eur. J. Eng. Educ.* **39** (5) 539
[19] Terrón-López M J, et al 2016 *Eur. J. Eng. Educ.* **42** (6) 618
[20] Song J & Dow D E 2016 *Proceedings of the 123rd ASEE Annual Conference and Exposition*, New Orleans
[21] Telegina N V, Drovosekov S E, Vasbieva, D G & Zakharova V L 2019 *EURASIA J. Math. Sci. Technol. Educ.* **15** 8
[22] Holmes V L & Hwang Y 2016 *J. Educ. Res.* **109** (5) 449
[23] Chiang C L & Lee H 2016 *Int. J. Inf. Educ. Technol.* **6**(9) 709
[24] Hosseini S M H 2014 *Int. J. Instr.* **7**(1)
[25] Kusmaryono I, Suyitno H, Dwijanto & Dwidayati N 2019 *Int. J. Instr.* **12** (1) 343
[26] Yeo J B & Yeap B H 2010 *Int. J. Math. Teach. Learn.*
[27] Indarti D & Pramudya I 2018 *In J. Phys.: Conf. Ser.* **983** 012147
[28] Marshman M, Clark D & Carey M 2015 *Int. J. Math. Teach. Learn.*
[29] Quinnell L 2010 *Aust. Math. Teach.* **66** (3) 35
[30] Kirkpatrick D 1996 *Train. Dev.* **1** 54
[31] Arthur Jr W, Tubré T, Paul D S & Edens P S 2003 *Educ. Psychol.* **23** (3) 275
[32] Shriki A 2010 *Educ. Stud. Math.* **73** (2) 159
[33] Leder G C & Forgasz H J 2018 *ZDM* **50** (4) 687
[34] Doabler C T, Smith J L M, Nelson N J, Clarke B, Berg T, & Fien H 2018 *Interv. Sch. Clin.* **54** (2) 97