Adaptation and creativity in mathematics learning

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Abstract. Learning is often seen as developing academic abilities and achievement through formative assessment. Students always hate their 'failure' and are not as happy as students with better theoretical results. Equally important is the fact that undue emphasis on results rather than the process is likely to scare students from originality. Taking risks without fear of failure is the foundation of creative effort. This study used qualitative research methods, and the research subjects are students of mathematics education in a class of Differential Equations. This article shows two processes in evaluating learning, with the aim of seeing how students see a mathematical problem based on the question of the problem. One student class is given an issue clearly and leads to one answer, and at another time the question is presented again with questions by emphasising the role of creativity in learning and skills development. Of the two results of the work will be seen in how students face a mathematical problem. How to think convergent and divergent affect learning outcomes, and what factors need to be developed to make students feel more creatively.

1. Introduction

The ability to develop creativity (thinking divergently) is essential in innovation and solving mathematical problems so that an efficient and effective way is needed to support the divergent thinking process [1]. Divergent thinking tests are often used in creativity studies. Divergent thinking does not guarantee actual creative achievement, but divergent thinking tests are valid predictors of specific performance criteria [2]. Meanwhile [3] states that there is a positive relationship between measures of intelligence, personality and divergent thinking in the sample of students. The results of the analysis showed a significant association between knowledge and divergent thinking. However, both convergence and divergence are essential mechanisms of creativity [4].

Unal [5] tested divergent thinking on achievement in four areas of mathematics (geometry, arithmetic, algebra, statistics and probability). The results of this study indicate that divergent thinking skills play an important role in mathematical achievement. Other studies examine whether and how general intelligence, domain knowledge, motivation, creative behaviour, and creative personality predict two models of creativity [6]. General intelligence and creative personality supported creativity as divergent thinking. However, general intelligence, knowledge domain, and motivation supported creativity as a form of a creative person.
Divergent thinking tests often assess creative students. First, the test score for divergent thinking is a prediction of several types of performance (for example, writing) but does not predict performance in other domains (for example, art). Second, the divergent thinking test has discriminant validity, but traditional scoring techniques (with fluency, authenticity, and flexibility) may be inadequate, and the examinee’s ability level must be taken into account when comparing an independent score with an intelligence test score. Third, some personality traits (for example, independence) and family variables (for example, birth order, family, size, age differences) are associated with performance on tests of ideational creativity. Finally, the performance of divergent thinking can be influenced by the model, including reasoning, encouraging and strengthening parents, task perception, environmental cues, stimulus characteristics, and age [7].

Meanwhile, Alfonso [8] analyzing development during childhood on differences in divergent and evaluative skills is implied in the creative process. Divergent thinking skills are characterized by presenting greater variability and irregularity and experiencing the most significant decline during the analyzed period. Whereas [9] investigated whether children with special needs showed superior competence in creativity. The results show that participants with special needs have higher significance and elaboration, compared to their peers. Nonverbal divergent thinking correlates with nonverbal IQ for participants with special needs. These results can show better performance in originality and lower performance in flexibility.

Students with talent have mathematical ideas that are more flexible and original than other colleagues. The results show a significant correlation between the learning background and domain creativity, and that creativity is domain-specific [10]. More training in the academic field and creativity will result in higher potential realization for students. Creative and imaginative thinking may be different because the first is more dependent on active thinking [11].

Attila Paztor [12] argued that relational reasoning fundamentally supports divergence for the dimensions of originality and fluency. The results show that direct teaching intervention from relational reasoning strategies supports creativity for students who are simultaneously very fluent, but the authenticity of thinking is low. However, without an easy-to-use assessment tool available for everyday applications in educational practice, systematic increase in creativity is far from a realistic choice [13]. This study explores the possibility of online assessments of different thoughts to contribute to the development of reliable technology-based tests. This paper also investigates the relationship between divergence thinking and mathematical achievement in different dimensions. Divergent thinking predicts mathematics achievement at a moderate level. The advantages of technology-based assessments make our instruments suitable for daily school practices and large-scale assessments.

From previous research, it is essential how to present divergent thinking in the learning process both in class and outside the classroom. Students with lower barriers have better performance on divergent thinking tests [14]. Selection of the right method and model will help students think more innovatively and diverge. So that in the end, students will be more creative in solving problems in classroom learning. On the other hand thinking, divergent thinking skills will be strongly influenced by students’ emotional factors (anxiety, self-confidence, health, etc.) [15]. Meanwhile, environmental (cultural) factors are also very influential in increasing students’ divergent thinking [16]. This article will discuss students’ convergent-divergent thinking skills based on the use of the questions used, namely closed-ended notes ended.

2. Methods
This research is a type of descriptive qualitative research. In the first phase, researchers took three subjects from all subjects in three classes. The selection of these three subjects uses a purposive sampling technique [17,18]. Next is a written test about the closed-ended type with a high, medium, and also low-value categories. Subjects with high-value categories were referred to as subject T, subjects with medium value category, from now on referred to as subject S, and subjects with low-value categories from now on referred to as subject R. The results of the written test subject to
consideration of the selection of the three subjects. The second stage, the researchers took the same three subjects in the closed-ended written test to be given a written test about the kind of open-ended. Taking the same subject is intended so that researchers can see the changes that occur in the same subject with a different test. In the third stage, researchers analyzed data on selected subjects using qualitative methods. This data analysis is used to describe and conclude the results in answering existing problems.

3. Results and discussion

3.1 Results

Test convergent thinking skills are given to all subjects in the three classes was given matter about differential equations. One of the questions given was presented in Figure 1.

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Solve the following differential equation

2xy \frac{dy}{dx} = 4x^2 + 3y^2
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Figure 1. The Problem Closed Ended Differential Equations

Figure 1 is an example of a problem of closed-ended differential equations. Lecturers usually give the question to students. Problems with this type usually only lead to one correct answer. In general, the results of the average grade of the three classes with routine test questions to measure convergent thinking skills of differential equation material are shown in Table 1.

| Class  | Min Value | Max Value | Average |
|--------|-----------|-----------|---------|
| First  | 62        | 87        | 80.40   |
| Second | 42        | 85        | 68.77   |
| Third  | 59        | 77        | 68.54   |

Based on Table 1, the results of the work of all subjects in the first class has an average value with the highest level among the other two classes. Subjects in class 1 can solve the problem of differential equations that are given well compared to the other two classes, namely classes second and third.

Subject T can understand the problem of differential equations and solve them by implementing the settlement plan by the questions. Subject T works the problem very closely but looks like what was exemplified in the example problem. Furthermore, in subjects with the medium category, the ability to solve problems in the written test questions are differential equations, subject S cannot understand the question questions. Subject S has difficulty when making a completion plan, and the subject's answer is not correct. Same as subject T, the answer to subject S is still like what is being exemplified by the question. The results in the subject S are experiencing difficulties when working on questions that have no examples of completion. In subjects with low categories, subject R has not been able to understand the problem in the problem. Subjects have not been able to plan a solution so that the answers produced are not correct. Just like the T and S subjects, the completion process on the subject R test work is still like the example of the problem. Subject R has difficulty working on a problem that has no example of a solution.

Furthermore, to find out the divergent thinking of students, all subjects in the three classes are given the same matter of differential equations as in Figure 2.
Figure 2. The problem of Opened-Ended Differential Equations

Figure 2 is an example of an open-ended differential equation problem. Lecturers rarely give questions like in Figure 2 to students. Problems with this type usually create answers and solutions. In general, the results of the three classes' average scores based on non-routine test questions to measure the ability of divergent thinking tests on the material of differential equations in Figure 2 are shown in Table 2.

| Class   | Min Value | Max Value | Average |
|---------|-----------|-----------|---------|
| First   | 5         | 87        | 39.17   |
| Second  | 23        | 87        | 60.82   |
| Third   | 59        | 77        | 55.39   |

Based on Table 2, the results of the work of all subjects in the second class have an average value with the highest level among the other two classes. Subjects in second class can solve problems of differential equations that are given well compared to the other two classes, namely class first and third.

Subject T can understand the problem well and solve the differential equation. In working on the given question, subject T does not write the conclusion of the answer. Subject T only writes the final result of the calculation, without concluding the answer. The results in subject T are not evaluating the results of the answers obtained. Subject T has not been able to believe the truth of the solutions obtained because it only uses one method of settlement. The completion stage of the answers made by subject T is very coherent, but it looks like what is in the example of the problem. Thus subject T has difficulty finding mathematical solutions when examples are incomplete.

Subjects in the medium category are quite understanding of the problem but when they do the completion plan has difficulty. This condition results in the subject S being incomplete in writing answers. Subject S only obeys the command question to find a solution to the equation without any awareness to use another method. Subjects with low categories have not been able to understand the problem in the problem. Subjects have not been able to plan a solution so that the answers produced are not correct. Just like the T and S subjects, the process of completing the subject R test work is still like what is being exemplified by the question which results in the R subject having difficulty working on the problem with no example of completion.

3.2. Discussion

The data obtained in this study illustrate the real situation in the field using detailed data in the form of written test scores, convergent thinking ability and divergent on the material of sixth-semester students' differential equations in mathematics education programs. The data results of the three subjects selected in the test are shown in Table 3.
Based on the results of the study in Table 3, the results of convergent and divergent test scores of T subjects experienced a significant decrease. This condition can occur because the subject T is more aware of the form of the question that the command is apparent as in the convergent written test form compared to the problem that provides other alternative answers such as the written divergent test form and does the tests according to the instructions. The subject T works on the problem by collecting the information obtained from the problem and then related to the knowledge that has been obtained in the previous material. Subject T prioritizes the answers produced right or wrong rather than thinking of alternative solutions.

The conditions experienced by subject S are precisely the opposite of subject T. The results of the subject S in the written test divergent thinking increased significantly compared to the written test convergent thinking. Subject S can give an opinion about the answers to other solutions in his way. When choosing alternative solutions, the subject S has not been able to determine which method is the most efficient. The subject S prioritises the process that is believed rather than thinking about the final result so that in completing, the answer to the subject S is less precise.

In contrast to subject T and subject S, subject R experiences constant conditions. In solving the given problem, subject R has not been able to think convergingly or divergently. Subject R also has not been able to determine how to solve the given problem. Subject R has not been able to get the solution to the desired answer. The three subjects are more aware of the form of the question that the command is clear as in the way of convergent written tests compared to items that provide alternative answers such as the written divergent test form. The type of the problem affects the subject in the process of thinking. Convergent and divergent ways of thinking in solving problems depend on the kind of questions used; both open-ended and closed-ended problems. Sak [19] classifies the problem into two, namely the problem that is clearly the answer (closed-ended) and the problem with many answers (open-ended). This classification was based on the relationship between problem statements, methods used, and problem-solving solutions. The first type of problem (closed-ended), the form of the problem is clear and well structured. While the second type of problem (open-ended) has a kind of questions that are not clear and unstructured. That is, in the type of open-ended problem, the problem was not determined, and the solution is also unknown. The results of this study indicate that opened and closed problem-solving involves different processes [20]. Thus students have the opportunity to struggle with not only getting the right answer, but by discussing what, and under what circumstances, makes the answer correct [21]. The affects the subject in working on the problem in a different form (open ended and closed ended). Students can improve their creative performance on mathematical questions only if the effects of the instructions on work are weak and limited [22].

Table 3. Selected Convergent and Divergent Test Results

| Subject Code | The Convergent Test Value | The Divergent Test Value |
|--------------|---------------------------|--------------------------|
| T            | 87                        | 65                       |
| S            | 62                        | 74                       |
| R            | 42                        | 39                       |

Cohen [23] said that adaptation and creativity have a mutually influential relationship. Adaptation can support or inhibit creativity. Adaptation supports creativity if the subject can think divergently in solving problems. Conversely, adaptation inhibits creativity if the subject is still thinking to converge in solving problems. Therefore, the types of questions that are unclear and unstructured (open-ended) require the subject to think divergently. If the subject is accustomed to being given this type of question, the subject quickly adapts to develop his creative ideas especially in solving mathematical problems.
4. Conclusions
This type of problem affects students in applying divergent thinking skills. The results showed that students who were given opened-ended type problems were required to think divergently in solving problems. Divergent thinking ability was obtained through the habit of providing opened-ended type questions so that students quickly adapt. Student adaptation to opened-ended questions is needed to support students' creativity in developing problem-solving ideas obtained through divergent thinking habits. This study has not examined the use of learning models or strategies that lead to divergent mind set [24,25] so that it is still open for further research.

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