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Turkey

The New Educational Review

Metacognitive Behaviours of the Eighth Grade Gifted Students in Problem Solving Process

Abstract

This research aims to examine how gifted students exert their metacognition in each problem-solving step while solving a problem. In this sense, the researchers gave four students of the 8th grade three mathematics problems. The data of the study was collected through clinical interviews. The voice recordings of the students during the problem solving process and the solutions they wrote on paper formed the data of the study. The findings show that gifted students display metacognitive behaviours in problem solving process intensity. It was also observed that gifted students display some metacognitive behaviours which had not been determined by researchers before. These behaviours are seen at the stage of looking back and they are revision of connections between topics which were learnt in the past after solving a problem and relaxation of brain in order to evaluate what has been done by thinking over alternative ways. The findings of the research are important in terms of determining how gifted students exert their metacognition in each problem-solving step.

Keywords: *metacognition, gifted students, problem solving.*

1. Introduction

Metacognition as a concept was brought forward first by Flavell (1988), albeit theoretically it is dated back to earlier times. Many researchers defined it in different ways. According to Flavell (1979), metacognition comprises knowledge which an individual has acquired from his/her experiences through the cognitive process.

Metacognition is meditation of an individual over his/her thinking and learning process (Yorulmaz, 2006; Garner, 1987).

People need to struggle in order to solve a problem. Cognition exists in this struggle process (Polya, 1957;Yımer, 2004). But cognition is not enough for solving a problem. While solving a problem, one should assess the knowledge given, make an analysis-based plan and evaluate whether the results are reasonable or not. These processes require thinking about the thinking processes, that is metacognition. Thus, metacognition is an important element of problem solving (Gardner, 1991; Karmiloff-Smith, 1992).

In order for students to be good at problem solving, what kind of metacognitive behaviours they display while solving problems should be found out and necessary support must be given upon knowing what they lack. So, it becomes important to determine students' metacognitive behaviours to understand their mental processes while solving a problem (Schraw & Dennison, 1994).

It is important to improve thinking skills for every student at every grade. However, some researchers state that thinking processes of gifted students are different from other students' (Shore & Dover, 1987). Metacognition, in fact, helps gifted students be aware of their thinking processes (Yong & Zhicheng, 2009). Because gifted students need thinking skills more in order to evaluate what they have learnt (Amick, 1985). Therefore, some researchers and pedagogues state that metacognition contributes to performance of the gifted (Cassidy, 1998).

When the studies on the problem solving processes of gifted students are reviewed, it can be seen that very limited studies have been carried out. Some of these studies are as follows:

Düzakın (2004) found that gifted students could make connections among the ideas which seemed irrelevant for each other, could conceptualize abstract things in the problem solving process and had skills for synthesis. Dover (1983) found out that gifted students were more comfortable while solving a problem and solved it correctly within less time owing to the fact that they made use of their metacognition more effectively. Stonecipher (1986) analyzed the similarities and differences in the *mathematical problem-solving processes* of *gifted* and *average junior high school students.* The findings concluded that the *problem-solving processes* among the *gifted students* were dissimilar, among the *average students* were similar, and between the *gifted* and *average students* were dissimilar. In another study, Ellerton (1986) asked students to make up a mathematical problem that would be difficult for a friend to solve. A sub-sample of 11 – to 13-year-olds was interviewed while they were working on the items in the study. The findings concluded that gifted students were quicker at realizing their errors while solving a problem.

1.1. Purpose of the Study

We found out that studies dealing with metacognitive behaviours of gifted students were limited in number when scanning the relevant literature. Therefore, this research aimed to find out what kind of a metacognitive process gifted students employ in each problem-solving step.

2. Method

2.1. Research Method

By focusing on an exclusive case and without generalisation, a case study method was used in this research.

2.2. Participants

Gifted students in Turkey are educated in Science & Arts Centers, which are different educational institutions and independent of formal school programs. Selection of gifted students to be enrolled in these education centers takes place at six stages. These stages are diagnosis, designation for candidacy, preliminary evaluation, group scanning, individual scrutiny and enrolment-placement (Science & Arts Centers Directive, 2007).

The students who manage to pass all these stages get the right to be educated in Science & Arts Centers. Thus, we can say that Turkey is fastidious about the selection of gifted students. The research was conducted on four students, two of them were male and two of them were female and 14 years old, who enrolled in Science & Arts Center in the spring term of the 2009–2010 school year.

2.3. Data Collection

A clinical interview was used while collecting data for this research. The questions of the clinical interview were determined pronouncedly. The problems used in the study were prepared using the mathematics curriculum and mathematics course books. The clinical interview questions and problems prepared by the researchers were reviewed by two field experts. The problems are presented in Appendix 1.

2.4. Data Analysis

Polya states that an individual goes through four steps while solving a problem. These steps are understanding the problem, devising a plan, carrying out a plan and looking back. In this study, metacognitive behaviours of students solving problems were assessed as coded in the context of Polya's problem solving steps.

3. Results

3.1. Gifted students' metacognitive behaviours in the step of understanding the problem.

These behaviours are presented in Table 1 together with the students' answers.

Table 1. Metacognitive behaviours displayed by gifted students in the step of understanding the problem

Metacognitive Behaviours	Students	
To determine the basic concepts	G1,G2,G3	R: What do you understand about the problem? Can you express what you have understood? G1: At the moment, I understand the difference of two squares. R: What do you think about this problem? G2: It can be solved by combination. R: How do you plan to solve the problem? G3: Two out of six colours will be selected. I will solve it through combination.
To determine what to do in case of not understanding the problem	G2,G3	"I read as mathematics at first."(G2) "If I don't understand a problem at all, I often draw figures"(G3)
To think over what has been given	G3,G4	"At first, I read the problem and try to understand what it wants me to do. Once I understand, if there are alternatives, I interpret them seeking to answer which one is the right alternative." (G3) "I plan to juxtapose the given data at first." (G4)
To act in accordance with whether they have a grasp of a subject or not	G1	"If I know the topic very well, I begin to solve directly. If I have difficulty, I think a little at first, then I begin to solve according to what I need to do." (G1)

(R: researcher, G1: first gifted student, …, G4: fourth gifted student)

It was observed that the students determined the basic concepts they found useful before solving a problem. As seen in Figures 1 and 2, the students would use two squares difference before starting to solve the second problem and a combination before solving the third problem as based on their schematic knowledge.

Figure 1. The solution of the G1 student through two squares difference

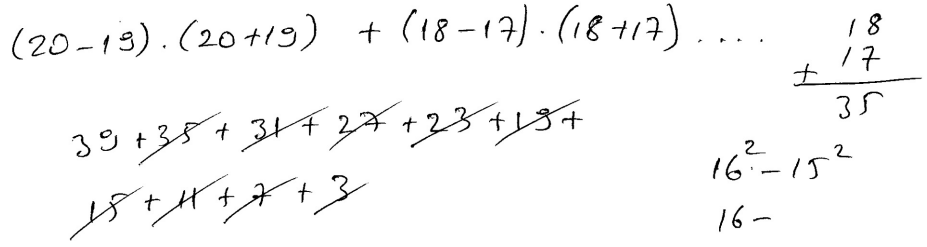
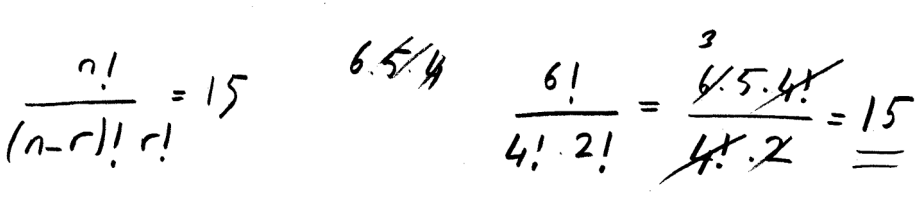
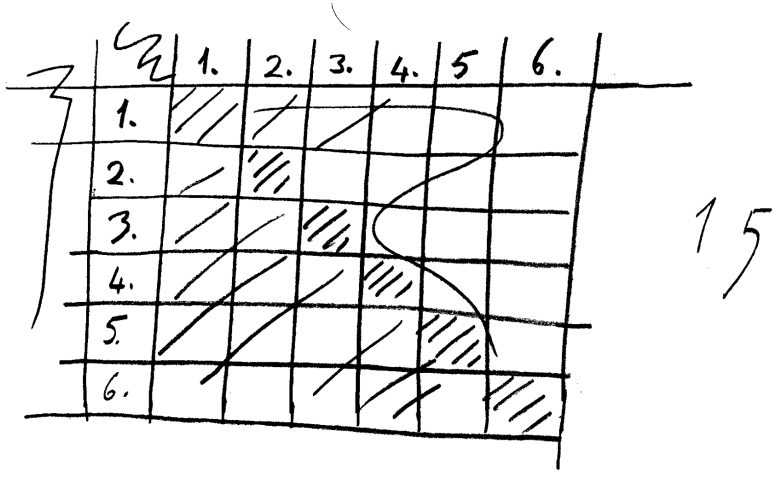


Figure 2. The solution of the G3 student through combination



However, as seen in Figure 3, the G3 student drew figures in order to understand the problem, which is possibly a metacognitive behaviour distinguishing the gifted students from the other students.

Figure 3. The drawing made by the G3 student while solving the third problem in order to understand it



3.2. Gifted students' metacognitive behaviours in the step of devising a plan

These behaviours are presented in Table 2.

Table 2. Metacognitive behaviours displayed by gifted students in the step of devising a plan.

Metacognitive Behaviours	Students	
To imagine possible solutions	G1, G4	"Before solving the problem, first I think how I can solve it."(G1) "Firstly I try to solve a problem in my mind, that is, I think how I can solve it. For example, if a problem starts saying there are 4 blue and 6 black balls in a bag, I imagine these balls" (G4)
To associate the given knowledge to real life via past experiences	G4	"I try to recollect my previous knowledge, that is, I think what is needed to solve that question. I try to solve it through associating it with real life as well."(G4)
To determine what to do according to the difficulty level of the subject pertaining to the problem	G1	"If I know the subject of the question well, I start to solve it instantly. If it is a difficult subject for me, I think for a while on what I should do and then begin to solve." (G1)
To devise alternative ways of solution	G2,G4	"I try to solve, I try different methods."(G2) "There can be different possibilities for a question. It can result in different ways according to its solution way. There isn't a way for a question." (G4)

One of the gifted students explained that he tried to recollect his previous knowledge and associate it with real life. By doing so, this student managed to concretize the problem by connecting the solution with real life. One of the gifted students, on the other hand, stated that he determined what to do according to his level of knowledge pertaining to the topic. Therefore, it can be said that the better a student knows a subject, the better he/she can solve a problem.

3.3. Gifted students' metacognitive behaviours in the step of carrying out the plan.

These behaviours are presented in Table 3.

Table 3. Metacognitive behaviours displayed by gifted students in the step of carrying out the plan.

Metacognitive Behaviours	Students	
To think about similar problems solved before	G1, G2	"I would do the same operation if I've solved a similar problem." (G1) "I use the subjects I know, that is, I use my previous experiences if question types are relevant." (G2)
To act in the direction of the plan	G1, G2, G3, G4	R: What have you done? You say you will apply 36× for this at first. G1: Yes. R: Why 36×? G1: In order to facilitate the operation. G2: Can we use proportion? R: Try it. G2: 2 over 4 divided by 3 over 4, because… R: Why 2 over 4 divided by 3 over 4? G2: Because these go on as 2 divided by 3 times 2 divided by 3, that is, as multiplication. G3: Let's suppose that this rises gradually falling out of 64 at the base. Let's calculate the distance of this rise. R:Ok. G3: 64 × 3/2 will rise. I can go on by calculating every peak at every rise… G4: Firstly, I draw a line symbolizing colours, I name each of them with different colours. R: Yes. G4: Each colour will form a couple with another but it will not repeat a couple it has formed before. I have found 15 different couples in this way.

Metacognitive Behaviours	Students	
To decide what to do in the next operation	G1, G3	R: Let's start to solve this aloud. Let's see what kind of a result we will obtain. G1: I will use 6 unknown letters here. R: Ok. Are all of them symbolizing colours? G1: Yes. R: You name them *x*, *y*, *z*, *a*, *b*, and *c*. G1: We will opt for two out of them. For instance, let's think, *x* and *y*, *x* and *z*, *x* and *a*, *x* and *b*, *x* and c. Now *x* is over. I will think other colours in this way. R: What do you plan to do? G3: First, I will try to find 2/3 of it, then 2/3 of the result again, then again and again, so I will find the proportion of the first through four multiplication operations.

After examining the metacognitive behaviours of the gifted students during this phase, we found out that they all tried to solve the problems in the direction of a plan. It can be asumed, on the one hand, that this is a normal behaviour that should already be displayed by a student who wants to solve a problem appropriately. On the other hand, the fact that some of the gifted students went on solving problems after deciding what to do in the next operation, can be an indication of determination in the step of carrying out a plan.

3.4. Gifted students' metacognitive behaviours in the step of looking back.

These behaviours are as in Table 4.

It was observed that, after solving a problem, the gifted students were reluctant about controlling whether the results they had obtained were correct or not. It can be said that this situation of reluctancy stems from the fact that gifted students are sure of the correctness of their results if they solve a problem via a rule or in the way they know well or find reasonable. Nonetheless, even if they are not sure, they try to see whether they will obtain the same results using different methods instead of classically controlling whether the result is correct or not by substitution of the values they have found. On the other hand, it was noticed that they revised the connection between the topics they had learnt before. By means of this revision, they could consolidate the topics they had learnt. Meanwhile, one of the

gifted students stated that he relaxed his brain in order to evaluate mathematical operations by thinking in different ways.

Table 4. Metacognitive behaviours displayed by gifted students in the step of looking back.

Metacognitive Behaviours	**Students**	
Not want to check	G1,G3	R: How do you prove the correctness of the result? G1: I am sure. R: What do you do after you solve a problem? Always after solving? G3: I check it, not always, if I am not sure about the result. R: Why are you absolutely sure of this question? R3: A question must be simple if I am absolutely sure. There must be no complexity in the question.. R: How have you been convinced that this result is correct? G3:The logic I have conducted is true eventually. If the logic is true, my reasonable operations and their result prove true.
To consolidate what has been learnt	G1	"I want to say something. This has shown me the difference between permutation and combination."(G1)
To rest the brain in order to evaluate operations by thinking in different ways	G2	"I wait for a while. I get my brain rested and try to remember different ways."(G2)
To predict possible errors	G1	"I think over possible errors as well while solving a problem." (G1)

4. Conclusion and Discussion

It was found out that the students determined the basic rules they found helpful for solving a problem before carrying out the plan step. Their extensive imagination in using these rules while planning helped them solve problems within shorter time. In a similar way, Wang (1989) and Ellerton (1986) concluded in their research that gifted students were good at effective planning. This conclusion concerning the

impact of imagination sounds unusual for students most of whom are accustomed to making plans using pen and paper. However, this way used by average students must not be regarded as an unwanted situation. Due to their characteristics, gifted students somehow show their difference from average students. What is important here is to help all students make plans in the proper way.

The students said that they resorted to thinking in alternative ways if necessary while carrying out a problem. Goos, Galbraith ve Renshaw (2000) stated that students needed to realize different approaches in order to solve a problem. Supporting this finding, Scruggs and Mastropieri (1985) concluded that gifted students tried more strategies while solving a problem. In the light of this conclusion, we can say that gifted students manage to solve problems through inventing several alternative ways while solving a problem.

The gifted students stated that, by being aware of their characteristics, they predicted possible errors while solving a problem. A student who is aware of his/her possible errors certainly knows him/herself well. Sternberg (1996) concluded that highly capable individuals were very good at determining their strong and weak points and skillful at compensating their drawbacks. In another study, Ellerton (1986) concluded that gifted students were quicker at realizing their errors during problem solving.

It was noticed that, in the looking back step, the gifted students were reluctant to check whether the results they had obtained were correct or not. On the basis of their observations, Lester, Garofalo and Kroll (1989) also concluded that students making successful plans in the problem solving process did not display the behaviour of checking their results. Owing to their self-confidence in making useful plans related to any problem, gifted students are reluctant to check. This means that it is necessary to help students acquire an appropriate planning behaviour prior to getting them to acquire a checking behaviour.

Besides, it has been observed that, while solving a problem, gifted students display some metacognitive behaviours not detected before. These behaviours include revision of connections between subjects which were learnt in the past after solving a problem and relaxation of brain in order to evaluate what has been done by thinking over alternative ways.

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Appendix-1

	PROBLEMS
1	A ball ascends 2/3 of its previous height when it is thrown from a determinedly high place and hits the ground. If the ball ascends 64 meters high after hitting the ground four times, what is the height of the place it is thrown in meters in total?
2	202–192+182–172+ … +22–12=? What is the result of this operation?
3	A contractor gives an owner of a house a catalogue to select the colour of parquets for rooms. In this catalogue, there are 6 different colours for parquets. The owner is to select two of these colours. How many different alternatives can he select?