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Ethnomathematics and creativity study in the construction of batik based on fractal geometry aided by GeoGebra

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A B S T R A C T
This study aims to describe geometric objects that used by students on constructing fractal batik using GeoGebra, procedure that used to construct fractal batik design, and students creativity on the process of constructing fractal batik. The qualitative descriptive research was applies including data collection, data separation, data analysis and conclusions. The data were obtained from 97 students of mathematics education at Islamic institution in Indonesia. The research results showed that fractal batik was constructed from a single geometric shape and combination of 2, 3, and 4 single geometric shapes through steps (a) made basic patterns using geometric shapes in GeoGebra, (b) Made New Tools to perform repetitions (iteration), (c) Determined the type of transformation that used to repeat the basic patterns, and (d) Constructed geometric fractal batik. Based on the creativity indicators fluency, 3 types of geometric fractals can be obtained, namely (a) Fractals with Repetition and Enlargement (FPB), (b) Fractals with Repetition and Change Position (FPS), and (c) Fractals with Mix Repetition (FPC). Based on the flexibility indicator, there are 32 basic geometric shapes that develop basic patterns by applying 15 types of transformation consist of Single Transformation, Double Transformation, Triple Transformation and Quadruple Transformation. Meanwhile, on the originality indicator, P3 is the basic shape that has been mostly developed into geometric fractal batik which is a combination of equilateral triangles and squares.

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1. INTRODUCTION

Currently, all sectors of life have penetrated into the era of the industrial revolution 4.0, one of which is the use of technology and information in various fields. The development of technology and information is a result of human creativity. The development of technology and information is based on the human desire to create changes in various fields of life. This change is in order to solve life's problems that require easier, more effective and efficient methods of solving problems. Many modern applications made by local children such as *Gojek*, *Grab*, *Ruang Guru*, *Traveloka*, *Link Aja*, *Dana*, *OVO*, *KAI Access*, etc. are some evidence that the results of creative thinking could solve problems not only in the sector of individual problems but also the problems of people in general.

All of the applications were the creative products that are the result of creative thinking heighten various efforts to encourage the ability to think creatively as a provision for life in facing the globalization era. One of the ways to heighten creative thinking is improving the quality of education. This is in accordance with the objectives of education in which states that education aims to shape students into creative, independent, and capable human beings. This opinion states that education in general plays a role in encouraging students' creative thinking skills (Presiden Republik Indonesia, 2003). To realize these efforts, it is necessary to provide skills and abilities to think creatively in learning activities at schools and at universities.

The government suggests that education at universities can be done by providing an enjoyable learning atmosphere and through activities that can develop creativity (Menristekdikti, 2017). This means that the government expects education in higher education to be carried out through fun activities in order to provide opportunities for students to be creative. Through this activity, it is hoped that students will have opportunities to create in accordance with their fields. To implement and give opportunities for students the learning process in class can be done through hybrid learning that combines conventional learning and ICT.

The importance of creative thinking ability and creativity is also the main focus in the development of the PTKI curriculum which refers to the SN-Dikti which states lecturer has a role as learning facilitator so that students are able to show creative performance by integrating cognitive, psychomotor and affective abilities as a whole (Direktur Jenderal Pendidikan Islam, 2018). The educational expectations expressed by the government have not been fully realized, this can be seen in the mathematics learning activities in the classroom that have not emphasized the development of student creativity. Mathematics learning activities are dominated by the use of formulas and verbal explanations of mathematical concepts without considering the development of student creativity. Mathematics learning activities in the classroom are arranged mechanically using the lecture method, where the teacher acts as the only source of learning and students listen, take notes, practice questions as the teacher instructed. This mathematical activity may affect the potential of students not optimal and limits their creative space.

Creativity and independent learning as a result of using ICT in learning (Geng, Law, & Niu, 2019; Munawaroh, 2017; Shao, Li, & Wang, 2022). The importance of using information and communication technology is an effort to enhance the creativity of students has not been matched by reality. Mathematics learning activities that have not optimally integrated ICT are caused by many factors including limited facilities in educational units, the unavailability of an educational unit curriculum that requires the use of information and communication technology in learning, the lack of the ability of teachers and students to operate and utilize information and communication technology.

In fact, learning mathematics in the classroom is a systematic activity that emphasizes cognitive abilities, which is the skills of working on math problems and overriding other activities on the psychomotor and affective components. Whereas learning activities in the classroom should be activities that combine cognitive, affective and psychomotor components. This fact can be seen in the field geometry lecture activities that prioritize students to have the ability in terms of simple geometric construction without any meaning and development of concepts to a more complex. Lectures are carried out solely to provide material provisions for prospective teachers in teaching mathematics in schools by disregarding the creative abilities of prospective teachers. Lack of lecture activities that can develop teachers' creative abilities causes mathematics material to not develop over time.

Based on the illustration, it is necessary to have learning activities or lectures that can develop students' creative abilities freely and do not rule out the content of the courses being studied. Several studies on creativity have been applied in the process of lesson planning, learning implementation and learning evaluation. In the process of lesson planning creativity is applied in the development of teaching materials, in the process of implementing creativity is applied in the application of learning models, strategies and methods to increase creativity, while in evaluation process creativity research is carried out to examine the characteristics of students' creativity in solving math problems(A Alvani, 2016; Juniati & Budayasa, 2017; Kusnati, 2018; T.F Nisa, 2011; Nurlelah, E, 2009; Patmalasari, Afifah, & Resbiantoro, 2017; Supandi, Kusumaningsih, Ariyanto, Nurlaelah, & Turmudi, 2013; Zainudin, 2014; Zulkarnaen, R, 2015).

GeoGebra can be integrated in mathematics learning to develop technology-based teaching professionalism (Suryani et al., 2020). In the process of learning mathematics in higher education, student creativity in Geometry lectures can be developed through learning activities by construct of fractal batik motifs aided by *GeoGebra*. Fractal batik designs are inspired by fractal geometry and Indonesian batik motifs that have been officially recognized by UNESCO as intangible human heritage. A fractal is a geometric image created using iteration. Iteration is a process of repeating the same pattern infinitely. Fractals are the same as themselves this means that small details with other smaller details have similar properties to the original form. One type of fractal that has been discovered is the Sierpinski triangle fractal as shown in Figure 1. This fractal has the form of an infinite number of repeated triangles (Boyd,C.J., Cummins,J., Malloy, C.E., Carter, J.A., Flores, A, 2008)

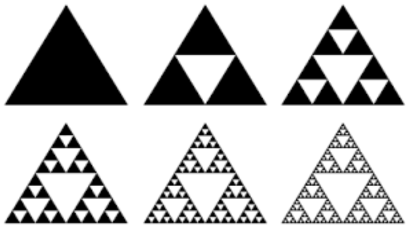


Figure 1. Sierpinski fractal

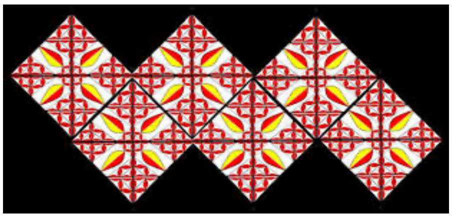


Figure 2. Batik with iteration (repetition)

All this time, batik designs has been constructed with the help of software *Jbatik*. For students and the general public *JBatik* software is not a familiar software so that when software is used by students will encounter many difficulties. The example of batik design using *Jbatik* is shown in Figure 2. In the world of mathematics education, there are many software that can help in the construction process and mathematical computation. One of the mathematical software that can assist in the process of geometric construction or mathematical analysis is *GeoGebra*. Aided by *GeoGebra*, researchers conduct inquiry on the creativity of mathematics education students in fractal batik construction with the help of mathematical software.

2. METHOD

This research was qualitative descriptive. This research described the geometric objects used, the tools in *GeoGebra* used and the level of creativity of students in the process of making fractal batik constructions assisted by *GeoGebra*. Therefore, the instrument in this study is the researchers who were collecting data on geometric objects, tools in *GeoGebra* and the level of student creativity in making farctal batik assisted by *GeoGebra*. This is in accordance with the characteristics of qualitative research put by Cresswell, Hatch, Marshall & Rossman in Creswell which suggests that researchers are the main instrument in qualitative research. In this case, researchers collect their own data through document assessment, behavioural observations or interviews with the object to be studied (Creswell, J.W, 2014).

This research subjects were 97 students of mathematics tadris department at IAIN Kediri, Indonesia. The consideration of location selection and research subjects is that only students on tadris mathematics program receive field geometry courses. Sources of data in this study are the work of students in the form of fractal batik which is processed by researchers to analyse their creativity. To determine the level of student creativity, researchers used an additional instrument in the form of guidelines for assessing the creativity of the work which was arranged based on the indicators of creativity. After the research data is obtained, the data is analysed using qualitative research analysis which is guided by a series of activities as follows.

2.1. Data Collection

This data collection is done by using data collection techniques, namely documentation and collection of audio visual material. In this process, process of collecting student works in the form of Geometric Fractal batik files in *Geogebra* format was carried out.

2.2. Data Separation

In the research process, the information obtained through data collection techniques sometimes provides too much information. Therefore, the data must be grouped according to the parts to the research needs. In this process, the documents / files made by students are separated into geometric patterns of the elements that make up the batik.

2.3. Data Analysis

After the data of the fractal batik work is separated into the basic patterns, fractal batik in each of the basic patterns is analysed for the level of originality, the truth of fractal motifs (fluency), and the types of development (flexibility).

2.4. Conclusion

Using the results of the data analysis process to make conclusions related to the theory used. To answer the first formulation problem, which geometric objects were used by students in constructing fractal batik aided by *GeoGebra*, a descriptive analysis was carried out by mapping the results of the fractal batik construction based on the basic pattern. Furthermore, the data regarding the basic pattern of batik is tabulated in such a way that it can be seen the various kinds of basic motifs constructed by students and how many students use the same basic motives.

To answer the second problem formulation regarding the tools in *GeoGebra* which are used by students in constructing fractal batik, a descriptive analysis is carried out through the fractal batik construction project files from students. Meanwhile, to determine the level of student creativity in constructing batik fractal using *GeoGebra* research data in the form of construction of batik Geometry using *Geogebra* are based on the indicators of creative thinking that includes fluency, flexibility and authenticity (originality). Fluency is the student's ability to produce a lot of answers /ideas appropriately and smoothly, flexibility means the ability to provide many different ways of presenting ideas, and authenticity (originality) means the ability of students to produce a new or unique way. Because of this, the formulation of the third problem can be identified by separating the data from the fractal batik work into the basic patterns of batik, then the fractal batik in each of the basic patterns is analysed for its level of similarity (originality), the truth of fractal motifs (fluency), and types of development of basic patterns of batik patterns (flexibility).

3. RESULTS AND DISCUSSION

3.1. Creativity

Creativity is always emphasized on the product or the final result of a series of orders/activities carried out. Moonley in Shouksmith suggests there are four approaches to creativity that is a product created, the process of creation, individual creator *(the person of the creator),* and the environment from which the creation of *(environment which creating come about*) (Shouksmith, G, 1979). Based on this opinion, it appears that creativity cannot be judged by the products produced, but can be seen from the manufacturing process, individual creators, and the environment used. This opinion is strengthened by Gie who argues that apart from the products produced, creativity can be assessed from objects in the form of new thoughts, ideas, information, concepts, experiences and knowledge that the maker has never previously known (Gie, T.L, 2003).

Hurlock suggests that the creativity of a product can be seen from the newness of the product and the small similarity of the resulting product compared to previous products(Hurlock, E.B, 1999). Apart from being new and different, creativity can also be observed from other indicators, namely creative products are new works of a series of activities that are purposeful and directed(Weisberg, R.W, 2006). This means that to assess the creativity of a product it can be seen from the newness of the resulting product, *unique* (different from previous works) and the resulting product is the result of purposeful and directed activities.

In the learning process, in addition to novelty and uniqueness, there are indicators of creative thinking in solving problems, namely finding possible answers to problems that emphasize quantity (many types of answers to problems), the truth of the answers produced and the diversity of types of answers(Munandar, U, 1999). There are many opinions about creativity, in order to obtain clear indicators of creativity it is necessary to clearly define the definition and indicators of creative thinking. Olson suggests two elements of creativity, namely fluency and flexibility (Olson, R.W, 1996). Fluency is related to the ability to express ideas smoothly and quickly, while flexibility is related to the ability to come up with different ideas to solve problems. Equipped by Williams in Al Khalili states that the characteristics of creative thinking are fluency (the ability to produce a large number of thoughts or questions), flexibility (the ability to produce many kinds of thoughts), originality (the ability to think in new / unique ways), elaboration (the ability to add or detail things in detail from objects, ideas, and situations) (Abdussalam, A.K, 2006). Based on the opinion, indicators of creative thinking can be defined into several things, namely fluency (the ability to find thoughts or ideas correctly), the ability to find different thoughts or answers, the ability to produce many kinds of thoughts, originality (the ability to think in new ways) and elaboration (the ability to add detail of objects / ideas / situations). Siswono which states that the assessment indicators used to assess the creativity level of students are as follows (Siswono, T.Y.E, 2018) :

Table 1. Creative thinking scoring based on the responses given (Second model)

Indicators	Point
The Completion	Correct answer, score 1 Wrong answer, score 0 (assessment not continued with)
Fluency (various answers or methods)	More than one correct answer and different from the first answer, score 2 Correct answer with one different answer but the way is same, score 1
Flexibility (more than one way of)	The solution method is more than one way and conceptually different, score 2 The solution method of completion is more than one way but not differ conceptually, score 1 The solution method is the same as the first one, score 0
Recency (different answers or solutions)	Answers more than one and do not show a different pattern, score 2 More than one different way, do not show a pattern, score 2 Answers or more than one way and only vary, the score 1 Answer or method is not more than one and only varies, score 0
Maximum Score for one task	7

The assessment indicators developed by Tatag and Bosch are indicators for assessing students in solving problems. In contrast to this, in this study it was not creativity in solving problems that were observed but the creativity of students in making a product based on the orders given. The products were analysed using indicators fluency which is the student's ability to produce a lot of answers / ideas appropriately and smoothly, flexibility *(flexibility)* which means the ability to give a lot of different ways of presenting ideas, and authenticity *(originality)* which means the ability of students to produce way new or unique.

3.2. Batik Fractal Geometry

Serra states that geometry includes the study of the properties of shapes such as circles, hexagons and pentagons (Serra, M, 2008). When seen in everyday life geometry patterns in nature are used into art forms. When observed, the shape of the leaf bone represents a line of symmetry when connected with geometrical concepts. In the concept of geometry this is called a *reflectional symmetry.* Another mathematical concept related to symmetry is *rotational symmetry,* which is to rotate an object with a certain degree and center point so that it will produce a beautiful pattern. One example of *rotational symmetry* is as follows:

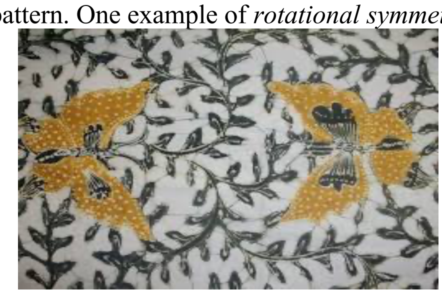


Figure 3. *Rotational Symmetry* in Batik

Based on Figure 3, the butterfly object in batik is rotated with a certain centre point and at a certain angle so that it gets a new butterfly position. Apart from the *reflectional* and *rotational symmetry* which can be applied in the representation of batik motifs, there is another mathematical concept, namely the *translational symmetry* which is obtained by shifting the same motif from one place to another.

As well as being defined according to the technique of displacement and repetition of batik motifs, Serra describes geometric art in several forms of design including line design, circle design, optical art, knot design, tile design in Islam (Serra, M, 2008). These geometric arts have also been used in the works of art which we know as Batik. Batik is an oral and non-material cultural heritage that is established by UNESCO as an illustrated work of art which is specially made by writing or lighting the night on a piece of cloth. The word Batik comes from the Javanese language *ambhatik* which comes from the word *amba* which means area and *point* which means point. What is further interpreted as a work of art created by connecting the dots to become a specific motif ("Batik," 2020).

For the purposes of this research, another term that must be understood is the term fractal. Fractals are geometric bodies that are rough at all scales and appear to be divisible in radical ways. Fractals can be broken down into several parts which are all similar to the original fractal. Fractals have infinite detail and have a self-similar structure at different magnification levels. A fractal can be generated by repeating a pattern, usually in a recursive or iterative process. Larson, et al stated that a fractal is an object equal to itself that can be expanded to see the whole object (Larson, R., Boswell,L., Kanold, T.D, Stiff, L., 2007). This is confirmed by Boyd, Cummins, Malloy, et al who state that a fractal is a geometric image created using iteration (Boyd,C.J., Cummins,J., Malloy, C.E., Carter, J.A., Flores, A, 2008). Iteration is a process of repeating the same pattern over and over again. Fractals are the same as themselves this means that small details with other smaller details have similar properties to the original form.

Based on some of the opinions, fractals are a form of geometry (the study of the properties and characteristics of a shape) which has something in common with itself when viewed with repeated magnification. Fractals are obtained by repeating To apply the principle of repetition or iteration of basic shapes into fractal batik, several used *tools are* in *Geogebra* as shown in Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8.

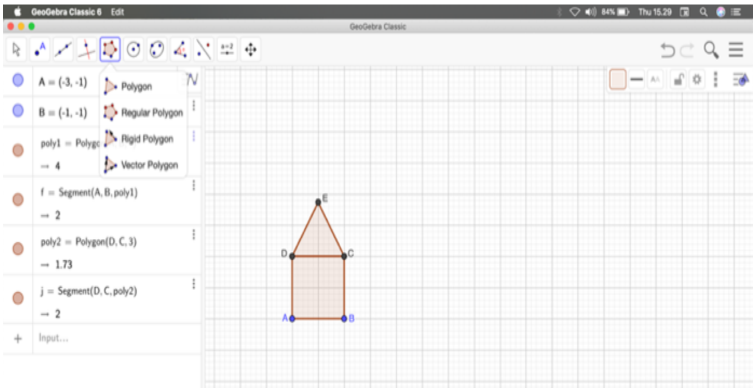


Figure 4. Basic Motive

The first step to making fractal batik with *Geogebra* is to make the basic motif that will be subjected to the process of *iteration*. In the example above, the basic motive used is a square and equilateral triangle which can be constructed using the *polygon tools.* The next step after constructing the basic motive is to create *special tools* by utilizing the menu *tools* then *create new tools.* This new tool will iterate according to the settings we made.

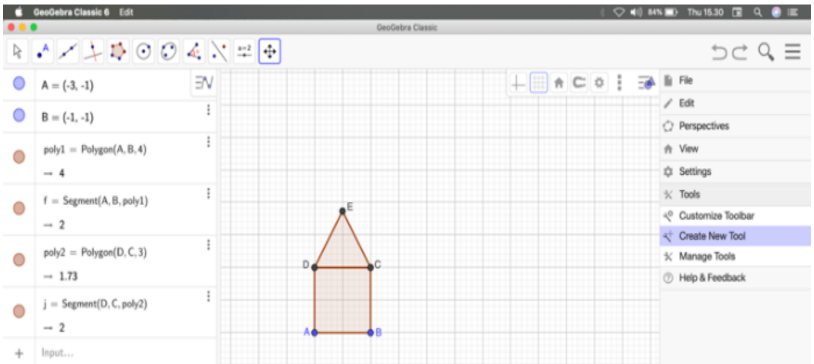


Figure 5. Creating *Iteration Tools The*

The process of setting these *tools* requires precision and depends on what kind of *iteration* you want. In the next part of the process of creating *iteration tool*, *Geogebra* users are asked to select the selected object as a command to iterate objects. Meanwhile, to set the output objects of the iteration results can be arranged in the section *output objects.* In the example below *the input object* is a point A and B so that when the *Geogebra* user click a point C and E that point will serve as the foundation of the basic motif as well as points A and B.

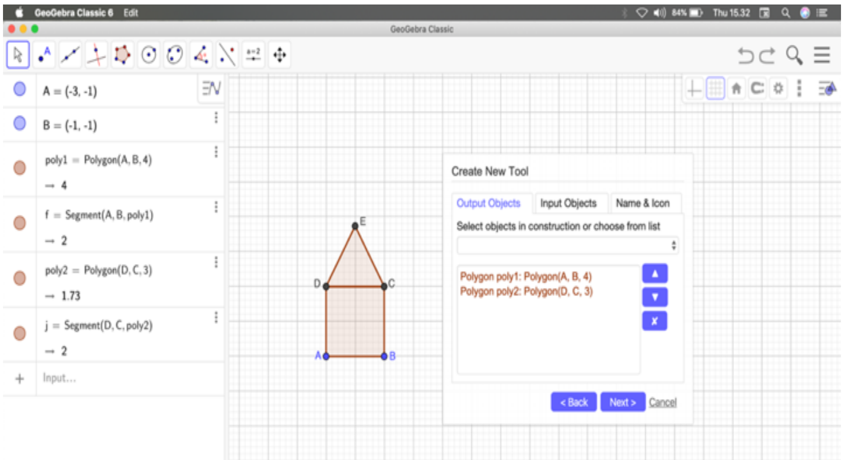


Figure 6. Settings *Output Objects*

In this example, the settings *output object* used are *polygon 1* and *polygon 2,* namely a square and an equilateral triangle. So that the output of the process *iteration* will result in a repetition of *polygon 1* and *polygon 2* with different bases. The next process is to name the *iteration tools* created in the section *name & icon.* In this example the iteration icon name is named *iteration 1* as shown in the following figure:

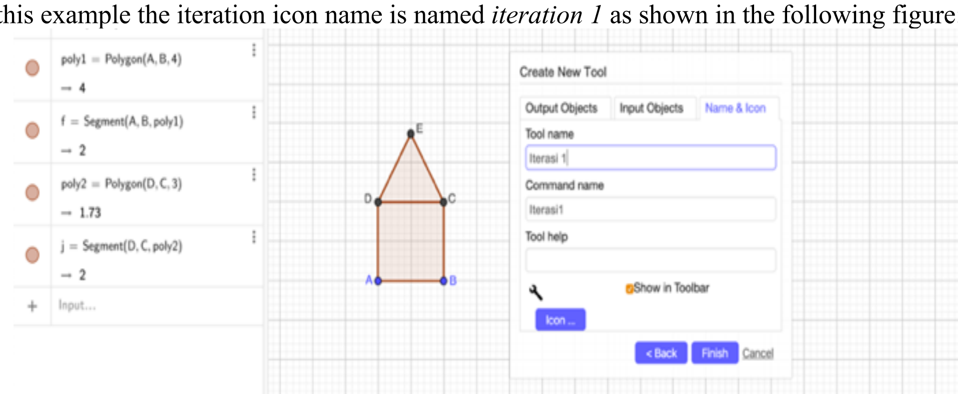


Figure 7. Name the *Tools Icon*

After the *iteration tool is* successfully created, the next step is to *iterate the* object. To perform the object iteration process, activate the *iteration tool* that has been created on the *toolbar* then perform the iteration process on the object according to the *input objects* that have been made.

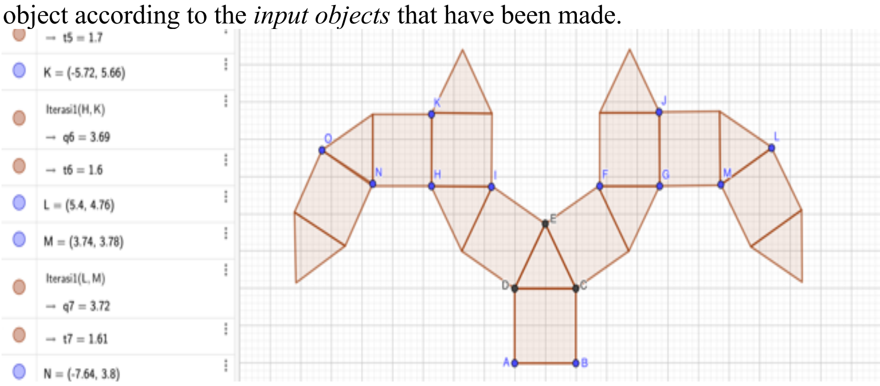


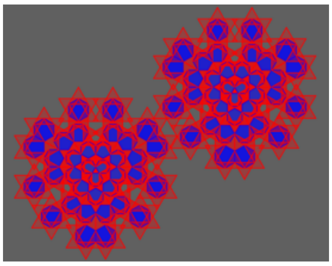
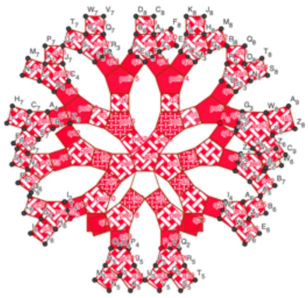
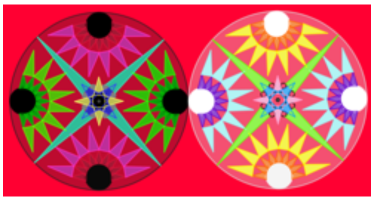
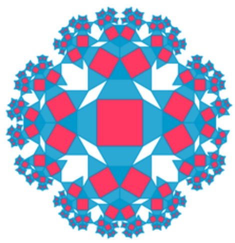
Figure 8. Results of *Iteration* Objects

The iteration process can be adjusted in such a way so that it is in accordance with the batik design to be made. By creating *tools*, other types of object iteration can be done even if using the same basic motive.

3.3. Batik Fractal Geometry Aided by Geogebra

Based on the results obtained by various forms of batik fractal geometric construction, basic shapes and types of the basic pattern transformation as follows:

Table 2. Basic Geometric Shapes, Construction Batik Fractal and Transformation type

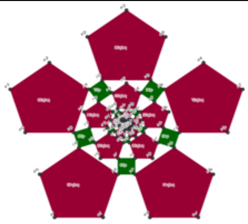
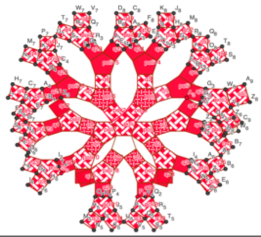
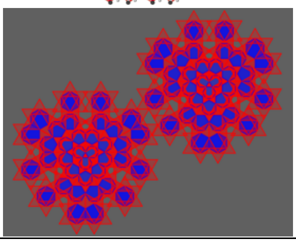
Geometric Basic Shape	Basic Construction of batik	Transformation Type of Basic Pattern
Hexagon and Equilateral Triangles (P1)		Dilatation, Rotation (DR)
Pentagon and Square (P2)		Reflection, Rotation (RRf)
Square and Equilateral Triangles (P3)		Dilatation, Rotation (DR)
Square and Equilateral Triangles (P3)		Dilatation, Rotation (DR)

Based on the results of this study, there are 297 basic geometric fractal batik constructions spread in 32 basic geometric shape patterns. For the next 297 batik construction is analysed using indicators creativity fluency, flexibility and authenticity (originality).

3.4. Student creativity in Batik Fractal Geometry Analysed by Fluency Indicator

The first creativity indicator is *fluency* that can be obtained by analysing the fractal motif truth in every basic batik fractal pattern made by students. The truth of this fractal motif can be obtained based on the definition of fractal in the previous section. Fractal is a form of geometry (the study of the properties and characteristics of a shape) which has something in common with itself when viewed with repeated magnification. Fractals are obtained by repeating geometric shapes. Based on this theory, we can group the results of student fractals into 3 types of fractals, namely (1) Fractals with Repetition and *Enlargement (FPB)*, (2) Fractals with Repetition and Position Change *(FPS)* and (3) Fractals with Mixed Repetition *(FPC)*. Some examples of fractal category is illustrated in Table 3.

Table 3. Fractal Categories based on Fluency Indicator

Geometric Basic Shapes	Basic Construction	Fractal Category
Pentagon and Square (P2)		FPB
Pentagon and Square (P2)		FPS
Hexagon and Equilateral Triangles (P1)		FPC

Based on the table and fractal category, the following can be seen:

3.4.1 **FPB** or Fractal with Repetition and Enlargement is a fractal batik motif obtained by enlarging the basic motif repeatedly. The result of this process is that if the process is carried out *zooming* on the fractal batik motif, it will obtain the same shape as the fractal batik motif before *zooming.*

3.4.2 **FPS** or Fractal with Repetition and Position Change is a fractal batik motif obtained by repeating itself by changing the position of the basic motif repeatedly. This change in position can be done by involving a type of transformation of reflection (reflection), translation (shift) and rotation (rotation) of the basic motif of batik. Therefore the batik motif produced from this *(FPS)* will be in the form of a basic motif that is lined up or a basic motif that is rotated in a circle.

3.4.3 **FPC** or Fractal with Mixed Repetition is a fractal batik motif that is obtained by repeating the basic motif through the process of enlarging the base motif while changing the position of the basic motif repeatedly. Therefore the batik motif that is produced from this *(FPC*) will be in the form of basic motifs that are lined, rotating as well as basic motifs that are getting bigger / smaller.

Categorization of fractal types above can used to analyze all the results of student fractal batik as follows:

Table 4. Results of *FPB, FPS* and *FPC*

Fractal Category	Number of Motives Produced	Percentage
Fractals with Repetition and Enlargement (FPB)	44	14.81
Fractals with Repetitions and Change of Position (FPS)	112	37.71
Fractals with Mixed Repetitions (FPC)	141	47.47

According to the table 9 can be concluded that based on indicators of fluency are 14.81% categories fractal using *FPB pattern,* 37.71% using *FPS* and 47.47% using *FPC.* Therefore, based on the work of geometric fractal batik, students of IAIN Kediri produced Fractals with the category of repetition and mixture *(FPC*).

3.5. Student creativity in Batik Fractal Geometry Analysed by Flexibility Indicator

Creativity of students analysed by flexibility indicator can be obtained by analysing the types of developing the basic pattern of batik. Based on the basic geometric fractal batik motifs from 97 students, the basic patterns is then grouped into the basic geometric shapes of batik. Based on the results of research from 97 respondents, 32 basic geometric shapes were obtained as shown in Table 5.

Table 5. List of Basic Geometric Patterns for Batik Fractals

Patterns Code	Basic Geometric Form
P1	Hexagon & Triangle
P2	Pentagon & Square
P3	Square & Triangle
P4	Hexagon & Square
P5	Hexagon & Pentagon
P6	Octagon & Triangle
P7	Triangle
P8	Square
P9	Pentagon & Triangle
P10	Square & Circle
P11	Pentagon & Circle
P12	Pentagon
P13	Circle
P14	Pentagon, Equilateral Triangle & Triangle
P15	Hexagon & Circle
P16	Paralellogram & Square
P17	Octagon & Pentagon
P18	Hexagon & Nonagon
P19	Heptagon & Square
P20	Triangle & Circle
P21	Pentagon, Square, & Triangle
P22	Nonagon & Square
P23	*N-gon* & Triangle
P24	Octagon, Pentagon, Square, & Triangle
P25	Hexagon, Square, & Triangle
P26	Hexagon
P27	Decagon & Triangle
P28	Heptagon & Hexagon
P29	Heptagon & Triangle
P30	Octagon & Square
P31	Heptagon & Pentagon
P32	Triangle, Square, Pentagon, & Hexagon

In addition another aspect in flexibility indicators batik fractal is also seen on the construction aspects of transformation used. The following are the types of geometric transformations used in each basic pattern as shown in Table 6.

Table 6. Types, codes & percentage of basic

Types of Basic Patterns Transformation	Transformation Code	Percentage
Reflection	Rf	1.01
Rotation	R	12.46
Dilatation	D	10.44
Translation	T	2.69
Reflection & Rotation	RRf	13.80

Reflection & Dilatation	DRf	6.06
Reflection &Translation	TRf	2.69
Rotation & Dilatation	DR	28.28
Rotation & Translation	TR	4.38
Dilatation & Translation	DT	6.06
Dilatation, Reflection, Rotation	DRRf	5.39
Translation, Dilatation, Rotation	TDR	3.03
Translation, Rotation, Reflection	TRRf	2.02
Dilatation, Translation, Reflection	DTRf	0.67
Translation, Dilatation, Rotation, Reflection	TDRRf	1.01

Based on Table 6, it can be seen that the fractal batik results of 97 students used the development of basic patterns by applying 15 types of transformations consisting of *Single Transformation, Double Transformation, Triple Transformation* and *Quadruple Transformation.* The most widely used development is by using *Double Transformation,* namely Rotation and Dilatation. Meanwhile, the least used is using *Triple Transformation* namely Dilatation, Translation and Reflection.

3.6. Student creativity in Batik Fractal Geometry Analysed by Originality Indicator

Creativity of students in the indicators of Authenticity *(Originality)* can be obtained by analyzing the students' ability to make basic motif fractal batik in new or unique way. Based on the basic geometric fractal batik motifs from 97 students, the batik is then analysed how many batik constructs are in each basic pattern. Based on the results of research from 97 respondents, the following data were obtained:

Table 7. Many Batik Motifs in Each Basic Pattern Developed

Code	Basic Geometric Forms	Count of Motifs
P7	Triangle	10
P8	Square	15
P12	Equilateral & Pentagon	11
P26	Hexagon	7
P13	Circle	4
P3	Equilateral Triangle & Square	67
P9	Equilateral Triangle & Hexagon	26
P1	Equilateral Triangle & Hexagon	29
P23	Equilateral Triangle & N- Gon	3
P29	Equilateral Triangle & Heptagon	1
P2	Square & Pentagon	31
P4	Square & Hexagon	37
P19	Square & Heptagon	2
P30	Square & Octagon	1
P22	Square & Nonagon	1
P10	Square & Circle	4
P16	Square & Parallelogram	1
P5	Pentagon & Hexagon	11
P31	Pentagon & Heptagon	1
P17	Pentagon & Octagon	4
P11	Pentagon & Circle	3
P28	Hexagon & Heptagon	4
P18	Hexagon & Nonagon	1
P6	Hexagon & Triangle	5
P27	Decagon & Triangle	1
P20	Circle & Triangle	4
P15	Circle & Hexagon	2
P21	Triangle, Square & Pentagon	2
P25	Equilateral Triangle, Square, & Hexagon	3
P14	Equilateral Triangle, Triangle, & Pentagon	1

P32	Triangle, Square, Pentagon, & Hexagon	1
P24	Triangle, Square, Pentagon, & Octagon	4

Based on Table 12, the basic shape that is mostly developed into geometric fractal batik motifs is P3, which is a combination of the geometric shapes of equilateral triangles and squares. While the basic shapes that are least developed into geometric fractal batik motifs include Square & Segidelapan (P30), Square & pentagon (P22), Square & Parallelogram (P16), Segilima & Segit Tujuh (P31), Segienam & pentagon (P18), Ten & Triangle (P27), Equilateral Triangle, Random Triangle & Triangle (P14), and Triangle, Square, Triangle & Hexagon (P32).

4. CONCLUSION

In summary, this study found that (1) the geometric objects used by students in constructing geometric fractal batik using GeoGebra include a single geometric shape, a combination of 2 single geometric shapes, a combination of 3 shapes, single geometric, and a combination of 4 single geometric shapes; (2) geometric fractal batik can be constructed with GeoGebra through a series of steps: (a) creating basic shapes geometric fractal batik using geometric shapes available in GeoGebra, (b) Creating *New Tools* that are used to *iterate* the basic pattern in the previous step, (c) Determine the type of transformation used to repeat the basic shapes, and the last step is (d) Construct geometric fractal batik; and (3) based on the indicators of creativity fluency, 3 types of geometric fractals can be obtained, namely (a) Fractals with Repetition and *Enlargement (FPB)*, (b) Fractals with Repetition and Position Change *(FPS)* and (c) Fractals with Mixed Repetition *(FPC).* Based on the indicators of flexibility can be obtained 32 basic shapes of geometry fractal that can be to develop to basic motif by applying 15 types of transformations consisting of *Single Transformation, Double Transformation, Triple Transformation* and *Quadruple Transformation.* While on the authenticity (originality) indicator it can be seen that the basic shape that is mostly developed into geometric fractal batik motif is P3, which is a combination of the geometric shapes equilateral triangles and squares. While the basic shapes that are least developed into geometric fractal batik motifs are Square & Octagon (P30), Square & Nonagon (P22).

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