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# Students' Creativity Profiles in Constructing Independent Gates Learning Activity Using 4Dframe

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## Abstract

Creativity is one of the 21st century skills that students require for the future. The implementation of STEAM education in teaching and learning, whether in content or learning activities, has contributed to the creativity development. The objective of the study is to investigate the students' creativity profiles by employing STEAM approach and 4Dframe to construct a miniature independence-day memorial gate. This activity was selected because Indonesian Independence Day, organized in August, is very special. Many activities are frequently conducted to celebrate this annual event. One of which is by building a gate in front of the village. This research utilized a qualitative research method with a narrative design. There was twelve 8th-grade students who were recruited as respondents with various abilities grouped into high, medium, and low. The student's products were evaluated by CPAM (Creative Product Analysis Matrix) instrument. The CPAM assessment score presented 88% in novelty, 72% in resolution, and 88% in elaboration. Overall, their creativity profile is 82%, included in the high category. The conclusion is that student creativity profile through the STEAM approach assisted by 4Dframe is in the high category and can be applied in learning.

**Keywords**: 4Dframe, creativity, CPAM, STEAM

## Introduction

As a huge multicultural country, Indonesian owns a diverse way in celebrating the big days, including in the Independence Day commemoration. During the entire month of August, numerous activities are conducted to celebrate it as raising Indonesian flag, red and white decoration, carnivals, as well as local community contests. The Independence Day festivities are frequently welcomed by Indonesian citizen with excitement and enthusiasm (Laeli, Maulana, & Hamid, 2020). People also generally build independence memorial gate, called "*gapura kemerdekaan*" in their communities' entrance as a tribal representation of cultural characteristic, tradition, or belief (Purnegsih & Kholisya, 2019). The gates will look more beautiful during the night as they are equipped with lamp decoration.

The familiarity and festivities of independence memorial gate make it a potential context for hands-on learning activity. However, since real memorial gate is not easy to build, the students prefer to build a miniature. Designing and building an independent gate miniature can be a platform for the students in learning to be an engineer and employ the knowledge they gained in science, mathematics, and technology to create a real product. Mathematics, for instance, can be utilized for precision and measurements. For the final touch, it is expected that they do not ignore the aspects of art and beauty in the design. Such an

educational approach, combining or consists of Science, Technology, Engineering, Art, and Math, is understood as STEAM.

Maeda (2013) explained that STEAM is adding Art to STEM. He asserted that "art and science were once inextricably incorporated, both dedicated to identifying that truth and beauty are better together." Eger (2013) elaborated that STEAM ensures the whole brain's development in STEM through art. Hence, it can be implied that STEAM Education is a learning approach which utilizes science, technology, engineering, by employing art and mathematics as the access points for directing student inquiry, dialogue, and critical thinking (The Institute for Arts Integration and STEAM, 2021).

The objective of STEAM approach is to create students who are able to solve the problem issues through innovation, creativity, critical thinking, effective communication, collaboration, and ultimately latest knowledge (Quigley & Herro, 2016). Particularly in increasing creativity, implementing STEAM Education can encourage and stimulate creativity, as learners produce better and more creative packaging designs (Sakon & Petsangsri, 2021). In a research conducted by Wandari, Wijaya, and Agustin (2018), it was discovered that the students' creativity through the STEAM project is calculated based on CPSS rubric concerning on tree dimension which are novelty, resolution, and elaboration synthesis. The study encompassed that upon the end of the project, the students' creativity on novelty gains 76%, on the resolution 78%, on the elaboration and synthesis 69%, with a conclusion that the overall creativity is categorized as good.

From the studies above, it is evident that STEAM is significantly suitable to assist the students in obtaining 21st century life skills understood as 4C skills, which are critical thinking, creativity, communication, and collaboration. In enhancing those goals, creativity in particular, teachers can opt for physical manipulatives, either naturally acquired from the students' environment or produced commercially. The related example of manipulatives is 4Dframe.

A set of 4Dframe consists of hollow tubes (similar to drinking straws) and combining stars (bridges). One prior benefit of the set is its flexibility, as the tubes can be cut to preferred sizes and connected with specific elements to lengthen them. Furthermore, the connecting stars are freely bendable (Park, 2013). The essential aim of 4D Frame is to elevate the students' familiarity with geometric structures, within the context of problem-solving. This approach is based upon the creative exploration of the structures, attained through the step-by-step, scientific analysis of each stage in the construction process (Lavicza et al., 2018).

4Dframe can be employed for geometric modelling and creative real-world problem-, particularly concerning engineering, architecture, and applied mathematics. 4Dframe also provides opportunities for children to experiment with creative methods associated with mathematical art which stimulates inquiry, problem solving, as well as inter and transdisciplinary cooperation in the classroom (Fenyvesi et al., 2016).

Based on the introduction above, we are concerned on scrutinising how students implement their creativity in constructing "*gapura kemerdekaan*" miniature in the context of Indonesia independence celebration by applying 4Dframe set. The knowledge of students' creativity profiles is useful as preliminary information on the students' creativity and is able to reinforce teachers to enhance their future teaching and learning process to better support the students' creativity.

## Methods

This research employed a qualitative approach, in which the researcher portrayed the things happening during class activities, then collected and explained stories about students' lives and experience in the form of narratives (Creswell, 2011) with a quantitative descriptive approach. According to the characteristics of qualitative research elaborated by Sugiyono (2013), this study illustrated the meaning of the research data obtained, and the findings were not generalized. In collecting data, the researcher owns a role as a participant in the study. The researcher involved in the classroom activities and also observed situation.

This research was conducted in a State Junior High School in Malang regency, Indonesia. The participants of this study were twelve $8^{th}$ grade students, of which four possess high cognitive ability, four medium, and four low. The number of participants is limited due to the availability or practical tools and the healthy protocol that we had to conform in the pandemic situation. The participants were selected through purposive sampling, in which researcher employed their personal judgment, to select participants who would likely provide the data they require (Fraenkel, Wallen & Hyun, 2011). In this case, the author considered the participants based on their learning outcomes.

Data was collected through observation and student worksheets and analysed by employing descriptive approach. Additionally, we also utilized Creativity Product Analysis Matrix (CPAM) rubric developed by Besemer and Trefinger (1981). Besemer and Trefinger (1981) explained that analysing creative products is tremendously crucial in the assessment and study of creativity. As this research applied a project-based learning using STEAM approach, the researcher administered CPAM rubric to profile students' creativity.

The students' creativity data is based on a product that they have designed during a STEAM project-based learning activity in the classroom. The students' creativity was scored from 1 to 3 scale for each criterion as presented in Table 1.

Table 1
*CPAM Rubric by Besemer and Trefinger (1981)*

| Creative Dimension | Criterion | Score | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Novelty | Germinal | The lower level of germinal:<br>The product inspires others with the creation | Medium level of germinal:<br>The product inspires others to try something new | High level of germinal:<br>The product inspires others to try something new by directly provide ideas to develop more product design |
| | Original | The lower level of originality:<br>Students mostly employ the previous finding as their product idea | Medium level of originality:<br>Students employ the previous finding as their product idea, but they create a modification of the product | High level of originality:<br>The product idea origins from their own understanding |

| Creative Dimension | Criterion | Score | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| Resolution | Valuable | The lower level of valuable: The product is not compatible with the purpose and does not relate to the concept | Medium level of valuable: The product is compatible with the purpose and does not relate to the concept | High level of valuable: The product is compatible with the purpose and relates to the concept |
| | Useful | The lower level of usefulness: The product can be utilized once | Medium level of usefulness: The product can be utilized continuously with a certain requirement | High level of usefulness: The product can be utilized continuously without any requirement |
| Elaboration | Well Crafted | The lower level of well crafted: The product is completed well | Medium level of well crafted: The product is completed well with the good-looking design | High level of well crafted: Students attempt to provide interesting product design by applying some materials |
| | Expressive | The lower level of expressive: The product is displayed with lacking body language and require controlling tone, not understandable | Medium level of expressive: The product is displayed with lacking body language and require controlling tone, but understandable | High level of expressive: The product is displayed in a communicative (by employing effective body language and clear voice) and understandable manner |

The research stages encompass identifying a phenomenon to identify an educational problem; designing and preparing learning experience, incorporating the tools and materials; selecting participants to study; observing the participants and analysing their product; describing the participants' learning experience in writing (adapted from Creswell, 2011). This study requires two meetings to complete all stages of STEAM project-based learning. First meeting, researchers conducted a preparation stage leading students to understand the theme and scope. Second meeting, researchers conducted an implementation stage which let students create the product based on their drawing design. The learning activities of each stage are illustrated in a Table 2 below.

Table 2
*Research Stage*

| Meeting | Stage | Activity |
|---|---|---|
| 1st | Designing | Students recognize the project theme and scope<br>Students identify the information from the internet regarding the basic concept in designing the project<br>Students discuss tools and materials which will be employed<br>Students produce design drawing |

| Meeting | Stage | Activity |
|---|---|---|
| 2nd | Implementation | Students create the project based on the design drawing<br>Students conduct an actual test of their product |

Before the first meeting, the researcher obtained permits, prepared proposals, purchased tools and materials, and the revised the proposals with the guidance of the advisory teams from one of *Southeast Asia Ministry of Education Organization* concerning on math teacher development. The researcher also validated the instruments (lesson plan and student worksheet) to two validators, comprising of the head of the Mathematics Teachers Group and a colleague math teacher at the school of implementation. The validation aspect was about the component of lesson plan, STEAM approach, and students' worksheet. The instrument validation results revealed that the research instrument was employed with revisions. The things that need to be revised encompasses learning objectives which should be clearer, and the reinforcement for closing activities that must be provided.

After the preparation is complete and the research permit is received, the research was conducted on September 4 and 5, 2021, taking place in schools with the implemented health protocols.

## Results and Discussion

On the first day, through a power point slide show, the teacher provided an initial overview of the lesson which would be performed, and the activities that students would conduct (refer to Figure 1). The students were tremendously curious and paid attention to the information provided, as presented in the following photo.


*Figure 1.* Apperception activities.

The next activity was that the teacher was distributing Student Worksheet 1 containing the problems which had to be solved by each group. The problem was that they had to help their society to design a gate for celebrating Indonesian independence. The success criteria of the gates were the strength and sturdiness against shocks and wind, the beauty and patriotism portrayed by the design, minimal use of material, and the inclusion of 2D geometrical shape(s).

In completing worksheet 1, students were required to employ the EDP (engineering design process) principle as they were expected to act as an engineer (refer to Figure 2). They began discussing what a strong and sturdy gate might look like and the way to create it *(ask)*, then

identified example in the internet *(research)*. Next, they discussed in groups which design they preferred, made *plan* for their own gate, and *created* it by drawing on their worksheet.

*Figure 2.* EDP stage.

After about 60 minutes, all groups were finally able to complete their designs and drew them in the worksheet 1. The gate designs that they produced were displayed in the Figure 3.

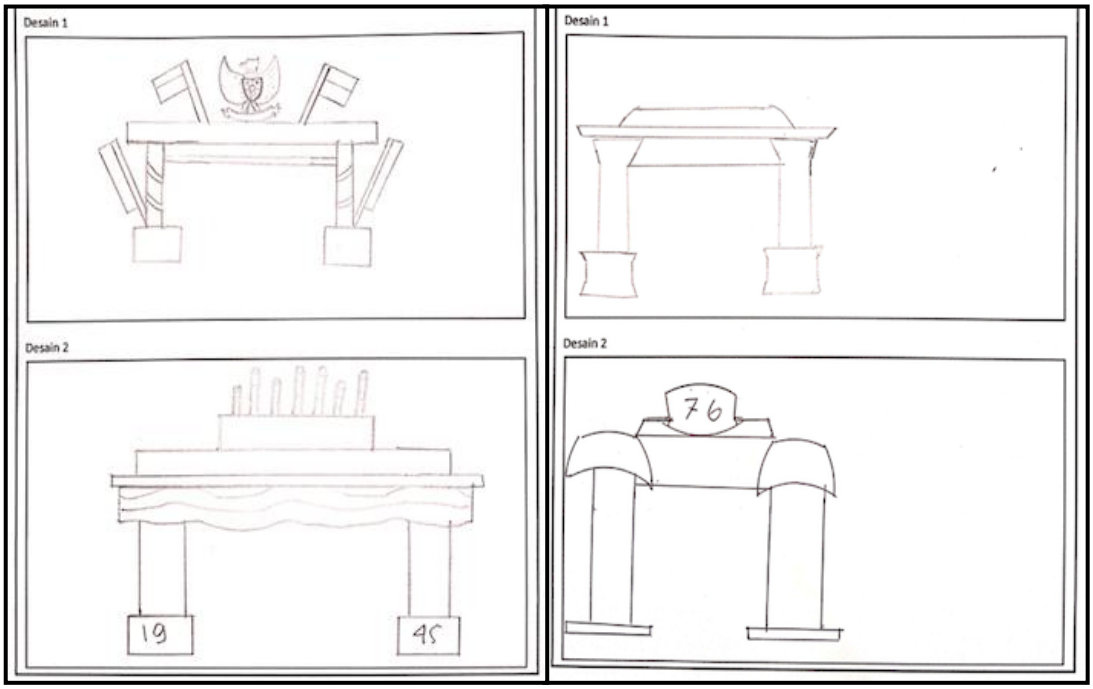



*Figure 3.* Students' gate design.

The next step was as instructed on the student worksheet. Each group had to discuss which design was the best and appropriate the success criteria, then drew it on flip chart paper and presented it to the other to obtain criticism and input from other groups. Their selected designs are shown in Figure 4.

*Figure 4.* Students selected gate design.

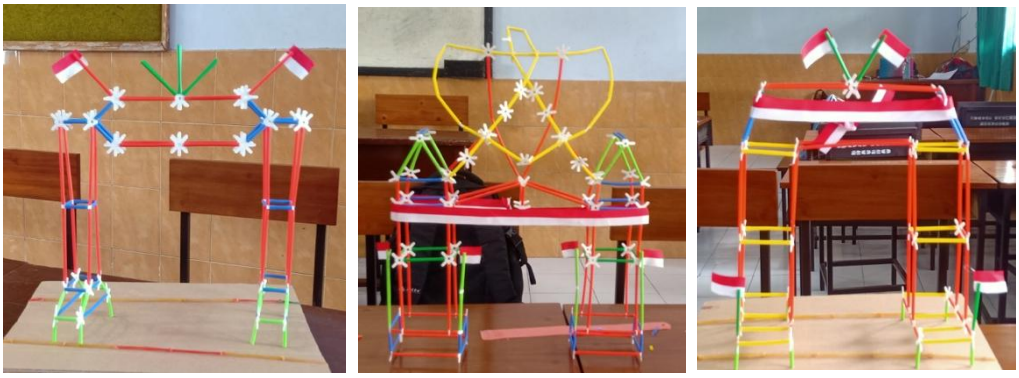
The second implementation day was the *create* stage. In this stage, the students were demanded to build their own independence gate design by utilizing 4Dframe. Aside from the success criteria mentioned previously, the students also had to consider the constraint, that was having to employ as little material as possible. In this case, they were only allowed to apply maximum 50 pieces of 4DFrame and 10 cm of red-and-white ribbon.

*Figure 5.* Students' activities with 4Dframe.

At this meeting, the teacher also provided reinforcement about what they had to perform in qualifying the success criteria. Each group was tremendously enthusiastic and excited to establish their gate using 4Dframe (Figure 5), because it was something new and fun for them. Their excitement is illustrated in the following photo.

*Figure 6.* Students' activities build and test their gates

After working for about 90 minutes, they finally completed it. To examine whether the design fulfilled the success criteria, each group had to assess the resistance of their gates to shocks and wind. The students were placing their designs on top of a specifically designed platform alongside a gadget with vibrometer application, shaking the platform with the increasing vigorousness, then taking note of the degree displayed on the gadget and the state of the gate on worksheet 2 (Figure 6). Some examples of the students' products are presented in Figure 7.



Group 1 Group 2 Group 3

*Figure 7.* Students' products

After they assessed their gates through shock and wind resistance, their products (independence gate) were observed for creativity with the help of CPAM rubric. The result is as follows (see Table 3).

Table 3
*Student Product Creativity Profiles*

| Creativity Dimension | Criteria | Group Score | | | Average |
|---|---|---|---|---|---|
| | | I | II | III | |
| Novelty | Germinal | 2 | 3 | 2 | 2.7 |
| | Original | 3 | 3 | 3 | |
| Resolution | Valuable | 2 | 3 | 2 | 2.2 |
| | Useful | 2 | 2 | 2 | |
| Elaboration | Well Crafted | 3 | 3 | 3 | 2.7 |
| | Expressive | 2 | 3 | 2 | |
| Total Average | | 2.3 | 2.8 | 2.3 | |
| | | | 2.46 | | |

Group 1 and group 3 acquired score 2.5 for novelty because their designs were almost similar with the gate designs discovered on the internet, while the novelty aspect of group 2 attained score 3 because its new design and concept. On average, the three groups received 2.7 for the creativity. For the resolution aspect, group 1 and group 3 scored 2 because their product almost fit or meet the problematic situation, while group 2 scored 2.5 because their product fit the problematic situation, and on average, the students received scores 2.2 for the resolution aspect. For the elaboration aspect, group 1 and group 3 also acquired score 2.5 because their product possessed a sense of wholeness or completeness, while group 2 obtained score 3 because their product worked with care to develop to its highest possible

level, and on average students gained scores 2.7. Overall, the product creativity score of the three groups was 2.46 or 82%, which based on the criteria incorporated in the high category. It is in accordance with the study of Aguilera and Ortiz-Revilla (2021) which unveiled that STEM and STEAM education both possess robust potential to foster students' creativity.

## Conclusion

Based on the results of the research, it was revealed that the profile of students' creativity in building the independence gate by employing 4Dframe was in the high category (82%). As the objective of this study, this research result can be utilized as initial information about students' creativity, particularly in STEAM learning assisted by 4Dframe. It has been evident to enhance elevating the students' creativity, hence, it can be implemented in mathematics learning. This research is merely preliminary research, thus, next research concerning on how to foster creativity by utilizing STEAM approach is highly recommended.

## References

Aguilera, D., & Ortiz-Revilla, J. (2021). STEM vs. STEAM education and student creativity: A systematic literature review. *Education Sciences, 11*(7), 331. https://doi.org/10.3390/educsci11070331.

Besemer, S. P., & Trefinger, D. J. (1981). Analysis of creative products: Review and synthesis. *The Journal of Creative Behavior*, *15*(3), 158–178. https://doi.org/10.1002/j.2162-6057.1981.tb00287.x

Creswell, J. W. (2011). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Prentice Hall Upper Saddle River, NJ.

Creswell, J. W. (2012). Educational Research (4th ed.). Nebraska: University of Nebraska-Lincoln

Eger, J. (2013). STEAM... now. *The STEAM Journal*, *1*(1), 1–7. https://doi.org/10.5642/steam.201301.08.

Fenyvesi, K., Park, H. G., Choi, T., Song, K., & Ahn, S. (2016). Modelling environmental problem-solving through STEAM activities: 4Dframes warka water workshop. *Proceedings of Bridges Finland Conference,* pp. 601–608. Retrieved from http://archive.bridgesmathart.org/2016/bridges2016-601.pdf

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education* (8th ed.). New York: Mc Graw Hill.

Laeli, S., Maulana, A., & Hamid, M. S. (2020). Penyadaran dan pengelolaan semangat Indonesia melalui perayaan ulang tahun Republik Indonesia ke 74. *Educivilia. Jurnal Pengabdian pada Masyarakat*, *1*(1), 71–77.

Lavicza, Z., Fenyvesi, K., Lieban, D., Park, H., Hohenwarter, M., Mantecon, J. D., & Prodromou, T. (2018). Mathematics learning through arts, technology and robotics: multi-and transdisciplinary STEAM approaches. *East Asia Regional Conference on Mathematics Education*, pp. 110–122. National Taiwan Normal University.

Maeda, J. (2013). STEM + Art = STEAM. *The STEAM Journal*. 1(1), 1–3. https://doi.org/10.5642/steam.201301.34

Park, H.-G. (2013). A workshop on n-regular polygon torus using 4D frame. *Proceedings of Bridges 2013: Mathematics, Music, Art, Architecture, Culture*, pp. 597–600.

Purnegsih, I. I., & Kholisya, U. K (2019). Representasi Kosmologi Jawa pada Gapura Kontemporer di desa-desa kabupaten karanganyar. *Cakrawala-Jurnal Humaniora*, *19*(1), 113–120.

Quigley, C. F., & Herro, D. (2016). "Finding the joy in the unknown": Implementation of STEAM teaching practices in middle school science and math classrooms. *Journal of Science Education and Technology*, *25*(3), 410–426. https://doi.org/10.1007/s10956-016-9602-z

Sakon, T., & Petsangsri, S. (2021). STEAM education for enhancing creativity in packaging design. *Archives of Design Research*, *34*(1), 21–31. https://doi.org/10.15187/adr.2021.02.34.1.21

Sugiyono. (2013). *Metode penelitian kuantitatif, kualitatif, dan tindakan*. Bandung: Alfabeta.

The Institute for Arts Integration and STEAM. (2021). What is STEAM education? Retrieved from: https://artsintegration.com/what-is-steam-education-in-k-12-schools/

Wandari, G. A., Wijaya, A. F. C., & Agustin, R. R. (2018). The effect of STEAM-based learning on students' concept mastery and creativity in learning light and optics. *Journal of Science Learning*, *2*(1), 26–32. https://doi.org/10.17509/jsl.v2i1.12878.