

Field-based tasks with technology to reduce mathematics anxiety and improve performance

Dwi Juniati & I Ketut Budayasa

State University of Surabaya
Surabaya, East Java, Indonesia

ABSTRACT: Many students feel anxious when learning mathematics and often do not know the benefits of the theory they are learning. So, a strategy is needed to reduce anxiety and increase motivation in learning mathematics. In the globalisation era, graduates are expected to develop competence in the use of technology, teamwork, and acquire specific knowledge, like mathematics. Therefore, this study aimed to develop field-based tasks with technology to reduce mathematics anxiety and increase student motivation in learning geometry, so that mathematics performance is improved. The developed tasks consist of three parts: application tasks, experiment tasks and field-based projects. Based on the test results, it was found that the students' anxiety level of 95% has decreased, while their motivation to learn geometry has increased. The findings also indicate that the students are motivated to learn geometry, because they know how to apply the theories that they have learned to solve various problems, and are excited as they realise how technology can make it easier to solve problems. By solving field-based tasks, students' mathematics performance has improved.

INTRODUCTION

The challenges of current globalisation necessitate highly competitive and reliable workforce. In this endeavour, education plays a very important role. Misra stated that globalisation ideally should be seen as a phenomenon that demands a broad change in the system of education [1]. Technology has impacted almost every aspect of life today, and education is no exception. The very rapid development of technology and information makes educators inevitably have to equip students with skills to use technology in various problem-solving tasks.

Efforts to improve the quality of education in Indonesia are carried out by changing to a new curriculum; namely, the KKNI-based curriculum. One expectation that graduates from KKNI-based undergraduate programmes must fulfil is being able to apply their expertise and take advantage of science, technology or the arts in their specific fields in solving problems, and being able to adapt to the circumstances at hand. Therefore, training in how to take advantage of the learned theory and technology in problem-solving is so important for students [2].

Geometry is the oldest branch of mathematics that focuses on space, shape, distance, size and the relative position of figures. It is an important branch of mathematics to learn, because many professions involve geometry, such as architects, mechanical engineers, technicians, surveyors, draughtsmen and many others. In some countries, geometry in higher education is only taught in theory. Students learn concepts and prove theorems, but they do not know how to use them to solve the problem they face. Students are not trained to solve problems using their mathematical knowledge.

Mathematics is about abstract theories, and many students have difficulty learning it. Many studies showed that students feel anxious when learning mathematics that negatively affects their mathematics performance. Students feel anxious when studying mathematics, because of its abstract nature, unclear benefits of the theory learned in class, and thence, arising lack of motivation or enthusiasm to learn it [3-7]. So, an effective strategy must be created to reduce anxiety and increase motivation in learning geometry, leading to an improved mathematics performance of students.

Training students is no longer about copying what the teacher does, but encouraging students to understand and develop their own method of inquiry. Therefore, teachers must facilitate the learning process by implementing teaching methods according to student learning techniques and capacities [8]. Real-world experiences in the field show to students that problems are sometimes much more complex than those described in textbooks. Field-based activities require students to complete tasks by utilising their freshly acquired knowledge to determine effective strategies to solve a problem. When solving field-based problems, students are expected to apply the learned theory, thereby directly experiencing the benefits of it, which in turn should reduce their anxiety and increase the motivation to learn it. This approach to learning and teaching gives students an opportunity to explore the science underlying complex, real-life situations. Most science textbooks present decontextualised or abstract knowledge. Field-based problems provide students with more opportunities to learn than illustrations or potential applications [9].

Therefore, field-based tasks using technology need to be designed and implemented to reduce mathematics anxiety and increase motivation to learn, with the overarching goal of improving mathematics performance.

FIELD-BASED TASK DEVELOPMENT WITH TECHNOLOGY

The role of technology in solving mathematical problems is multi-faceted, as technology can be used for checking the correctness of methods, strategies, hypotheses and the results obtained; for exploring and identifying mathematical concepts and relationships, creating general models or rules; facilitating the solutions of complex problems that are difficult to do manually. The use of technology in mathematics education, and the effects of it, have been widely reported; for example, technology in teaching group theory [2], technology used to strengthen mathematics teaching and learning [10], the effects of technology use on student achievement, motivation and attitude [11], or the use of persuasive technology and its cognitive and affective implications on mathematics instruction [12].

The use of technology in learning mathematics in higher education is certainly different from that in middle school. Besides students being able to use technology to complete assignments, students are also expected to construct general rules or models or make generalisations with the help of technology. They are also encouraged to choose the appropriate mathematics program to effectively and efficiently carry out their strategies and ideas in solving problems encountered in the field.

The main advantage obtained from field-based assignments is that students get the opportunity to apply theory in practice and they can think about different points of view based on various sources. Students are trained to design strategies and steps to find solutions and reflect on the results they have achieved, so that later the successful approach can be used to solve other, real-life problems. The problems that students work on during their tasks relate to their field of study, specific future occupation and their daily lives [13].

In this research, each task is arranged in three stages, the first stage is the application task. This task's aim is to encourage students to apply the learned theory and concepts of geometry to problems that are not too difficult, but interesting enough to motivate students. The role of technology in this task is to check students' understanding and help them to implement their ideas or strategies in completing assignments. The second stage is the experiment task. An experimental task is arranged in such a way that by conducting experiments students can make general conclusions regarding the given task. Each experiment task involves two steps. In the first step, students are expected to solve the problem without doing experiments. In the next step, students are asked to carry out experiments to check the correctness of their answer, revise it if necessary, and make general conclusions from the given problem. The role of technology in this task is to help students to create a generalised model/rule. The third stage is a field-based project, where the given assignment relates to an existing problem, but is adjusted to the students' environmental conditions. In completing this task, students are expected to use all the geometric theories learned thus far, make a plan with strategies, and to choose the most appropriate technology to carry out their ideas or strategies in solving the given problem.

Application Task

1. The task of secret code using spirolateral.

Students are asked to draw the spirolateral form of their name or several sentences or to decode the code in the form of a sentence from the spirolateral image given. They can use spirolateral software programs to check their answers.

Spirolateral is a geometric figure formed by the repetition of a simple rule that is made to resemble a spiral with the length of each segment following certain rules. The following figure is the spirolateral form of the sentence *Aku suka geometri* (I like geometry) with the code of *123 1321 75645299*.

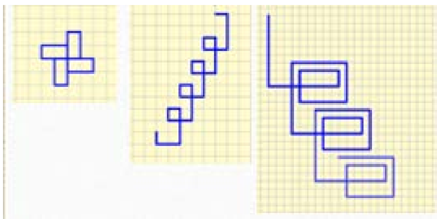

Figure 1: Spirolateral form of the sentence *aku suka geometri* (I like geometry).

2. The task of forming natural objects with simple geometric objects.

Students are asked to form natural objects that they encounter in the environment, such as plants or others through the iteration of simple geometric objects using Affine transformations (rotation, dilation, translation). To help them carry out their design ideas, they can use several software tools, such as the Lindenmayer program or the IFS Construction Kit. Figure 2 below is an example of a tree creation through the iteration of four-line segments using the Lindenmayer program.

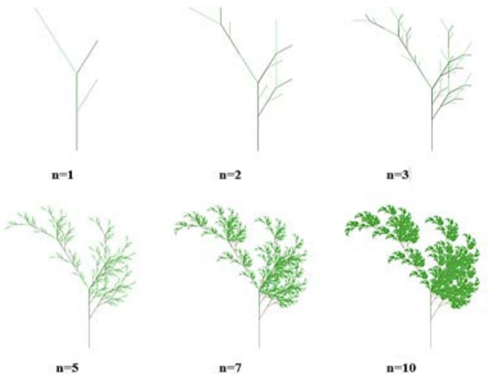

Figure 2: Construction of a tree by the iteration of four-line segments.

3. The task of measuring the distance of two ships in the sea.

Students are asked to find a strategy to determine the distance of two ships in the sea.

Experiment Task

1. Maximum packing problem.

This task is about determining the maximum number of items of a certain size that can be arranged in containers of a certain shape and size. Students are asked to determine the shape and size of the optimal container as economical as possible to enclose objects of all shapes and sizes. The initial task starts with only one arrangement involving the area, then the items can be stacked so that the geometric shapes and their properties, areas and volumes must be considered. To determine general formulae, students can use software applications, such as packing circles or trying different shapes of objects using the Boxshot 4 software for 3-dimensional problems. A method is needed to determine the solution to the packaging problem [14].

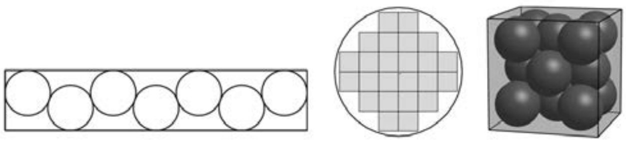

Figure 3: Packing problem.

2. Geometric Steiner tree problem (shortest path problem).

This problem is about determining the shortest path connecting all the points. After solving the problem by conducting experiments at different scale sizes, students can use the GeoSteiner software to test their hypotheses and make general conclusions [15].

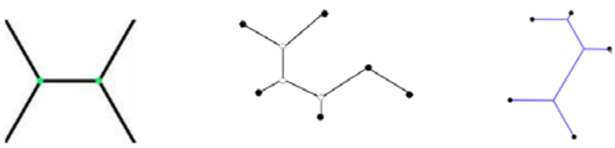

Figure 4: The shortest path that connects points.

The Field-based Project

1. Determination of the location of residence to register for the nearest school.

The new government regulation for selecting the location of public secondary schools is based on the location of residence, that is, students must choose the school closest to their place of residence. In this regard, this assignment requires students to determine the boundaries of the residence area to identify who has the right to choose a school in the city where they live. Students must determine the strategy and stages of its completion by applying appropriate technology.

2. Determination of the location of new libraries.

Suppose that three city libraries will be built in the city where students live. This assignment requires students to determine the location of the library buildings, so that they are evenly distributed across the population.

3. Designing a 3-dimensional map of campus.

This task requires students to make a 3-dimensional map of their campus.

4. Regional batik design with technology.

This assignment requires students to design several batiks using the principle of isometric function with software programs. The batik patterns should reflect the traditions of the city where they live and study, so one batik with the theme of the State University of Surabaya and one based on mathematics symbols.

5. Determination of the minimum CCTV requirements and locations.

Students are asked to determine the minimum CCTV requirements and their locations, so that the entire Mathematics Department building where they study is fully covered. Students must explore and determine the steps, strategies and appropriate software needed to carry out their ideas to solve this problem.

RESULTS AND DISCUSSION

The subjects of this study were second-year mathematics students at the State University of Surabaya (Universitas Negeri Surabaya) who took the Geometry course. A total of 65 students participated in this study. More than 85% of the students completed application assignments correctly. They were enthusiastic about making the spirolateral form of sentences and of their names. The students were also passionate about designing natural objects using simple geometric objects through iterations. They could make various kinds of plants (Figure 5 left), such as bamboo, banyan trees, coconut trees, and so on. However only 60% of the students could find the right strategy to solve the distance between two ships in the middle of the sea (Figure 5 centre). Some examples of student works can be seen in Figure 5.

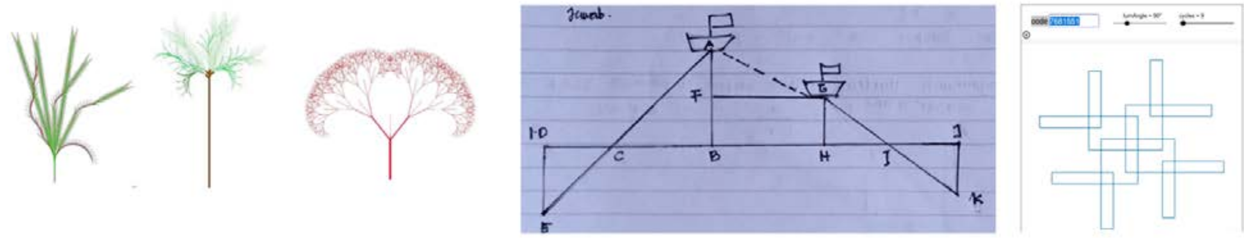

Figure 5: Examples of student works from the application assignments.

In regard to the experiment assignment, only 30% of the students could solve the problem correctly before experimenting. Most students immediately used the method of dividing the area/volume of the container by the area/volume of the object to be packed. Of course, this method does not fit the context of the problem.

It was only after experimenting with real objects and various sizes of containers that students realised that their previous method was wrong. Eighty percent of the students could solve problems correctly after completing experiments, and about 60% of them could draw general conclusions for cases with certain objects and container shapes with the help of software. This also occurred in solving the problem of the shortest path connecting several points.

Before the experiment, the students tried several methods and chose the minimum distance, so that it was not necessarily the shortest path. This showed how important the experimental process is in making students aware of how to determine strategies that are appropriate to the context. Also, the use of software makes it easier for students to draw general conclusions. Figure 6 below shows some examples of student works.

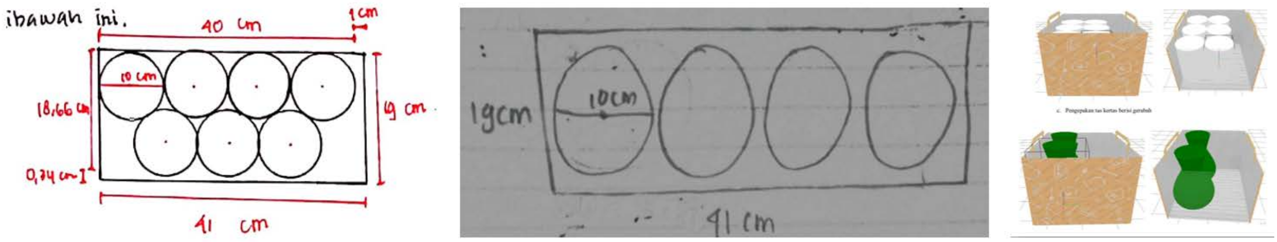

Figure 6: Examples of student works from the experiment tasks.

All students completed field-based assignments. The differences in student outcomes relate to the methods and strategies used and the choice of software to solve problems.

In the task of determining the location of residence for public secondary schools in Surabaya, the students entered a map of the Surabaya city in the Geogebra program, and then some of them used the Voronoi method to divide the area according to the nearest school, while others used the bisector perpendicular lines of the segment that connected the relevant schools. Figure 7 below shows some examples of student works in this task.

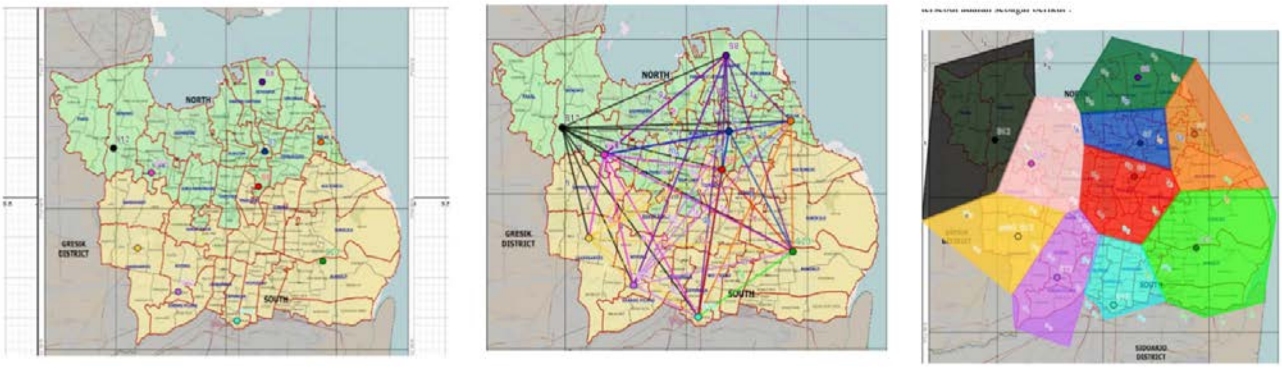

Figure 7: Examples of student works on determining the school zoning in Surabaya.

Task about the Determination of Three Locations for New Public Libraries

To complete this task some students used the Geogebra program and others used the C-MAP and Desmos programs. The methods used varied widely. Some students divided the city area into three equal parts and then determined the centre point as the location of the libraries. Others created three congruent circles that covered the city map and determined the centre of the circle as the location of the libraries. Some students created a rectangle or parallelogram that covered the map of the city and divided it into three congruent rectangles or congruent parallelograms with the diagonal point of each rectangle or parallelograms as a library location. Figure 8 below shows examples of student works in this task.

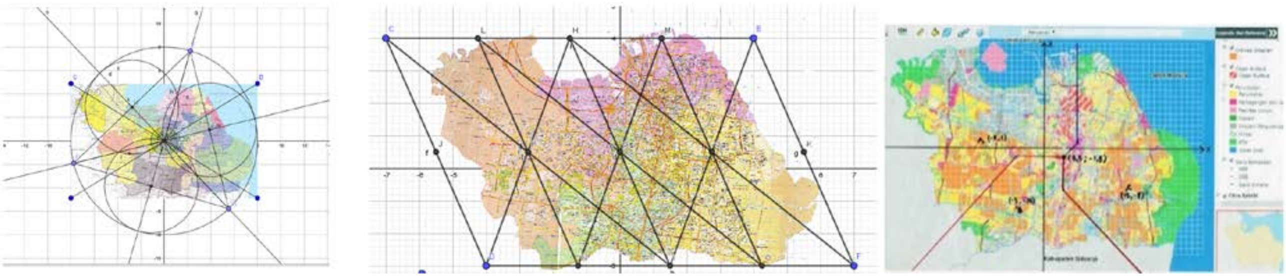

Figure 8: Examples of student works on determining three locations for public libraries in Surabaya.

Designing a 3-dimensional Map of Campus

The students designed a 3-dimensional map of the State University of Surabaya with various software programs, such as Icogram or MaxDraw. The difference between student works lies in the steps they used to make the map and its scale. Some students put more emphasis on the accuracy of the scale by utilising the Google map of their campus, while others emphasised more the aesthetic value and the scale used was based on approximate dimensions. Some created maps by paying attention to the shape of each building and trees around the building. Figure 9 below shows examples of student works in this task.

Figure 9: Examples of student works on a 3-dimension map of their campus.

Regional Batik Design with Technology Assignment

The students used various software, such as Kali, Tess, Geogebra or Batik Fractal software. The students' strategies used were almost the same; namely, they determined the characteristics of the basic image, such as the University logo or used features that exist in a city, such as famous buildings, city symbols or icons, traditional houses, etc. After the basic image was drawn with the chosen program, the students used the isometric function of the program to design the batik as a whole by adding colours that matched their option. Figure 10 below shows batik images based on the State University of Surabaya logo; a shark and crocodile image which is an icon of Surabaya; and some typical buildings of Kediri.

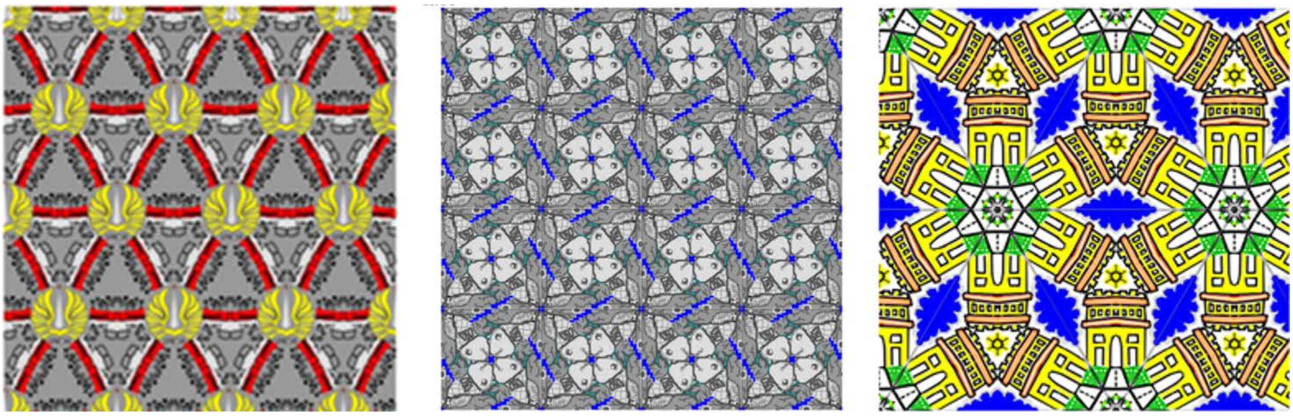

Figure 10: Examples of student works: *Unesa batik*, *Surabaya batik* and *Kediri batik*.

Task about Determining the Minimum CCTV Requirements and CCTV Locations of a Building

In determining the minimum CCTV requirements and locations to monitor the Mathematics Department where they study, the students uses several steps. At first, they made a building design with the help of software (DreamPlan Home Design by NCH or others), and then applied the vertex colouring or rectangular algorithm method to determine the minimum CCTV requirements. Some students used the IP video system design tool application to describe the location of the CCTV and the situation in the room controlled by the CCTV. Figure 11 below shows some examples of student works in this task.

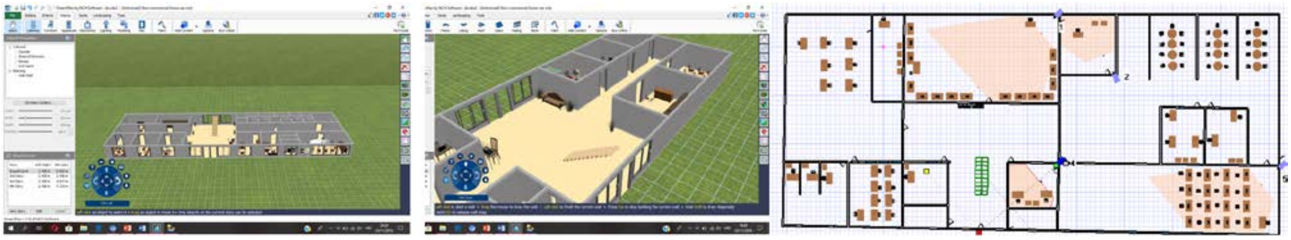

Figure 11: Examples of student works to find the minimum CCTV requirements to control the Mathematics Department.

Each assignment was presented in class, so that each student learned to communicate their strategies and ideas. In that way, the students had the opportunity to find out various solutions, strategies and perspectives, so that they could reflect and improve their approach to the next assignment.

A mathematics anxiety questionnaire was given at the beginning of the lecture and at the end. The results of the questionnaire for each student were compared. The results showed that more than 95% of the students' mathematics anxiety has decreased. The students' opinions on the implementation of learning with field-based assignments were positive. The students indicated that they were excited when learning, because they knew how to solve various real problems by practising first. When completing the field-based assignments, the students felt challenged, but were not bored, as they would, if they had just to prove theorems. The students felt more confident about what they had learned after successfully solving various field-based problems, which reduced their anxiety when learning geometry.

CONCLUSIONS

Field-based assignments enabled students to understand the concepts and their properties better. This type of task can improve students' mathematics performance, as students are trained to explore the problem, determine the effective strategies using their knowledge and reasoning of mathematics, and then select the most appropriate software that fits the context of the given problem.

The use of appropriate technology in field-based tasks helps students to generalise models and rules, and helps them realise their ideas and strategies to solve problems that sometimes are too difficult to be tackled manually.

Field-based assignments increase students' motivation in learning geometry, because students learn how to apply the theories studied before and feel satisfied knowing that they are able to apply their knowledge to solve various problems. This assignment makes students more interested in learning mathematics, so that their mathematics anxiety is reduced.

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