

Chapter #4

THE IMPACT OF INTELLECTUAL CREATIVITY SKILLS ON MATHEMATICS

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ABSTRACT

Creativity may be defined in the most general sense as producing different solution strategies apart from ordinary solutions when individuals encounter with a problem. The production process of such solutions should be designed with original ideas, which are sufficiently flexible and fluent. The aim of the research is to identify the methods used by mathematics teachers for the formation and development of creative, analytical and probabilistic thinking skills of students by taking both student and teacher views into consideration. In this context, it has been conducted in order to reveal the environments prepared, the methods applied and the assessment made by the teachers. The research was conducted in 2015-2016 at two public schools (colleges) which students can enrol after passing entrance examinations. The study group of the research consisted of 8 mathematics teachers and 8 college students randomly chosen from the public schools. Eight teachers and eight students determined by the convenience sampling method formed the sample of the research. Semi-structured interview forms containing open-ended questions were used as a data collection tool. In line with the results obtained from the research, it has been observed that the collected data support the views of teachers and students.

Keywords: creative or (intellectual creativity) thinking, analytic thinking, connective thinking ability, mathematics.

1. INTRODUCTION

The importance of mathematics in today's world is increasing day by day, as it is one of the important tools we use to solve the problems in our everyday life. Mathematics is important because it enables individuals to solve problems that individuals may encounter in daily life (Yenilmez, & Uygan, 2010). Therefore, the target behaviours, in other words, outcomes in mathematics, which students should obtain, are included in all curricula from the beginning of the school life to the university (Baykul, 2009). Different meanings can be imposed on the word 'problem' in mathematics education. Generally speaking, the problems are considered as unknown and the solution is not obvious (Haghverdi, Semnani, & Seifi, 2015). In such questions, it can be said that students can reach a solution by reasoning with their existing knowledge. Therefore, this study emphasizes that the necessity of acquiring advanced level thinking skills as well as analytical, creative and probabilistic thinking skills are important.

Creativity is thought to continue without losing its importance from the past to the present day, Dziedziewicz and his colleagues (2014) conducted a study to show the development of products that made our lives easier, and these have been regarded as new ideas, objects or concepts. It is also emphasized that mathematics is important at the level of creativity from the view of the universe being lived in, along with the perspectives of individuals, and that their ideas change in different forms (Sriraman, Haavold, & Lee 2013).

It can be said that it is necessary to teach not only creative thinking skills but also creative thinking. Dikici and Soh (2015) also seemed to be particularly interested in the students' ability to acquire creative thinking skills and discussed in their study it should be used as a tool in education so as to develop education.

Thus, in order to enable students to learn to think creatively in their mathematics lessons, teachers need to pay attention to their attitudes and movements in the classroom. It is important for the students at the level of collaborative learning to have different motivations for creating different ideas by assuming the role of the teacher as a guide (Karataş & Özcan, 2015). Likewise, Ekici (2016), for example, highlighted in his study that students should have the opportunity to solve a problem in the classroom, the necessary and right time should be provided to support them, they should be encouraged with prizes, and they should have the right environment to create different ideas, to work in cooperation and to act in a cooperative manner.

Roberts (2002) notes that creativity exists in every individual, but appears earlier in some depending on the frequency of exercises.

According to Ersoy and Başar (2009), creative thinking ability can be defined as the ability of the individual:

- a) to be fluent
- b) to think flexibly
- c) to detail
- d) to be original
- e) to be able to diversify
- f) to be able to identify the problem
- g) to be able to visualize

Cognitive processes that are linked to problem solving and to be able to solve problems are important to creativity (Korkmaz & Gur, 2016). In this context, it should be emphasized that it is necessary for the individuals to deal with methods that are much newer, more current and unconventional than the traditional. There is also a need to look at how useful and effective new methods designed and these should be measured and evaluated (Sriraman et al., 2013).

Similarly, Sriraman (2004) revealed in his study that mathematical creativity could be examined in five dimensions, which are social interaction, heuristics, intuition, proof, and facts. At this point, teachers with creative thinking skills will need sufficient background knowledge and new activities to transfer them (Sæbø, McCammon, & O'Farrell, 2006). Therefore, first of all, it is important to train teachers who can think and then to train them to transfer creative thinking to their students.

This study is important as it includes creative teaching activities, teachers' creative thinking ability at a sufficient level and the ability to teach this to their students. Therefore, the methods which students and teachers can develop together with the aim of developing creative thinking methods should be aimed instead of the techniques used in the past.

It can be said that in addition to the increasing importance of knowledge today, the steps that will take place in our minds at the stage of obtaining information are important. Problem solving is considered to be important because the imaginary part of the human brain representing the right lobe and the part representing the left lobe are thought to consist of concepts called analytical thinking (Lumsdaine & Lumsdaine, 1995).

It is thought that creative thinking in the field of mathematics can be achieved more integrally with students by using problem solving and analytical thinking skills together. In this context, Sternberg (2006) described analytical thinking as the ability:

- a) To separate a problem into parts and to make sense of these parts,
- b) To explain the functioning of a system, the reasons for something to happen, or the steps to solve a problem,
- c) To compare two or more cases,
- d) To evaluate and criticize the properties of something

As can be seen from this classification, comparisons can be said to be an integral part of analytical thinking.

According to Ruskin (2011), analytic thinking is often associated with thinking by focusing on a specific goal, in other words, problem solving, researching the truth, developing understanding. Briefly, analytical thinking can be viewed as a study of a small number of studies that focus on solutions and can see the whole.

According to Cottrell (2008), analytical thinking is "weighing up the arguments and evidence for and against".

In its base it includes three elements, which are;

- a) To think carefully and over on a topic,
- b) To evaluate the evidence set forth to support the views or perspectives,
- c) To assess the point where the point of view reaches (what conclusions can be drawn from them, are these conclusions reasonable and logical, if not, should this belief and perspective be reassessed?).

Analytical thinking involves the whole process of fragmentation, redefinition and classification. It is a way of thinking based on analysis. It divides the concrete problems of nature into small pieces and collects information (logical functional vs. links) from the characteristics of the parts. It links the data and events. It also defines the basic relationships between them, examines complex relationships.

Analytical thinking can be defined as a cognitive activity in which mental functions are used. From this point of view, we can think of analytical thinking as a set of processes in which a set of mental processes, such as attention, memory, reasoning, perception and inference, interact in coordination. Critical and analytic thinking such as selection, categorization, induction, deduction, metaphor, analogy, decomposition and abstraction are the other components of such thinking styles.

Probabilistic thinking is the ability to think of all possibilities of an event or hypothesis at all stages from the beginning to the conclusion (Acar, Tola, Karaçam, & Bilgin, 2016).

According to Çuhadaroğlu (2013) described the probabilistic thinking ability of an individual as:

- a) the tabulation of data
- b) the interpretation of the graphics
- c) the ability to think about all possible aspects of flexibility

It may be said that when an individual encounters unexpected situations, he needs flexibility to find a solution by being able to courageous enough to avoid the uncertainty that exists, but he also needs ability to think reasonably to be able to judge possible solutions. It can also be said that probabilistic thinking is further than correlational thinking. The ability of a student to evaluate events symbolizes that the individual has developed a combination logic basis. At the same time, with probabilistic thinking, it is also possible that the individual can associate four probabilities in his mind, can eliminate the ones that are not suitable, or even keep one of them and make the other ones variable.

For example, asking students to think that they have 6 balloons in their hands and to find how many different ways there are to blow up these balloons in 3 shots at most will help the students to try all possible ways of thinking.

Lawson (1978) emphasizes that all extrinsic reasoning involving probable thinking skills is related to the content of science education in determining variables and relationships. In particular, information presented in the form of problem situations has a positive impact on the development of students' relational and probabilistic thinking skills (Brickell, Ferry, & Harper, 2002).

It is thought that one of the most important stages of dissemination of thinking skills in education is teacher training. Firstly, teachers need to acquire thinking skills and apply it to their real life. Once teachers have gained these skills, they can make their students develop their own skills (Köse, Ercoşkun, & Balcı, 2016). For this reason, making teachers' gain thinking skills is an important step in educational activities. Some specific teacher behaviours influence student achievement, self-esteem, social relations, and ability to think. It is also stated that teacher's work or sayings in class can greatly influence the thinking skills of students. Kentmen and Çağanağa (2015) argue that creativity can also be gained through the materials that teachers develop. Therefore, there are a number of issues that teachers should pay attention while teaching creativity. First of all, it is important that while teaching creativity in the classroom students should be supported and encouraged to produce different solutions while solving problems (Karataş & Özcan, 2015). When questions or problems are directed to the students, time will be given to them to produce different solutions so as to encourage them to be creative by concentrating and supporting them (Korkmaz & Gür, 2016). On the other hand, it should be conveyed to the students that a problem has a single answer but that it can be obtained in different ways. For example, the substitution or the destruction method can be used to find the solution, which is the only answer in the systems of equations in the 8th grade mathematics curriculum. To reach the solution, the right time and asking the right questions are also important. For example, when a question about how to solve a problem during a lesson is asked, they should first be given time to do so, and then share their solution with their friends, asking them why they chose this method and what steps they followed. It is important for the teachers to show the ways of solving the questions, to explain the way they follow along with their steps and reasons.

Teachers should aim for the development of their students' skills as well as the ability to improve their diversity by showing the solutions in a short and easy way. Thus, categorizing ideas to be created and solutions that are put forward in an original form, should be appreciated (Çepni, Ayas, Johnson, & Turgut, 1997). Likewise, Mrayyan (2016) stated that there are five different methods, namely expansion, analysis, change, re-implementation, management and the factors hinder creativity, which are developed to reach more effective results while teaching creative thinking. With these methods, it is tried to be conveyed that every problem can be solved with appropriate strategies as a result of thinking. It is also emphasized that new discoveries can be made by associating existing information with the problems that require multiple processes. Even though there is more than one way to solve these problems with these methods, it is possible to eliminate the ambiguity by indicating why teachers use the solution that they prefer to use.

In this context, it is aimed to investigate how the thinking skills can be taught to students by taking the views of both students and teachers and what can be done especially in teacher dimension.

2. METHOD

In order to develop creative, analytical and probabilistic thinking skills of students, it is aimed to determine the methods used by mathematics teachers by taking the views of both students and teachers. In the 2015-2016 academic year, this study conducted in two schools (colleges), which offer places to students with a special examination done by the Ministry of National Education. It was carried out with qualitative research methods and case study was applied. The case was considered as a rich content discourse or interpretation that gave the opportunity to support the obtained data with scientific findings (Yaman, 2010). In the selection of samples of such patterns, "snowball", "convenience sampling methods" can be used. The sample size should generally be around 10 (Yıldırım & Şimşek, 2005). Therefore, it is important that the sample should be formed from people, events, objects or situations that have the qualities determined in relation to the problem in the researches that have taken the convenience sampling method (Büyüköztürk et al., 2009).

By using convenience-sampling method, 8 mathematics teachers were randomly selected from the schools related to the Ministry of National Education and their competence and attitudes about their thinking skills and the ability to develop creative thinking skills of their students were taken into consideration. Convenience sampling is defined as the inclusion of the number of subjects that can be reached from the target group during the study (Cohen, Manion, & Morrison, 2006).

2.1. Data collections tool

The interview method was used as a means of collecting data in order to find out what kind of environment the teachers prepared for their students, what kind of methods they applied and how they evaluated. The semi-structured interview technique was used because it allows the participants to be more comfortable and to gather more detailed information about the subject (Elma & Bütün, 2015). The data were collected through semi-structured interview forms consisting of open-ended questions, which were prepared by researchers.

The questions in the interview forms for the teachers are:

- 1) What are your views on being able to think analytically / probabilistic / creative and to teach these ways of thinking?
- 2) What are the methods that should be used to think analytically / probabilistic / creative?
- 3) What should be done to teach analytical / probabilistic / creative thinking?

The questions in the interview forms for the students are;

- 1) What are your views on being able to think analytically / probabilistic / creative and to learn these ways of thinking?
- 2) What are the methods that should be used to think analytically / probabilistic / creative?
- 3) What should be done to learn how to think analytically / probabilistic / creative?

1 of these questions is about creativity / analytical / probabilistic thinking skills, 2 is about teaching dimensions.

2.2. Data analyses

In order to analyse the obtained data in the research, themes were formed in accordance with the views given by the mathematics teachers using content analysis. In content analysis, there are four stages: processing of qualitative research data obtained from documents, coding of data, finding of themes, regulation of codes and themes, identification and interpretation of findings (Yıldırım & Şimşek, 2008).

3. FINDINGS AND DISCUSSION

In this part of the research, findings obtained from the interview forms applied to the teachers and students were discussed.

In the study, 3 questions were asked to the teachers and the data obtained from the answers were explained below with the theme, code, frequency and percentage distributions. In addition, some of the comments made by the teachers were also included and the related subject was emphasized.

Table1.
Teacher views.

| Theme | Code | f | % |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------|---|------|
| Analytical / probabilistic / creative Ideas for teaching thinking styles | Problems arising from basic education prevent such thinking | 1 | 12,5 |
| | Student profile differences in the class are problematic | 3 | 37,5 |
| | It is necessary to support it with visual materials | 1 | 12,5 |
| | Creating multiple solution ways of pre-gained information is required | 2 | 25 |
| | The necessity of determining appropriate strategies for solution ways | 1 | 12,5 |
| Methods to improve analytical / probabilistic / creative thinking | Group work | 2 | 25 |
| | Brainstorming | 1 | 12,5 |
| | Mind Mapping | 1 | 12,5 |
| | Learning by doing-by living | 1 | 12,5 |
| | Mathematical Project | 2 | 25 |
| | Problem solving Strategies | 1 | 12,5 |
| What to do to teach analytical / probabilistic / creative thinking | Using Material | 2 | 25 |
| | Daily Life Examples | 2 | 25 |
| | Discussion environments | 2 | 25 |
| | Making learners read crime and murder novels | 1 | 12,5 |
| | Taking the advantage of games that require creative thinking | 1 | 12,5 |

As can be seen in the table, 12.5% of the teachers said that the curriculum of the schools had an obstacle to the basic education in primary education while teaching creative/probabilistic/ analytical thinking skills while 37.5% of them thought that they were having problems with the student profile. Some of the teachers 12,5% of whom stated that they could use visual materials in order to teach them in their lessons, said there was not any

teaching like this and it was not included in their curriculum. The aim of modern human education is to educate people who are able to solve problems, use mathematics in daily life, gain analytical and probabilistic thinking skills and keep alive the need for learning information (Craft, 2014). Teachers have important tasks when students acquire these skills. In North Cyprus, it is observed that predicting different events are included only in the curriculum-based probability learning category, and that there are also contingent probabilities (Özreçberoğlu & Çağanağa, 2016).

It is seen that 25% of the teachers stated that such thinking skills were used with pre-acquired knowledge of students so they created more than one solution and 12.5% of them were effective in determining the strategy. It was also evident that these teachers contributed to the teaching of thinking skills when creating suitable environments for elimination of traditional methods in class. Dewey (2007) indicated that analytical thinking skills were needed to gain in the process of resolving non-specific situations, while logical thinking was an element that was required in both problem-solving and analytical thinking.

In addition, the participant's comment on the subject is remarkable.

"It is necessary to develop the thinking skills that can produce alternative solutions by systematically using different strategies when there is a problem so the person can bring to their own proposals and propose unique solutions by using the pre-existing information." (Participant 3)

In order to be able to think creatively / probabilistic / analytically, it appears that teachers have been using and implementing strategies such as group work, brain storming, mind mapping, doing-by-life learning, mathematical project and problem solving strategies. A number of studies showed that information presented as problems had a positive effect on the development of relational, composite and probabilistic thinking skills of students (Brickell, Ferry, & Harper, 2002).

Here are just a few of the participants' comments on this;

"It is important to restructure a realistic education system where the learning-by-living model can be applied more." (Participant 3).

It was seen that Yurtbakan and his colleagues (2016) also included practical activities for learning by doing among the preferred methods to increase the achievement in mathematics in their studies.

"The method of question-answer, brainstorming, Gordon's method, mind maps, metaphorical thinking techniques and group work must be the methods that can be used because different ideas can be exchanged." (Participant 2)

In order to teach teachers to think creatively / probabilistic / analytical, it was suggested that more materials should be given to the students using daily materials as examples, debates should be made by gathering controversial ideas, teachers should have students read crime and police investigation novels, and games should be played for creative thinking. In addition, classroom communication should be supported by motivational words or praises and clear and understandable instructions should be given (Cremin, Burnard, & Craft, 2006).

The remarkable words of the participant on this are stated as follows.

"Students should be made to read crime novels that can teach these kinds of thoughts and learn different ways of solving such as crime and murder which I believe will help them to develop themselves in their Daily life as well as to bring abstract thoughts in order to approach the events with different perspectives"(Participant 7).

In the study, 3 questions were asked to the students as well as to the teachers and the data obtained from the answers were explained below with the theme, code, frequency and percentage distributions. In addition, a few comments made by students were stated.

Table 2.
Student views.

| Theme | Code | f | % |
|--------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---|------|
| Ideas for teaching analytical / probabilistic / creative Thinking styles | The necessity of acquiring different perspectives for maintaining permanence | 2 | 25 |
| | Creating discussion environments for individuals to develop their interpretation power by taking individual differences into consideration | 3 | 37,5 |
| | Using application courses besides teaching theoretical knowledge | 3 | 37,5 |
| Methods to improve analytical / probabilistic / creative thinking | Group Work | 4 | 50 |
| | Question and answer method | 2 | 25 |
| | Development of different solution ways by inquiry method | 2 | 25 |
| What to do to learn to think analytically / probabilistic / creative | Being curious, being innovative | 1 | 12,5 |
| | To be able to come up with different solutions | 3 | 37,5 |
| | Creating questions | 2 | 25 |
| | To be able to interpret solutions | 2 | 25 |

As can be seen in the table, 25% of the students about learning creative / probabilistic / analytical thinking skills pointed to the necessity of gaining different perspectives to ensure persistence. 37.5 % of the students pointed out the necessity of creating controversial environments in which individuals develop their interpretation power by taking individual differences into account and 37.5% of them revealed that practical lessons should also be included with theoretical knowledge.

The participants' comment about this is remarkable.

"Learning these thinking skills that will contribute to the development of our intelligence and our interpretation by ignoring the individual differences in the classroom will ensure the permanence of different solutions" (Participant 1)

Fletcher (2011) noted that individual differences needed being addressed by supporting diversity in order to enable students to think creatively in their work. The students who emphasized that practice should be included in the process of teaching them in these contexts, also indicated that these thoughts were not only able to reach the best solution but also improve their characters.

Regarding this, the participant emphasized it with the following explanation.

"These thinking skills that are practiced during the lessons, and even if it is necessary, statistic teachers teaching us once or twice a week for these lessons, will enable us to look at events up to date. Thus, it will not only provide different solutions but also it will contribute to our character to develop." (Participant 6)

Erbaş and colleagues (2014) pointed out that using the using the applied modelling from the modelling approaches, students can gain the ability of problem solving and modelling.

It was explored that 50% of the students paid attention to the group work for the methods that could develop creative / probabilistic / analytical thinking, 25% to the question-answer methods and 25% to the opportunity to reach different ways of solution by using the questioning method. Thus, it is considered that making comparisons of the

different solutions and the ways to the solutions will affect the development of the students' interpretation and visual skills.

The participant said the following words about the subject concerned.

"Time should be given for the solution of the questions. During this period, we should be asked to explain our thoughts about the solution steps and after being given clues about the solution to question." (Participant 8)

Mrayyan (2016) also emphasized that while learning creative thinking, new ideas were obtained in the order of steps and also that it was important for the students to be guided by asking the right questions for analytical thinking skills. It is also evident that some students should be encouraged to acquire and learn these thinking skills. Similarly, Cremin et al. (2006) showed in their study that encouraging in the teaching of thinking skills such as creativity played an important role.

In order to learn these thinking styles, 12.5% of the students expressed opinions about being open to new ways, 37.5% able to derive different solutions, 25% to create question types and 25% to interpret the steps used to solve the questions.

The words of the participant are as follows.

"It is important to be supported to increase our courage while trying to find different solutions" (Participant 2).

4. CONCLUSION AND RECOMMENDATIONS

In many countries, it is known that the education systems based on problem solving are renewed according to changing and developing conditions in order to achieve the highest level of education (Tataroğlu, 2009). This research compared teacher and student views about gaining high thinking skills that will support students' ability to cope with the uncertainties that will be encountered in real life. In the direction of the results obtained from the research, it was seen that the collected views of the both teachers and students were supportive for each other. It was concluded that teachers were partially informed about the teaching of creative / probabilistic / analytical thinking skills in general, but that they do not have sufficient knowledge to teach it, however, they have theoretical knowledge in teaching methods. In addition, teachers stated that they are trying to use teaching techniques obtained from pedagogical courses. Students suggested that learning these thinking skills would not only contribute greatly to them but also would help them to develop as an individual not only in terms of teaching but also in society. The result of high-level thinking skills which are aimed to be acquired after obtaining student and teacher's views can be realized by the development of new solution ways and group workings with the active student participation in the active classroom environment.

4.1. Recommendations

Firstly, the teaching of creative / probabilistic / analytical thinking skills should be used not only only during the course but also outside the course. For this purpose, it is suggested that new methods and teaching techniques should be developed and implemented. Also, it is suggested that in-service seminars should be given in order to teach the new methods to be taught and developed.

In addition, it is recommended that teachers should design materials in order to make the lesson interesting and provide a sense of remembrance. It is important that both sides are encouraged so that not only the students but also the teachers can be motivated. For this reason, teachers should pay attention not only to their speech but also their behaviour. In addition to these, it may be advisable to analyse teacher performances. While presenting the

questions, visual presentations and technologies should be utilized. In addition, students' classroom seat order should be changeable. Lesson attendance should be ensured with the help of games. It should be taught that only risk should be taken, force should not be applied. By adopting the view that there is more than one solution to a problem, it is expected that they should develop solutions to find the maximum ways to solve the given questions. Sufficient time should be given. The questions should be solved step by step and the students should be given the opportunity to establish the link between the transitions and to improve their ability to make comments by asking about the cause-and-effect relationships. Routing tips should be used to answer questions. Problems should be solved in the classroom. They should be able to develop hypotheses and discuss them. At the time of the examination, the student may be asked to write a new question and solve it, considering his / her own view. Thus, the use of probabilistic and creative thinking skills will be supported since students will be able to guess by abstract thinking and giving key concepts. While the choice of questions is linked to problems in everyday life, the readiness levels of students should not be ignored.

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