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Research Article

The Game-Based Learning Process of Two Gifted Students for The Surface Area Knowledge of Geometric Shapes: Case Study [1]

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Abstract

The learning processes of the concept of surface area of geometric shapes by two students determined to be gifted by RCC (Research Center for Counseling) through a building game were investigated. Data was collected in this study through the qualitative research methods of semi-structured interviews and observation. A building game for composing shapes was utilized in the collection of the data. When preparing the game, the shape creation levels determined by Clements et al (2004) were taken as a basis. In this study the qualitative research case study method was employed. For data analize, the case study was preferred as it was possible to obtain a large amount of data with a small amount of participants.

Keywords

gifted students, game-based learning, building game, surface area knowledge of geometric shapes

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Introduction

According to Piaget play is an adaptation. Play is the method enabling the child to learn subjects that no one can demonstrate to the child through the child's own experiences (Yavuzer, 1984). Play is one of the means for children to express themselves. Children utilize play to understand the world, investigate usual relations, and comprehend the past and the future. In this respect, play is a tool for learning, and it is a universal language employed by every child (Muro & Kottman, 1995; Erkan, 2002). Play is not a process for the child, but actually, development. This is a fact to keep in mind in the approach to children of adults and educators. (Mangır and Aktaş, 1993). The most natural means of learning for a child is learning through play. Learning and play are not two contradictory things for children; they function together (Uluğ, 1997). "Playing games in the lesson is not a loss of time; it is a learning instrument that can be consulted by everyone" Dauvillier (1986).

According to Dogbeh and Diaye play has seven educational objectives complying with Bloom's classification (Dogbeh & N'Diaye, 1980). These are (Baykoç, 1992; Soylu, 2001) knowledge, comprehension, application (abstract concepts, use of principles and rules in new settings), analysis, synthesis (summarizing the components taken from resources, planning etc), evaluation (criticism of information, thought and methods), and creating-discovering (converting obtained information into creative activities). Through the game-based technique subjects become interesting and classroom activities become more motivational and comprehensible. However, it requires more attention, creativity, imagination, humor, and synthesis power compared to other techniques (Bilen, 1999). When selecting a game, the teacher has to consider criteria such as the objectives, characteristics of the subject to be taught, teaching period, student age group, cognitive development levels, socio-cultural environments, material means of the classroom or school, physical conditions of the classroom, the season (for especially physical games), authenticity of the game, its ability to draw attention etc. Paul Valery states, "There is no space for skepticism when there are game rules, because the principle they are based on is absolute reality. Their world falls apart as soon as the rules change". The rules of the game create equality among those participating in the game (Uğurlu, 1996). Rules in the subject should not be directly given in teaching with games and activities. As children are expected to reach the rules instinctively and see the solution within them; the teacher should not instantly tell the correct result when the student makes a mistake and should direct them to enable them to reach the solution. Therefore, according to Baykul (2003), the most preferred strategy in games and activities is the discovery learning strategy. Discovery learning is one of the most suitable learning models for the structure of mathematics. In addition to the development of the skill of problem solving; students are ensured to discover mathematics on their own with the guidance of the teacher (Baykul, 2003). Some findings indicate a positive impact on productively utilizing digital games as an instructional tool (Meletiou-Mavrotheris and Prodromou, 2016).

With all this, mathematics education should be interesting and fun. When students are able to enjoy mathematics education, their motivation in education shall increase (Cornell, 2000; Köroğlu &Yeşildere, 2002). Despite the intense curriculum of mathematics, the best way of including students in the activity is to ensure that they establish bonds with their own world through games (Foster, 2004). Most of the time, games are a way of exercising and making mathematics applications entertaining. The best games cover some thinking and guessing strategies (Dunn, Stewart & Williams, 2003).

"Children like playing games and would like to repeat something they like. Why shouldn't mathematics be a game? Enjoyable competitions, coloring activities with surprises, puzzles and riddles can create a more entertaining educational process" (Gelmedi, 2004).

Smith and Dutton (1979) investigated the relation between the manipulative play and problem solving. A group was provided the opportunity to deal with and play with items in a problem, and the other group was provided guidelines for the solution of the problem, but not given permission to play with the items. It was observed that the group playing with the items solved the problem easier and was more successful in the solution of complicated problems compared to students in the control group. (Gander & Gardiner, 2004; Meadows, 2016). According to Güven (1995) play makes the complicated and abstract learning in science and mathematics become more concrete and interesting. The most important difference of teaching with games compared to other teaching methods is focusing attention on the taught subject and shifting the student to an active mode form a passive mode (Hazar, 1991). The child can learn many concepts through games such as size, shape, color, dimension, weight, volume, measurement, counting, time, location, length and space and many cognitive operations such as matching, classifying, ordering, analysis, synthesis, and problem solving (Mangır & Aktaş, 1993). According to Piaget (1954) if the individual can connect information particles within active interaction in a meaningful manner, s/he shall be able to classify, organize, and code that information in an easier manner. Thus, one of the conditions for the actualization of meaningful learning in mathematics teaching is to enable the student to process his/her own cognitive processes, directly participate in the learning process, have concrete experiences, and not to impose external information on the student. Teaching through games and activities is an approach covering all these issues. Randel, Morris, Wetzel, and Whitchil (1992) have conducted eight studies on the use of games in mathematics classrooms and in seven of these studies; they have determined that games are superior in the development of mathematical achievement compared to traditional education.

Sarama, Clements, Henry, and Swaminathan (1996) investigated the behavior of preschool children when forming shapes in their studies, and they observed that these children underwent similar developments. It was reported that children demonstrated a development from placing shapes separately to placing shapes together by considering them together, from hand movement and limited perception strategies to shaping cognitive imaging, from placing

shapes through trial and error to acting with knowledge and awareness and guessing the successful placement of the shape at the end, from considering the shape as a whole to considering them based on side lengths and angles. Considering these observations (Sarama et al., 1996) and existing studies, it was argued that children underwent various levels of thinking and skills in the shape creation domain and 6 levels of thinking were developed (Clements, Sarama & Wilson, 2001). Afterwards, another level was added (Clements, Wilson & Sarama, 2004) and 7 levels of thinking were identified in the shape creation domain. These levels and explanations have been provided below.

1) Precomposing: In this level, children are able to use the shapes separately; however, they are unable to combine these shapes to compose larger shapes.

2) Piece Assembling: Children in this stage can place shapes contiguously to form pictures. They can compose pictures, in which each shape assumes a single role. Children can fill simple structures through trial and error; however, they have limited turning or flipping skills. They are unable to use actions to see the shapes from different perspectives.

3) Picture Making: Children at this level can bring many shapes together to make a part of a picture. They use trial and error. They can turn and flip. They are unable to anticipate the composed state of the new geometric shapes and act accordingly.

4) Shape Composing: In this level, children are able to compose new shapes or fill in puzzles with growing intentionality (I know what will fit). When selecting shapes, the angles are taken into consideration besides side lengths. Flipping and turning are used intentionally for selecting and placing shapes. They can fill complex structures requiring the use of many shapes to be completed.

5) Substitution Composing: The child in this level can make new shapes from smaller shapes by new ways and uses different shapes as substitutes for a group of shapes through trial and error in order to form new shapes. They recognize and use varying relations between shapes.

6) Shape Composite Iterating: In this level, children can intentionally compose units (shapes composed of other shapes) and make copies. They can understand multiple small shapes and large shapes. They can continue the pattern of shapes enabling it to be covered with shape parts. They can repetitively use shape composition in composing a shape or model.

7) Shape Composing with Superordinate Units: In this level, children can make and use units of units.

There are many cognitive characteristics that distinguish children with superior intelligence and gifted children from their peers with normal intelligence. Even though it is not accepted as a general rule, it has been suggested that most children with superior intelligence and gifted children acquire some characteristics at an earlier stage compared to their peers (Davaslıgil, 2004; Tortop, 2015). They have an extensive imagination and imagery skill, and they have a high potential of producing unique products based on this (Silverman, 1993). Owing to their early cognitive development,

they are able to establish logical reasoning at smaller ages and generate solutions for complex problems by employing their creativity (Getzels and Jackson, 1962). Spatial-visual ability is a distinguishing feature that separates gifted and talented children from their peers and is different from their peers in shape creation thanks to this ability (Gardner, 1983; David, 2015). Some sources emphasize that children superior intelligence and gifted children are advanced compared to their peers in terms of cognitive skills under the scope of spatial visual abilities such as rotation in the mind, establishing ground-shape relations, envisioning, and perspective (Eliot & Smith, 1983; cited by Stumpf & Eliot, 1999). Gifted children spend more time playing compared to reading and studying. The interest of gifted children and moderately gifted children towards play generally demonstrate similarity rather than oppositeness. Some differences in between appear to be due to gifted children being cognitively more mature (Miles & Huberman, 1994).

Within this context, the game-based learning process of two gifted students concerning the surface area of geometric shapes was investigated. The purpose of this study is to investigate through a play the process of learning the concept of geometric surface areas by two students determined to be gifted by CRM National Education Board in (Counseling and Research Center).

Method

Revealing both the observable and unobservable student behaviors and intellectual processes of gifted students when solving problems and examining them in-depth are of significance for the purpose of the study. Due to this reason, the qualitative research case study method was employed in this study. Case studies were employed as they provide the opportunity to perform an in-depth investigation of intellectual processes, rather than making generalizations (Fraenkel & Norman, 2009; Yin, 1994). Furthermore, case studies are based on the questions of "how" and "why" and are a qualitative research method enabling the researcher to perform in-depth investigations of cases s/he is unable to control (Yıldırım & Şimşek, 2008).

Participants

The participants of the study are two students determined to be gifted by the CRM (Counseling and Research Center) and attending the Balıkesir Science and Art Center in the 2013-2014 academic year. The participants were selected through the extreme or deviant case sampling, which is one of the purposeful sampling methods. As purposeful sampling permits cases to be studied in-depth, it provides benefits to the researcher in discovering facts and events (Yıldırım and Şimşek, 2008). The extreme or deviant case sampling is a method enabling the uncovering of richer data with a limited number of sample cases compared to normal circumstances and in-depth investigation of the problem (Yıldırım and Şimşek, 2008). Thus, participants of the study were randomly selected from students in the metacognitive level and the special skill development level, by taking care so that one had higher mathematical achievement and the other had lower mathematical achievement. The code

name Sefa was used for the student in the special skill development (higher) level and the code name Ali was used for the student in the metacognitive (lower) level.

Data Tools

In order to achieve the objective of teaching through games it is necessary to understand the capacity of the individual and observe the extent of reception of things that are intended to be provided. Observation is the most important instrument when evaluating students engaged in games and activities.

This study aims to investigate the behavior of gifted students during game based teaching and obtain knowledge on their cognitive processes. Within this context, the data of the study was collected through semi-structured interviews, which is a qualitative research method, and observation. A building game for composing shapes was utilized in the collection of the data. When preparing the game, the shape creation levels determined by Clements et al (2001) were taken as a basis. The process of the participants playing with this building game at 6 different levels of difficulty (at shape composition levels determined by Clements et al and other levels determined by experts to be higher than these levels) was investigated.

Necessary permissions was obtained prior to the application in the second semester of the 2013-2014 academic year and the administration of the Balıkesir Science and Art Center, students participating in the study, and their parents were informed.

During data collection, the following points specified in Aracı's study (2001) have been taken into consideration: The game was thoroughly taught prior to the application, a preliminary application was performed, and a game plan was prepared. Prior to the game, game materials were prepared and the tools and instruments of the building game to be employed were introduced to the students. Game materials are a game board, a bracket, 12 pentomino. Care was taken so the materials used for the game were made of wood not containing chemical paint.

Figure 1. 12 Pentomino consisting of the letters of I, L, Y, N, V, P, U, Z, F, T, W, and X

The rules of the game were explained in a comprehensible manner and as the game progressed, the rules to be applied were explained when necessary and not at the beginning. The easy level was selected for the beginning. Ordering in 6 different levels depending on the structure and instrument of the game were formed. When a decrease in interest was observed, necessary changes were made in the game's same level.

The case study was performed in the mathematics laboratory of the Balıkesir Science and Art Center in the second semester of the 2013-2014 academic year

separately with students participating in the study within the same week. This study lasted a week. When necessary, the students were asked various questions considered to determine the nature of thinking of the students. The participants were provided an adequate amount of time, so they can perform their solutions and observation notes were kept during interviews. Each interview was recorded with a video recorder placed on a platform visible by students. Interviews took 53 minutes and 41 seconds for Sefa and 36 minutes and 18 seconds for Ali. The observation notes, video recordings, and responses to the questions were analyzed.

Data Analysis

In the analysis of the data, the processes of "data reduction,", "data display," and "Conclusion drawing/verification" were utilized (Miles & Huberman, 1994). The data was analyzed through content analysis. Thus, prior to initiating the study, some codes were determined within a general framework. New codes were added to these codes in the analysis process of the study. The obtained themes were ordered in a manner establishing relations and an entirety with each other. Then the findings were reported and presented.

Results

In this section of the study, data obtained from interviews with Sefa and Ali has been presented on a sample from each of the 6 building levels of the game. Afterwards, depending on analysis results of semi-structured interviews conducted with these students, the behaviors of students in the shape composition process, have been presented by taking various levels of the building game into consideration.

Investigation of Different Building Levels and the Behaviors of Sefa and Ali

An example from each building level for the surface area of geometric shapes and the observed behaviors of 2 gifted students have been presented in this sub-section (Sefa: S, Ali: A, Researcher: R).

Thema: LTY Pentominos

First building level:

The participants were directed the question of "*Try to cover the surface corresponding to the area of 3x5 by using the pentominos of L, T, and Y when the slider is at number 3...*".

Interviews of Sefa and Ali concerning the first level have been provided in Table 1.

Table 1. Interview with Sefa and Ali concerning the first level.

Interview with Sefa concerning the first level	Interview with Ali concerning the first level
He first held all the pentominos. (behavior) He centered the T pentomino and relocated it, changed his mind, leaned it on the lowest side of the game frame. (behavior) R: Orange, brown, and green T… He shook his head and continued to place them. (behavior) R: …you are trying to cover this area by using them. He completed covering the surface. (behavior) R: Very good, thank you. (cited from the video recording)	R: Yes, you can start. He picked up the Y pentomino and leaned it to the left. (behavior) He turned the L pentomino with a reflection action. (behavior) R: …for the area of 3x5… He correctly placed the T pentomino and completed covering the surface. (behavior) R: A, Yes, Thank you. (cited from the video recording)

Sefa covered the surface in his 2nd attempt and in 9 seconds. He reached the solution by turning the shapes and through trial and error. Rather than intentionally placing the pentominos, it was observed that he placed them randomly. This is a behavior in the 3rd level defined by Clements et al (2001).

Ali covered the surface in his first attempt and in 4 seconds. He turned and flipped them intentionally in order to select the shapes and place them. This is a behavior in the 4th level defined by Clements et al (2001).

Thema: LPVY (Changed LPTY) Pentominos

Second building level:

In the second building level, the participants were directed the question of "*Try to cover the surface corresponding to the area of 4x5 by using the 4 pentominos given to you while the slider is at number 4*".

Interviews of Sefa and Ali concerning the second level have been provided in Table 2.

Table 2. Interview with Sefa and Ali concerning the second level.

Interview with Sefa concerning the second level	Interview with Ali concerning the second level
The pentominos of L, P, V, and Y were used. He started with the V pentomino. He turned the L pentomino with a few reflection movements. (behavior) … (1 minute 40. seconds, 8th attempt) he stood up and sat down again. (behavior) … S: It's not correct. (10th attempt) … S: If there were two of these (L). (2 minutes 35. seconds)	The pentominos of L, P, T, and Y were used. R: Now you are drawing it to 4 and saying this (P). … (20th second, 6th attempt) Combined the L and P pentominos in the air and composed a new shape. (behavior) … A: Oh gosh. (Got bored in the 11th attempt) (behavior) … A: Oh gosh. Didn't work again. (16th

R: As you can see, there is one of them. … R: Does the game appear to be different? Isn't this your first attempt? (22nd attempt) S: Yes, only if there was another similar one of this (P). R: (Smiling) Actually they are all equivalent blocks. They are all 5 units. … (28th attempt) After placing the L and Y pentominos, he places the P pentomino correctly, adds the V pentomino and completes the surface. (behavior) R: Hurray… (cited from the video recording)	attempt) If I place it here… A: Didn't work out again. (17th attempt) (18.deneme) After placing the Y and L pentominos, he placed the T pentomino correctly, added the P pentomino and completed the surface. He moaned. (behavior) R: Yes, thank you. (cited from the video recording)

Sefa covered the surface in the 28th attempt and 4 minutes and 35 seconds. Even though his solution took some time, he reached the solution when he designed the unit of the unit and used this knowledge. This is a behavior in the 7th level defined by Clements et al (2001).

Ali covered the surface in the 18th attempt and 1 minute and 43 seconds. He composed a new shape out of the L and P pentominos and used some shapes in place of other shapes through trial and error in order to compose a new shape in different ways. This is a behavior in the 5th level defined by Clements et al (2001).

Thema: FPTUY (Changed LPTWY) Pentominos

Third building level:

In the third building level, the participants were directed the question of "*Try to cover the surface corresponding to the area of 5x5 while the slider is at 5 using the 5 pentominos given to you.*".

Interviews of Sefa and Ali concerning the third level have been provided in Table 3.

Table 3. Interview with Sefa and Ali concerning the third level.

Interview with Sefa concerning the third level	Interview with Ali concerning the third level
The F, P, T, U, and Y pentominos were used. He first took the T pentomino. (behavior) … There is space left only for the I pentomino. (1 minute and 16th second) A: (He smiles). … He tried the F pentomino in every direction. (20th attempt) (3 minutes 52 seconds) … He brought the T, U, and Y pentominos	The L, P, T, W, and Y pentominos were used. He started with W. (behavior) A: I do not know if I am proceeding correctly. (16th second) R: It is not definite till the last moment, don't worry. A: Ugh, can I take this (V)? R: No. (Smiles) … An area corresponding to I remains empty. (behavior) A: I want that… (I) (55th second)

together with a very different way of thinking. (behavior) (25th attempt) (4 minutes 29 seconds) … He placed the T pentomino in the center. (27th attempt) … He brought the F and Y pentominos together in his hand. (behavior) He missed the solution in the 28th attempt. (behavior) (5 minutes 28 seconds) … He covered the surface in the 30th attempt. (behavior) R: Hurray… (cited from the video recording)	R: No. (Smiles). Then it would have been very easy. (10th attempt) … A: Let's break it (L). (Smiles). Luckily it's not made of plastic. (14th attempt) R: You would have broken it then. … There is only space left corresponding to Y. (18th attempt) R: No…(Smiles) A: (he picks up the F pentomino) I need really need this (F). (Attempts). Oh it did not work. (Leaves it back) (behavior) … A: Why am I placing this here? This place remains empty. (23rd attempt) It is complete in the 24th attempt. A: OK, it's finished. R: Yes. Well done. He brings the slider to number 6. (cited from the video recording)

Sefa covered the surface in the 30th attempt and in 6 minutes and 2 seconds. He intentionally used turning and flipping to select and place the shapes. He made a new shape with the F and Y pentominos and used other shapes to replace a group of shapes through trial and error in order to compose a new shape in different ways. Furthermore, he designed a unit of a unit and reached the solution by using this knowledge. These are behaviors in the 4th, 5th, and 6th levels defined by Clements et al (2001).

Ali covered the surface in the 24th attempt and in 3 minutes and 33 seconds. He designed the unit of a unit and reached the solution using this knowledge. This is a behavior in the 7th level defined by Clements et al (2001).

Thema: LPVWYZ (Changed FNPUVZ) Pentominos

Fourth building level:

In the fourth building level, the participants were directed the question of "*Try to cover the surface corresponding to the area of 6x5 while the slider is at 6 using the 6 pentominos given to you.*".

Interviews of Sefa and Ali concerning the fourth level have been provided in Table 4.

Table 4. Interview with Sefa and Ali concerning the fourth level.

Interview with Sefa concerning the fourth level	Interview with Ali concerning the fourth level
The L, P, V, W, Y, and Z pentominos were used.	The F, N, P, U, V, and Z pentominos were used.
He first set the pentominos he would use aside. While he had picked, Y, he then changed it and picked L. (behavior)	He started with U. He combined U and F. He added N and V. (behavior) A: It seemed a little easy. Or I was

…
(28th second) He combined L and Z. He separated the entirety into separate units.
…
(2 minutes 32nd second) He put W in the middle in his 5th attempt.
…
He combined L, P, and V in the 10th attempt.
He covered the sides prior to the 11th attempt. He placed Y in the center.
R: You were very close. (in his 12th attempt)
…
He achieved a large unit in the 17th attempt.
He placed W in the middle in the 18th attempt.
…
There was space left for I in the 29th attempt. He picked up I and placed it in the space.
R: (Smiles) You are not the only student that has tried this. I was wondering when you would try this. You lasted a while.
…
(31st attempt) S: Maybe I have tried the same thing many times.
R: How many times you have repeated or whether or not you have repeated the same thing will be revealed when we watch the video. Maybe you have not repeated it.
S: I definitely repeated it. Why did they put (Z)?
R: Not many like Z. Other than me…(smiles)
…
(36th attempt) he tried W in various forms. (behavior)
…
(39th attempt) He only placed W in the center. (behavior)
(40th attempt) he took U.
R: Ok, no transfer.
…
(43rd attempt) S: Oh gosh!
…
(45th attempt) He placed Y and P.
…
(48th attempt) He was about to pick up U mistaken. (he removed V)
R: You shouldn't be tricked by the appearance. But, you never know.
A: (He takes N) I should separate this. (He separates the unit cubes) 1, 2, 3, 4, and 5. (He counts the squares in the gaps) It fits exactly.
R: (Smiles) They are all 5 unit cubes. Especially that one.
He only leaves U and F.
A: I believe we should break these and burn them as firewood.
R: How?
(3rd attempt) A: We should break these and burn them as firewood. It would be more useful.
R: (Smiles)
(4th attempt) There is only a gap corresponding to P and he places P and covers the surface.
(cited from the video recording)

due to inattentiveness, he noticed it and dropped it. (behavior)
S: Can I give up?
R: (Smiles) I don't know. Should you be able to?
S: I think so. (He places Y)
R: Why? Are you very tired? Or did you get irritated?
S: Both.
R: It is kind of an irritating game when you can't do it. I accept it; it is very fun when you can do it.
(51st attempt) he placed W in the middle.
The bell rings.
R: Would you like to have some rest?
He tries U. (behavior)
R: There is no yellow transfer. Should we have some rest? We can continue later.
S: Ok. (he continues trying)
R: Maybe you would have done it.
Break.
(52nd attempt) S: Is this game based on arbitrariness?
R: What do you mean?
S: Do we randomly make up these shapes?
R: Of course. But, thinking about what goes where is another perspective is. You are using your spatial-visual intelligence when playing this game.
(54th attempt) He placed the W and Zs vertically.
R: (Smiles)
…
(58th attempt) Only Z is not placed.
S: Oh… Gosh!
(59th attempt) There is space remaining for a second Y.
S: Only if there was another one of this (Y)…
R: Consider it to be like Tetris.
(61st attempt) He placed L and Y vertically. He smiled. He separated V and Z on the ground while they were combined. He formed a unit smaller than the other ones.
(62nd attempt) He tried a new combination with W and Z.
…
(64th attempt) He placed W in the center.
(65th attempt) He turned W, P, and Y as a block. (behavior)

(66th attempt) he removed Z and V as a block and flipped them and completed it R: Hurray… S: Thank god. I've been trying for hours. I was going to give up at 35 past; it is 34 past. R: Super… (cited from the video recording)	

Sefa covered the surface in the 66th attempt and 32nd minute. He intentionally used turning and flipping to select and place the shapes. He combined the shapes and obtained new units and he used these units in new attempts by turning these units in the form of blocks. These are behaviors in the 6th and 7th levels defined by Clements et al (2001).

Ali covered the surface in his 4th attempt and in 1 minute and 27 seconds. He designed a unit of a unit and he used this knowledge and reached a solution. This is a behavior in the 7th level defined by Clements et al (2001).

Thema: NPTVWYZ Pentominos

Fifth building level:

In the fifth building level, the participants were directed the question of "*Try to cover the surface corresponding to the area of 7x5 while the slider is at 7 using the 7 pentominos given to you.*".

Interviews of Sefa and Ali concerning the fifth level have been provided in Table 5.

Table 5. Interviews of Sefa and Ali concerning the fifth level.

Interview with Sefa concerning the fifth level	Interview with Ali concerning the fifth level
S: Should or shouldn't I do 7? R: It's up to you. Do you want to do it? S: No, because it will take longer on this. I will try. Should I do 12? R: Yes. (cited from the video recording)	The N, P, T, V, W, Y, and Z pentominos were used. He started with N and added L, P, and T. (behavior) A: It seems that it got a bit easier as it got bigger. R: Maybe. This can be considered. May be you are getting used to it. A: Maybe. It sounds logical. Can I give this brown one (Y) and get the blue one (I). R: No. (Smiles) No swapping. He acted like he was detaching W. (behavior) When Z was outside, there was a gap corresponding to Y. A: Isn't there a part fitting this (for a space corresponding to Y)? R: Brown. (Smiles) Only if there were two brown ones. He took Y again and tried it in the gap.

	A: (Pointing out to the other gap) Let's stick pieces of paper here, it will be over… R: You are witty. (Smiles) A: I will break this (Z) and throw it in the trash. R: Think from another perspective. Turn the game board. (behavior) R: This means the solution is not here; but you are very close. Because, it seems similar to one of the pieces in your hand. Think in a different manner. You definitely will find a solution. There is no giving up. A: Yes there is. (Smiles) R: No there isn't. (Smiles) A: (he grabs W) How can I fit this (W) here (gap)? It doesn't fit. (2nd attempt) He placed Z, W and N. A: (He points to one of the gaps) No shape fits here, isn't that correct? R: This means you thought incorrectly. It doesn't' work with the ones I have. He turned W and N in the form of a block a few times. A: Ugh… R: Once you have found ones that fit each other, you don't want to let them go. Don't you? A: That's true (3rd attempt) He placed N first. A: (while placing W) This always happens… R: Yes, it is a difficult phase. But you like challenges. (4th attempt) A: No, I don't! (Smiles) R: No. (5th attempt) He placed V, N, and Y. A: I am starting to get irritated. R: (Smiles) He removed Y. (6th attempt) He combined N and P. He placed Y, W, and T and stroked his cheeks. A: Ugh! (7th attempt) He removed Y, W, and T as a block. He placed P, N, and Y. He placed W and Z. R: remember, last time you found it while you were complaining.

	A: Should I start talking again? (Smiles) R: Speak… You are free to do so. A: (Makes rhythmic sounds) He completes covering the surface. (cited from the video recording)

After demonstrating signs of weariness, Sefa stated that he did not want to solve this level and move on to the next level. When it is considered that he spent a long period of time on the solution in the 4th level, and also his age is taken into account, this is an expected behavior.

Ali covered the surface in his 7th attempt and in 4 minutes and 42 seconds. He combined the shapes and obtained new blocks. He turned units in the form of blocks for new attempts. These are behaviors in the 6th and 7th levels defined by Clements et al (2004).

Thema: ALL Pentomino

Sixth building level:

In the sixth building level, the participants were directed the question of "*Try to cover the surface corresponding to the area of 12x5 while the slider is at 12 using the 12 pentominos given to you.*".

Interviews of Sefa and Ali concerning the sixth level have been provided in Table 6.

Table 6. Interviews of Sefa and Ali concerning the sixth level.

Interview with Sefa concerning the sixth level	Interview with Ali concerning the sixth level
S: I guess I am going to use all of them. R: Yes. S: Then, I should continue here. He added I, where he covered level 5. He placed U and F and tried N. … (77th attempt) he placed X in the center. R: Logical. … R: You may need to detach the other sections you have completed. He took the L from the block he previously had composed and placed it somewhere else. R: He took them all out, even though he did not want to. (Smiles) He removed them all. S: I have spoiled it. (9th attempt) He started all over. He placed L. … He covered an area of 4x5. He centered T. He removed the others outside of the area of 4x5. He covered the edges. He could not	A: I should take all of them (12 pentominos). R: I am giving you all of them. A: This is probably the easiest. R: Let' see. He started by placing V. He placed P, He leaned and got I. R: Witty. (Smiles) He placed W, X, and T.(by making a rhythmic sound) (2nd attempt) He placed V, T, P, and I. A: I wanted to place this a lot (I). R: I believe you wasted that very early. A: Really? R: I don't know. Maybe it's good. Let it stay. You will remove it if you need it. He removed I. A: Or, I should place it. (He placed I). R: Leave it, Do it as you think so, Never mind. My opinion is not very important at the moment. He placed N, L, and Y. A: Am I proceeding correctly? R: I don't know.

place F. He ruined the edges.
S: I guess I won't be able to do this until the bell rings. (He placed T vertically).
R: (Smiles)
He tried X and Y. He removed Z and W as a block. He placed all of them except for Z.
R: But you were very close.
S: No! I am going to kill myself now…
R: (Smiles) What next!
S: Yeah, but this is Z (points to the shape of the space). It would have been done if there were 2 of these (W).
R: But there is none left.
He tried to place Z in an area corresponding to W.
He pushed the game from the table.
S: I don't want to see it anymore. I won't spoil this, my teacher. That's all I could do. I think we should leave it like this.
R: Are you sure?
S: Yeah.
R: Ok.
(cited from the video recording)

A: I guess it is this (N), I feel as if it is here in the answer key (he points to the gaps).
R: (Smiles) well, well, well… someone has seen the answer key
A: I couldn't help it?
R: You didn't miss the opportunity.
…
He randomly placed W in the gap. He changed his mind.
…
He respectively placed F, W, and U and removed them. He placed W and tried to place F.
He turned N, which he had previously placed. He pushed it.
A: Why won't you get in?
R: (Smiles) Place the orange one.
A: I was about to think of that. (He placed L).
…
He placed U, N, and Y.
…
He combined X, W, and Z in his hand and made a unit. He removed the section in the form of a block with his other hand.
(10th attempt) A: Can we look at the answer key? Yes.
R: Should we look? Are you sure?
A: One minute, my teacher… (he continues trying)
The bell rang. He looked at the solution.
(cited from the video recording)

Sefa quit covering the surface in his 9th attempt and in 8 minutes and 32 seconds. Ali quit covering the surface in the 10th attempt and 5 minutes and 41 seconds. They intentionally used turning and flipping in order to select and place shapes in this level. They combined the shapes and obtained new units, and they made new attempts by turning these units in the form of blocks. Furthermore, Sefa placed the shapes vertically. All these behaviors are in level 6 and 7 shape composition levels defined by Clements et al (2004). Even though they were unable to achieve the entire solution at this level, below, there is the photo of the final positions they achieved in this level.

Figure 2. Final position achieved by Sefa in level 6.

Figure 3. Final position achieved by Ali in level 6.

Discussion and Conclusion

In this study, it was determined that students performed trial and error more when they demonstrated low performance and when selecting and placing shapes, they were less successful in the turning and reflecting movements, they were able to experience difficulties in cognitive imagery, they were unable to perform mental turning and reflecting even if they achieved cognitive imagery, they had difficulties in perceiving shape units, and they had difficulties in perceiving newly composed shapes as a whole. This result is also supported by the study of Sarama et al (1996).

As levels 5 and 6 of the building game are considered to be higher than the levels defined by Clements et al, it does not come as a surprise that the achievements of students are lower at these levels. A striking issue here is that, the student in the lower program (metacognitive) was slightly more successful compared to student in the special skill development program. The reason for this may be the effectiveness of other variables such as creativity in such problems. As expected, in addition to this, it was determined that both students demonstrated higher performance in levels requiring the determination of units.

The findings of the study indicated that students demonstrated a lower performance than expected in some levels of the game. The levels determined by Clements et al can be interpreted as not dependant on the age or intelligence level and dependant on experience. As children in our country have not

frequently encountered shape creation and shape disassembly games, their skills in this field may have not been adequately developed.

This study is considered to provide some hints for the development of various educational games and activities in order to be used in the mathematical education of gifted students, constitute an example for studies to be conducted in Turkey on "Games and Mathematics Education," and contribute to the studies on the inadequacies experienced in mathematics teaching, even though they may be limited.

Recommendations

Scientific studies can be conducted in various branches, topics, and levels concerning education through games and activities. A game and activity repertoire can be developed for each grade level. The inclusion of the emotions and thoughts of children on education through games and activities can enhance effectiveness.

Space can be allocated for games in schools or classrooms. Classrooms can be equipped with equipment-materials for the content of the course or subject depending on the characteristics and purpose of education. Necessary physical changes can be made by considering external factors such as light, color, temperature, sound, etc. The game setting and materials to be sued should be designed in a manner that would not cause damage to the child. All sorts of risks should be avoided. Uniform games and activities should be avoided. Games should be made so that they are entertaining and enjoyable. They should be supported with interesting materials designed in a manner activating sensory organs as much as possible. The materials should be colored and have a flexible structure (Yıldız, 1997). The teacher should thoroughly plan and by initiating the game process in a good manner, s/he should be able to structure it. Preliminary preparations should be completed prior to commencing the game.

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