Jurnal Pendidikan Kimia (JPKIM)
p-ISSN: 2085-3653| e-ISSN: 2549-3116
https://jurnal.unimed.ac.id/2012/index.php/jpk/index

OPEN ACCESS
10.24114/jpkim.v16i1.49649
J. Pendidik. Kim 2024, 16(1), 1 – 6

Original Research Article

Students' creativity dimension in chemistry e-module based on augmented reality with project based learning approach

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Citation: Harefa, N., Sumiyati, S., & Tamba, R.M. (2024). Students' creativity dimension in chemistry e-module based on augmented reality with project based learning approach. Jurnal Pendidikan Kimia (JPKIM), 16(1), 1 – 6. https://doi.org/10.24114/jpkim.v16i1.49649

ARTICLE INFO

Keywords:
Augmented reality;
Creativity dimensions;
e-module;
Learning based e-project

History:
♦Received - 08 August 2023
♦Revised - 28 November 2023
♦Accepted - 09 December 2023

ABSTRACT

The dimension of creativity is an important aspect that must be developed in the learning process. A good dimension of creativity will stimulate students to produce creative, innovative and applicable products. In this study, analysis and interpretation of the dimensions of creativity were carried out which consisted of disciplined, imaginative, inquisitive, persistent, and collaborative. The analysis and interpretation is carried out through a project-based learning approach integrated with augmented reality. The research was conducted at SMA Negeri 2 Jonggol, West Java, in class XI SMA with a total sample of 148 people. The results of interpretation and analysis of research data show that the average score of the dimensions of creativity is 78.6 in the high category, where the highest average score is in the persistent element of 80.04 in the very high category and the lowest average score is in the inquisitive element of 76.68 in the high category. In general, the implementation of a project-based learning approach integrated with augmented reality is able to stimulate an increase in the dimensions of student creativity.

Introduction

The project-based learning approach is a learning approach that emphasizes the student-centered learning process. Through a project-based learning approach, students are given the opportunity to contribute more to the learning process (Saad & Zainudin, 2022; Dyorina et al., 2023; Purwianingsih et al., 2023). Students are given a greater proportion of learning activities to elaborate and explore material and content (Rodríguez-Peñarroja, 2022; Mursid et al., 2022; Ferres & Moehler, 2023). The project-based learning approach focuses on efforts to stimulate students' cognitive, affective, psychomotor, and other science skills (Ilijoski & Ackovska, 2022; Pepperell & Edwards, 2022).

The project-based learning approach essentially emphasizes the exploration of learning materials and content that can be elaborated in the form of subject products (Kartika & Rahman, 2022; Chen et al., 2022). Through a project-based learning approach, students are given the proportion to develop their ideas related to learning materials and content into the resulting product form. Students are accommodated to be creative in producing relevant products from learning materials and content. Through the creation of these ideas, students are expected to be able to translate learning content independently, so that learning outcomes can be obtained optimally (Kavlu, 2022; Livet et al., 2023).

The project-based learning approach guides students in producing creative and innovative products that can be utilized by the community. These products will stimulate students' understanding of learning materials and content, and can be applied to everyday life. Applicative learning materials and content will stimulate students to understand learning outcomes for the environment and society (Urem et al., 2022; Viñuela & de Caso Fuertes, 2023). The resulting creative and innovative products are able to stimulate students to generate ideas other relevant matters which may be elaborated in the future.

Digital development is actually a great opportunity to develop a project-based learning approach (Thanyaphonphot, 2022; Kurniasari et al., 2023; Burns et al., 2023). Digital developments open up opportunities to develop project-based learning approaches, either directly through project integration with digital-based technology or indirectly. Digital development actually provides a fairly broad project integration idea, especially in the integration of learning materials and content with technological developments (Sayaf et al., 2022; Izadi et al., 2022).

Digital development is actually an additional option for developing a project-based learning approach (Hammer, 2022; Karal et al., 2022). Products produced through the integration of digital developments with conventional projects will actually produce new products that are more innovative and applicable and able to accommodate the times. The need for digital products that is so great is actually an opportunity to develop innovative and creative products integrated with learning. The elaboration and exploration of digital-based projects that are carried out early on is actually a good capital for students for further developments, both in terms of products and elaboration of learning materials and content (Pakpahan et al., 2021; Harefa, 2022; Zhang & Hwang, 2023; Boss & Kraus, 2022; Ahmadi et al., 2023).

One of the project integrations and digital developments that can be elaborated is integration with augmented reality. The characteristics of augmented reality that are able to translate content in 3D form actually provide broad options in the elaboration of learning materials in the form of projects (Buchner & Kerres, 2022; Perifanou et al., 2022; Lampropoulos et al., 2022). Through the development of content and material in the form of 3 dimensions, it will optimize the elaboration and exploration of learning materials which have an impact on optimizing the creation of the resulting products (Amanatidis, 2022; Papakostas et al., 2023; López-Belmonte et al., 2023). Integration products with augmented reality are applicable and easy to understand and in accordance with the needs of users in today's digital era.

On the side of optimizing understanding of learning material, projects that are integrated with augmented reality are able to improve cognitive, affective, psychomotor, and science skills aspects of students. Elaboration and exploration of learning materials in 3D form will increase students' understanding of learning content. In terms of integration with augmented reality, students are accommodated to create innovative works that are integrated into learning projects. The accommodation to create works independently will help students to increase their creativity (Liu et al., 2022; Mystakidis et al., 2022; Low et al., 2022; Shen et al., 2023). The large proportion given to students in the context of augmented reality-based project development indirectly gives students the freedom to optimize their understanding of learning material independently.

One aspect that can be stimulated through a project-based learning approach integrated with augmented reality is the dimension of student creativity. Accommodation of student creativity in producing applicable products independently can stimulate the dimensions of student creativity both directly and indirectly (Bruno, 2022; Khan & Abbas, 2022; Balakrishnan, 2022). The large proportion that is given to students to design and create innovative work can stimulate an increase in the dimensions of student creativity, so that innovative and applicable creative products are obtained. The increased dimension of creativity is able to stimulate students to produce relevant products that are innovative and applicable in the future.

Methods

This research was conducted at Jonggol 2 Public High School, West Java in September 2022 - March 2023. The research sample consisted of 148 class XI students. This research was conducted using a project-based learning approach, in which students were given an augmented reality-based project to analyze the dimensions of each student's creativity. The dimensions of creativity analyzed consist of 5 as shown in Fig-1.

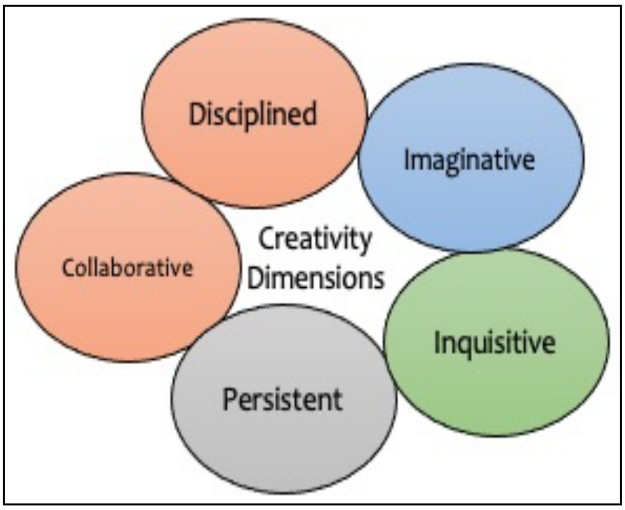

Fig-1. Creativity dimensions (Lucas, 2016)

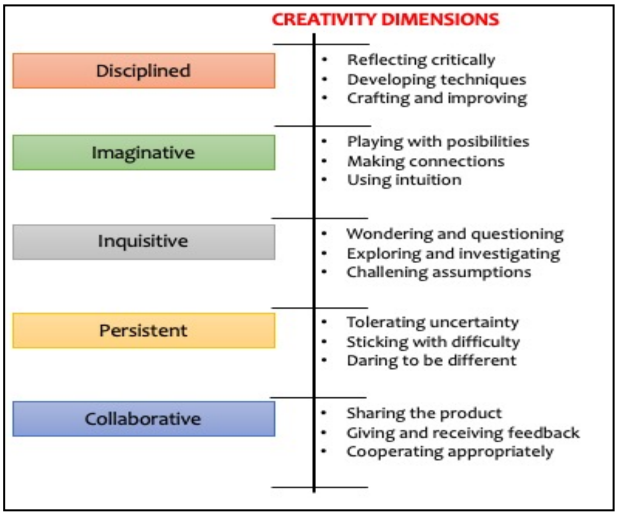

Fig-2. Creativity dimension indicators (Lucas, 2016)

These dimensions are analyzed based on indicators of creativity by providing both test and non-test research instruments, as well as observation sheets as shown in Fig-2. Each student who became the research sample was given an augmented reality-based project, where the entire project exploration process was analyzed and interpreted based on indicators of the dimensions of creativity. The data obtained were analyzed and interpreted using Microsoft Excel for windows.

Results and Discussion

The dimensions of creativity analyzed in this study are disciplined, imaginative, inquisitive, persistent, and collaborative elements (Lucas, 2016). Each dimension consists of 3 indicators, where data for each indicator is collected by giving research instruments to samples consisting of test instruments, non-test instruments, questionnaires, and observation sheets. Based on the analysis and interpretation of the data, the value of the dimensions of creativity in the disciplined elements is shown in Fig-3.

Based on Fig-3, the average score on the disciplined elements of the creativity dimension is 79.22 in the high category. The highest creativity on the crafting and improving indicator is 82.25 and the lowest is on the developing technique indicator at 76.75. The data shows that the majority of students have high enthusiasm for projects based on augmented reality which are very high. Observational data shows that most students are able to express their creative ideas through the elaboration of a given project. In addition, the data shows that students have weaknesses in developing new techniques in the exploration of a given project. Observational data shows that students feel they have not understood the material optimally so that the development of new methods to explore projects cannot be elaborated optimally. In this context, students need a variety of advanced programs so that understanding of the material can be optimal which has a positive impact on exploring similar projects. Student involvement in the learning process can be identified directly through the use of AR-based e-modules. Student engagement can be monitored by teachers through access to e-module utilization data. This direct identification stimulates student discipline in exploring and elaborating learning material (Supriasih et al., 2022; Rahmasari & Kuswanto, 2023). Apart from the disciplined element indicators, an analysis was also carried out on the imaginative element indicators as shown in Fig-4.

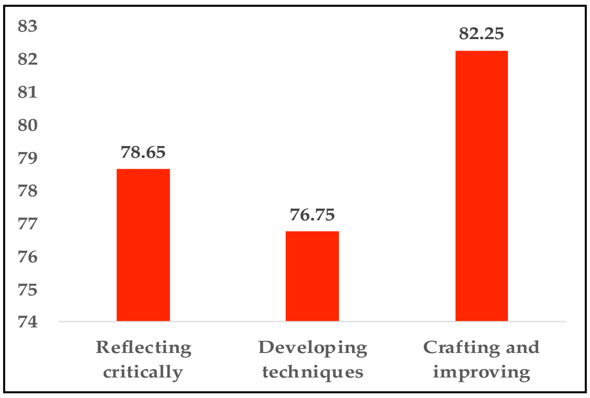

Fig-3. Disciplined indicators

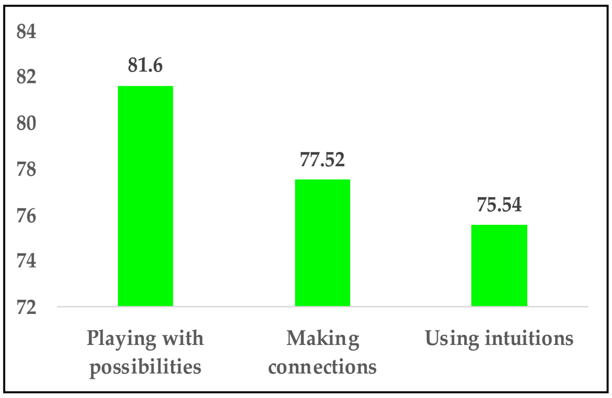

Fig-4. Imaginative indicators

Based on Fig 4, the average score on the imaginative element is 78.22 in the high category with the highest score on the playing with possibilities indicator of 81.6 in the high category and the lowest score on the using intuitions indicator of 75.54 in the high category. The data shows that most students are able to interpret the given project into a reasonable job. Students are able to design a job that can be implemented. However, students need more learning experiences, so that they are able to optimize the involvement of intuition in learning. Implementing an e-module based AR that is able to accommodate the elaboration of material in 3D can improve students' imagination skills regarding learning material. Students can be optimally stimulated in translating learning material into real form (Wannapiroon et al., 2021; Sreejun & Chatwattana, 2023). Apart from the imaginative element, an analysis is also carried out on the inquisitive element as shown in Fig-5.

Based on Fig-5, the average score on the inquisitive element is 76.68 in the high category with the highest score on the wondering and questioning indicator in the high category and the lowest score on the challenging assumptions indicator of 74.56 in the high category. The data shows that most students are able to ask constructive questions about the projects presented. However, students need more learning experiences so that the optimization of the elaboration and exploration of the assumptions obtained can be optimally explored. The implementation of an e-module based AR that presents material in 3D form is able to stimulate students' curiosity about the real form of the material and the learning content that is elaborated. Students tend to want to elaborate and explore learning material according to the AR-based e-module material and content that they apply in class (Yadav et al., 2020; Bülbül & Özdinç, 2022). In addition to inquisitive elements, analysis is also carried out on persistent elements as shown in Fig-6.

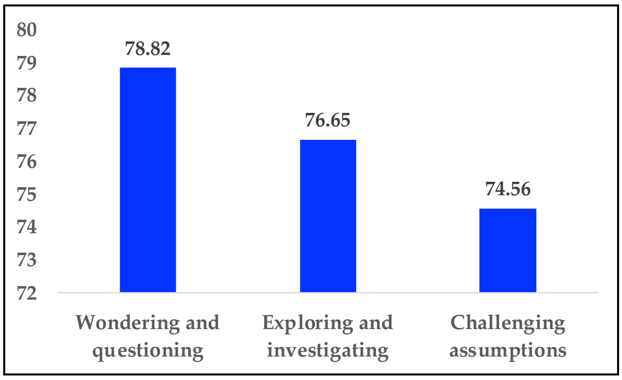

Fig-5. Inquisitive indicators

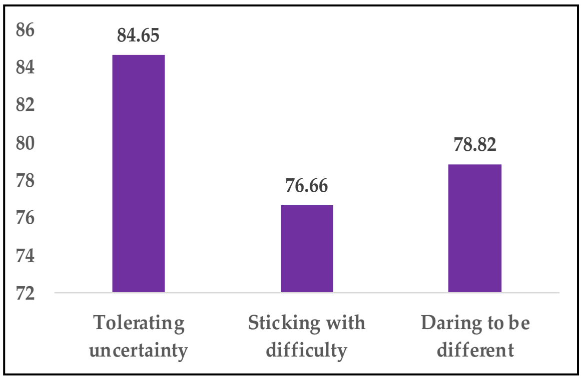

Fig-6. Persistent indicators

Based on Fig-6, the average persistent element score is 80.04 in the very high category with the highest score on the tolerating uncertainty indicator of 84.65 in the very high category and the lowest score on the sticking with difficulty indicator of 76.66 in the high category. Students have high tolerance in learning, they are able to mingle with one another without discriminating against ethnicity, religion, race, and class. In the given project elaboration and exploration activities, students can work together with their colleagues and are able to respect other students who have different ethnicities, religions, races, and classes. However, students must continue to be honed in translating and describing the challenges and difficulties encountered in the learning process so that the elaboration and exploration of learning materials and content can be optimized. The implementation of an e-module based AR which provides various features that accommodate student creativity is able to stimulate students to be more persistent in exploring and elaborating learning material, students have ample space to translate each material according to the creativity they want to develop (Abarkan et al., 2022; Baker & Baker, 2022; Limbong & Silaban, 2023; Asmi et al., 2024). In addition to persistent elements, analysis and interpretation are also carried out on collaborative elements as shown in Fig-7.

Based on Fig-7, the average score on the collaborative element is 78.82 in the high category with the highest score on the sharing the product indicator of 81.25 in the very high category and the lowest score on the cooperatively appropriate indicator of 74.45 in the high category. The data shows that most students have been able to share the products produced from the given project. Students are able to present what products are obtained, their advantages and disadvantages, and are able to integrate them with relevant chemical material and content. Skills in presenting the resulting product are a good capital for students to explore relevant ideas that can be elaborated on other occasions. However, most students need more learning experiences so that the delivery of ideas and the presentation of the resulting products is more cooperative, so that the discussion process is more transparent and students are able to express their ideas optimally. The integration of e-module based AR which have various features that can be optimized in the elaboration and exploration of learning material accommodates and stimulates students in collaborating to complete various projects that are relevant to the learning material. Students are given space to create a project with other students so that they obtain a project that can translate the material and learning content that is elaborated (Sereno et al., 2020; Toriz Garcia et al., 2022). In general, the dimensions of creativity analyzed in this study are shown in Fig-8.

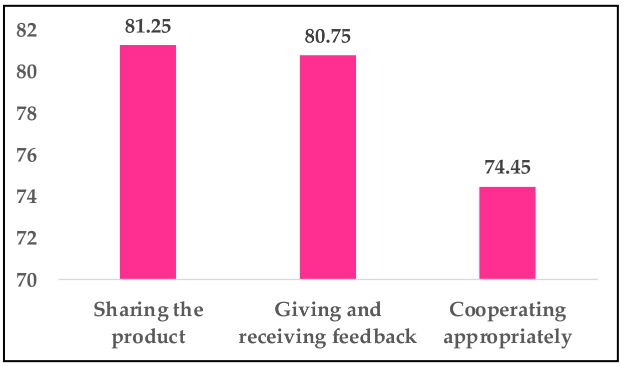

Fig-7. Collaborative indicators

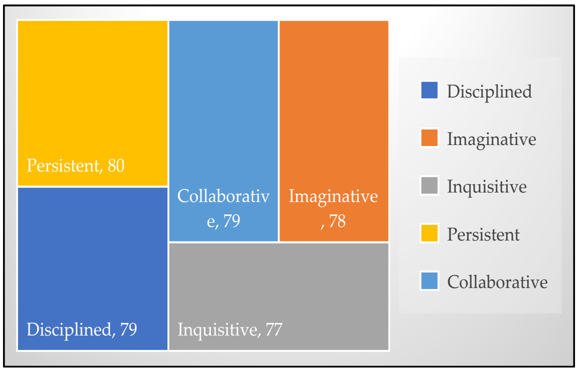

Fig-8. Creativity dimensions

Based on Fig-8, the average score of the creativity dimension is 78.6 in the high category (persistent is 80.04, disciplined is 79.22, collaborative is 78.82, inquisitive is 76.68, and imaginative is 78.22). These data indicate that augmented reality-based projects that are applied to research are able to stimulate increased dimensions of student creativity so that the elaboration and exploration of learning materials and content can be optimal. The AR integrated e-module which has various learning support features can accommodate students' creativity in exploring and elaborating learning material. integration with AR provides space for students to produce various innovative works that are able to translate learning materials and content (Yousef, 2021; Chen et al., 2022; Lin & Wang, 2023). However, students need a more structured learning experience, so that project elaboration is more optimal and its integration with content and learning materials can be explored more comprehensively.

Conclusion

The dimensions of creativity analyzed and interpreted in this study consist of 5 elements, namely disciplined, imaginative, inquisitive, persistent, and collaborative. Interpretation and analysis of the data shows that the average score of the creativity dimension is 78.6 in the high category. The data shows that a project-based learning approach that is integrated with augmented reality is able to stimulate the dimensions of student creativity. Each element of the dimensions of student creativity increased in the high and very high categories, where the highest average score on the persistent element was 80.04 in the very high category and the lowest average score on the inquisitive element was 76.68 in the high category. Nevertheless, students need more learning experiences, so that project integration with learning materials and content can be optimized.

Conflict of Interests

The author(s) declares that there is no conflict of interest in this research and manuscript.

Acknowledgment

This research was supported by International Youth Researchers Fund 2022.

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