Evaluation of Students' Opinions on Mathematics Teaching Process Designed According to Multiple Intelligence Theory

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Abstract

In this research, it is aimed to introduce the teaching process related to the mathematics course designed according to multiple intelligence theory and to evaluate the students' opinions about the teaching process. Action research design was used in the research. Purposeful sampling method was used in the research group. The research group consisted of 18 students attending a high school. As a result of the evaluation of the observation forms applied, the students developed materials and activities related to their own intelligence areas related to trigonometry. The interview form was analyzed with descriptive analysis method. As a result of the research, it was determined that the students stated that the lessons were more fun and they learned the subject more easily with the activities designed according to multiple intelligence theory. It was concluded that the students learned by doing by themselves because they prepared the materials themselves, they participated in the classes more actively but the application process took too much time and the learning environment was noisier.

Keywords: Multiple intelligence theory, mathematics teaching, trigonometry

This Article can be cited as:
Kutluca T., Laçin S., Gündüz S., (2020). Evaluation of Students' Opinions on Mathematics Teaching Process Designed According to Multiple Intelligence Theory, *Journal of Arts and Social Sciences. VII* (2), 256-268.

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Introductıon

Intelligence that has been studied for years, is an abstract expression that is constantly wondered, questioned and marked out (Wang & Liu, 2018). Although there are many theories about intelligence, this theories can be handled under two headings, namely "a structure with one kind" and "a structure with more than one kind". According to Campbell and Campbell (1999), theories that consider intelligence as a single-factor structure were generally introduced in the first years when the subject of intelligence started to be examined. Later on, it was noticed by psychologists that the majority of people did not achieve the same degree of success in all of the items measuring different mental skills in an intelligence test. For this reason, the researchers have put forward many theories that bring different explanations about the question of how the structure of intelligence (Campbell and Campbell, 1999). One of the theories that sees intelligence as a structure with more than one type is Gardner's Multiple Intelligence Theory. In this theory put forward by Howard Gardner in 1983, it has been suggested that each individual has different degrees of intelligence, unlike a single intelligence concept, and this theory has found wide application in the field of education in a short time (Armstrong, 2000, p.38). In 1983, when multiple intelligence theory was first introduced, while the number of intelligence areas was seven, intelligence areas were redesigned with the addition of the "natural intelligence" field in the "Intelligence Reframed" book published by Gardner in 1999 (Saban, 2005). According to the multiple intelligence theory redesigned by Gardner in 1999, there are a total of eight intelligence fields: verbal-linguistic, musical-rhythmic, mathematical-logical, visual-spatial, physical-kinesthetic, personal-self-directed, social-interpersonal and natural intelligence (Gardner, 1999).

Multiple intelligence theory draws attention to individual differences and predicts a shift from a teacher-centered teaching approach to a student-centered teaching approach (Akamca & Hamurcu, 2005). This theory argues that some intelligence field of people develops more than other intelligence fields (Saban, 2005). Also, according to this theory, the traditional education approach that gives importance to mathematical and verbal intelligence should change (Al-Zoubi & Al-Adawi). Every class of plants looks like the same but each grows differently and gives different products (Abenti, 2020). For this reason, individuals who are successful in a field of education can be successful in all fields, and should be replaced by the opinion that individuals can be successful in different fields (Abenti, 2020; Algani, 2019; Al-Zoubi & Al-Adawi; Doğan, 2019). Multiple intelligence theory, which advocates that multiple intelligence fields can be used for individuals to develop different strategies for teaching and learning, helps teachers to learn by using the active learning model in their lessons and to make students learn by doing (Estrella, 2016; Shearer, 2004).

It is very important to prepare activities for different intelligence areas where students is be able to participate effectively in mathematics lessons (Kutluca, Bulut & Kılıç, 2016). Because learning mathematics requires more than verbal-linguistic and mathematical-logical intelligence. However, today, mathematics in high schools is still taught with traditional understanding and is one of the courses that students fail. Durmuş (2004) determined the difficulty index of the subject of trigonometry in his study to determine the subjects perceived as difficult by students in mathematics lesson. Accordingly, the topic of trigonometry has been the 5^{th} subject among the most difficult topics that the students participating in the study have ever seen. In order to achieve meaningful learning, teachers need to be aware of students' learning difficulties in mathematics teaching and to plan the education and training process accordingly (Walshatri, Wakil, & Bakhtyar, 2019). Because, the teaching process, which is planned by considering multiple intelligence theory, has been shown to increase students' mathematics achievement, attitudes towards mathematics and permanence of information positively (Wang & Liu, 2018). It is thought that contemporary approaches, which take into account the individual differences of students, should be adopted from the traditional education approach, especially in subjects such as trigonometry, where students have difficulties in understanding operations and seeing these functions as functions (Güntekin and Akgün, 2011). Each teacher should apply the activities that appeal to different intelligence areas in the classroom environment, to allow students to learn in different ways (Walshatri et al., 2019). Because learning mathematics requires more than verbal-linguistic and logic-mathematical intelligence.

Students often have difficulty learning abstract subjects using traditional methods (Durmuş, 2004; Kutluca & Baki, 2009). In order to facilitate the teaching of mathematics, teachers should organize the classroom environment according to the most developing intelligence areas of their students and use the teaching methods and techniques that address different intelligence areas (Algani & Eshan, 2019). Designing the teaching process with the activities for the most developing intelligence areas of students is important as it is easier to learn abstract subjects (Kutluca et al., 2016). In the light of all these explanations, in this research, it is aimed to introduce the teaching process related to the mathematics course designed according to multiple intelligence theory and to evaluate the students' views regarding the teaching process.

Method

The action research model, which is one of the qualitative research methods, was used in the research. Action research, which means 'learning by doing' in its simplest definition, is expressed as the research process carried out by the teacher in order to organize and improve educational activities. This research method allows teachers to gain a more in-depth view and understanding of the nature of their own practice (Cohen & Manion, 1996). In this direction, in order to enrich the teaching activities in the study, the teaching process was designed in accordance with the multiple intelligence theory and various activities were organized. At the end of the activities, students were asked to evaluate the teaching process and their opinions regarding the teaching process were taken. Thus, it is aimed to develop and improve existing teaching activities.

Study Group

Eighteen students who continue their education in a high school in Sur district of Diyarbakır constitute the working group of the research. Purposeful sampling method was used to select the study group. In this context, multiple intelligence observation forms were applied to students who want to take project homework from 9^{th} grade mathematics lesson. By evaluating the results obtained from this form, students with moderate intelligence, advanced and highly developed students were included in the study group. According to the results of the multiple intelligence observation form, the students included in the study group were asked to design materials related to the subject of trigonometry in the intelligence areas that they expressed as the most advanced. During the material preparation process, the teacher assumed the students as a guide and enabled the students to actively participate in the process.

Data Collection Tool

“Multiple Intelligence Observation Form” developed by Selçuk, Kayılı and Okut (2004) and “Student Interview Form” developed by researchers were used as data collection tools.

Multiple Intelligence Observation Form

Developed by Selçuk, Kayılı and Okut (2004), this form consists of eight separate sections. These sections can be listed as verbal-linguistic, mathematical-logical, musical-rhythmic, visual-spatial, bodily-kinesthetic, personal-self-directed, social-interpersonal and natural intelligence. Each part of the form is designed for one of the intelligence areas mentioned above. In each section, there are a total of 80 expressions, ten related expressions related to the intelligence field. For each expression in the form, there is a rating scale between (0) and (4).

Student Interview Form

The interview form created consists of 5 open-ended questions. While preparing the questions in the interview form, the relevant literature was used. After the questions were created, expert opinion was consulted to ensure validity and the interview form was finalized by organizing questions in line with the opinions received. Questions in the interview form; What are the positive aspects?, What are the negative aspects? What are the activities you like? What are the activities you do not like in math lesson taught with materials and activities prepared according to multiple intelligence theory?

Data analysis

The answers given by the students to the multiple intelligence observation form were analyzed according to the criteria specified by Selçuk, Kayılı and Okut (2004). In the form, there are 80 items in total, 10 items per intelligence field. The five options in each item are scored between 0 and 4. The expression (0) means "not suitable at all", (1) "very little suitable", (2) "partially suitable", (3) "quite suitable" and (4) "completely suitable". Accordingly, the lowest score that can be obtained from each intelligence field is 0 and the highest score is 40. The score calculated for each intelligence area; is classified as "Undeveloped" between 0-7, "Slightly Advanced" between 8-15, "Moderately Advanced" between 16-23, "Advanced" between 24-31 and "Very Advanced" between 32-40.

Descriptive analysis method was used while analyzing students' answers to the questions in the interview form. In descriptive analysis, the aim is to present the findings obtained in an organized and interpreted way to the reader. Direct quotations are often included to reflect the views of individuals interviewed or observed. Data interpreted and summarized in descriptive analysis are carried out to a deeper process, and concepts and themes that are not noticed by descriptive approach in descriptive analysis can be discovered as a result of this analysis (Çepni, 2014).

The participants were coded as "S_1, S_2, S_3 ..." in the research. In coding, S: refers to the student, and the numbers represent the sequence number. These codes were used when direct quotes from students were included.

Application

"Multiple Intelligence Observation Form" developed by Selçuk, Kayılı and Okut (2004) was applied to the students before starting to work in the research. Analysis of data obtained from observation form, students were asked to create materials suitable for advanced intelligence areas and organize activities related to trigonometry. Thus, it was tried to ensure that students learn by doing and living. In this process, the teacher is fully in the role of guide. In addition, the teacher has prepared a concept map in order to guide students' material and activity preparation activities and enable students to see the subject as a whole.

Image 1. *Concept map prepared by teacher*

The materials and activities organized by the students are given below, classified according to their intelligence fields.

1. Materials and Activities for Verbal-Linguistic Intelligence: Regarding this field of intelligence, students have prepared and made presentations on the posters that include the lives of scientists who contributed to trigonometry, the studies of these scientists on trigonometry, the historical development of trigonometry and its place in daily life.

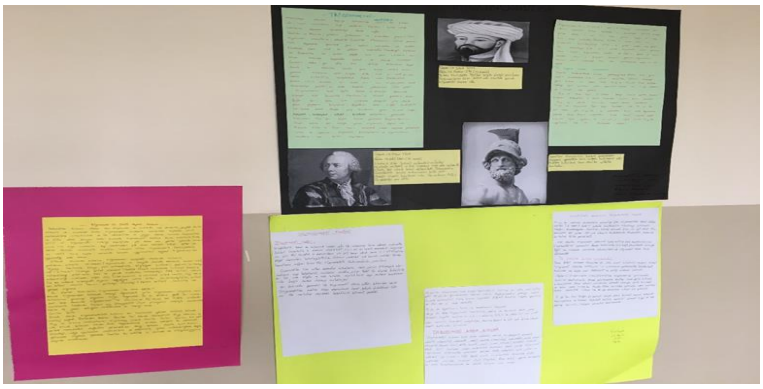

Image 2. *Poster preparation activity*

2.Material and Activities for Musical-Rhythmic Intelligence Field: Regarding this intelligence field, students prepared and sang songs whose lyrics are related to trigonometry.

Image 3. *Singing activity*

3. Materials and Activities for the Field of Mathematical-Logical Intelligence: Regarding this intelligence field, two activities were organized by the students as "puzzle solving activity" and "trigonometric chess activity". The puzzle-solving activity consists of two worksheets. In the first worksheet, it is aimed to introduce trigonometric and inverse trigonometric functions. On the second worksheet, there are questions in the form of filling the spaces for these functions.

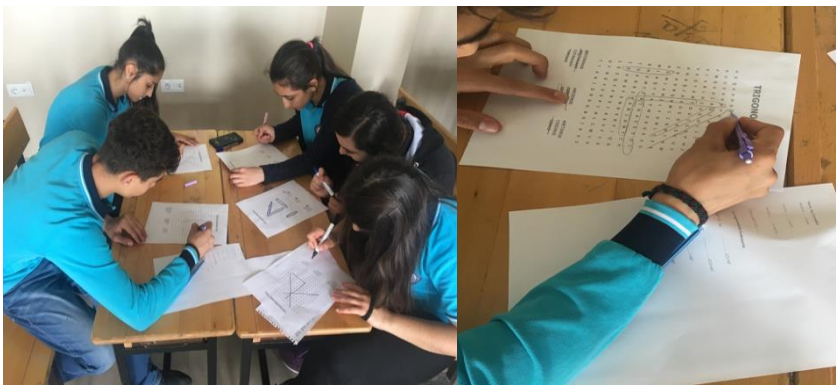

Image 4. Puzzle solving activity: In the trigonometric chess game developed by students, special right triangles were used instead of chess pieces. The right triangle used as 10 pawns was used in each group. Narrow angles of these right triangles with known edge lengths are given names such as α, β, θ.

The 30-60-90 right triangle, whose angles are known, acts as a queen, and the 45-45-90 triangle as a king. In each of the moves, the students asked the opponent's player about the trigonometric ratios of the right triangle they made. When the player in the opposite team gave the correct answer, he gained the right to move and the game continued in this way. The party who lost the king lost the game.

Image 5. *Trigonometric chess game*

5. Materials and Activities for Visual-Spatial Intelligence Field: Regarding this intelligence field, students developed egyptian pyramid material and prepared cartoons by making use of trigonometry within the scope of three-dimensional object design.

Image 6. *Egyptian pyramid activity*

Image 7. Cartoon activity

6. Materials and Activities for Physical-Kinesthetic Intelligence: Regarding this intelligence field, students have prepared two different activities, namely "finger account trigonometry" and "conversion ball activity".

Finger calculation trigonometry activity aims to learn the values of some angles on the trigonometric scale. For this purpose, students designed a hand model using fabric and cotton pieces. The angles of this hand model are written at 0º, 30º, 45º, 60^0 and 90^0 respectively. The sine value of the angle in the closed finger has been shown to be half the root of the number of previous fingers, and the cosine value is equal to half the root of the number of subsequent fingers.

Image 8. *Finger account trigonometry activity*

In the conversion ball activity, the student who catches the conversion ball should say the desired conversion or inverse conversion formula within five seconds. A game is designed to eliminate the student who cannot say the formula within a certain period of time.

Image 9. *Conversion ball activity*

7. Materials and Activities for Personal self-directed intelligence: In the Hacivat-Karagöz event organized for this intelligence field, students were asked to write their favorite relation about the subject of trigonometry and what trigonometry meant to them in speech bubbles.

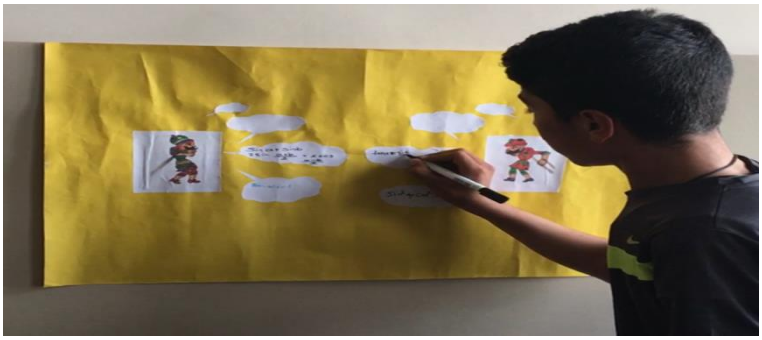

Image 10. *Hacivat-Karagöz activity*

8. Materials and Activities for Social-Interpersonal Intelligence: A sketch activity was prepared to teach the periods of trigonometric functions for this intelligence field. The activity called Homework skech consists of reviving the dialogues between family members while doing trigonometry homework for the families of two students.

Image 11. *Homework skech activity*

9. Materials and activities for naturalist intelligence: Two events, namely, "I make a circle from the tree" and "My gifts in the Pine Tree" were prepared for this intelligence field.

In the I'm Making a Unit Circle from Tree activity, a unit circle showing these functions was made in order to enable the students to recognize trigonometric functions.

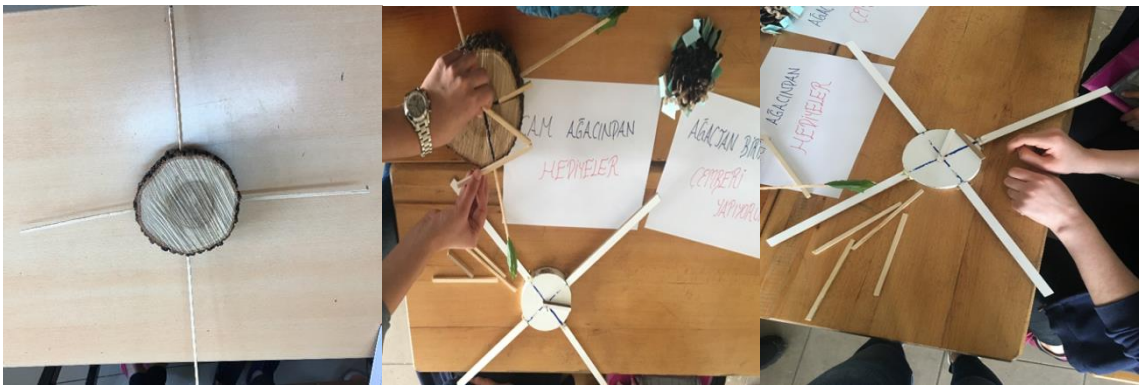

Image 12. *Making a unit circle from tree activity*

In the My Gifts in Pine Tree Activity, students prepared a model in the form of a pine tree. There are gift cards with trigonometric relations in this model pine tree. A game is designed in which students who choose gift cards according to their colors will read the trigonometric relation in the card and share it with their friends.

Image 13. *My gifts activity in the pine tree*

Fındıngs

In this part of the study, findings related to students' advanced intelligence fields and findings obtained from students' answers to open-ended questions are presented with frequency tables and direct quotations from some students' views are included. The distribution of the scores of the students from each intelligence field in the multiple intelligence observation form is given in Table 1.

Table 1. *The Distribution of the Scores of the Students from Multiple Intelligence Areas*

Intelligence Area	f	Minimum	Maximum	Average	Level
Verbal-Linguistic	18	20	36	26,94	Improved
Musical-Rhythmic	18	16	39	27,67	Improved
Logical-Mathematical	18	24	40	30,56	Improved
Visual-Spatial	18	16	36	29,33	Improved
Bodily-Kinesthetic	18	21	35	28,56	Improved
Interpersonal	18	20	33	26,22	Improved
Social-Interpersonal	18	22	38	29,28	Improved
Naturalist	18	21	39	30,72	Improved

When Table 1 is analyzed, it is seen that the average of the scores that the students get in each intelligence field varies between 26.22 and 30.72. While the lowest average among intelligence fields is 26.22, it belongs to the self-directed intelligence field and the highest average is 30.72 with natural intelligence field. According to the multiple intelligence form evaluation criteria, the score between 24 and 31 for an intelligence field corresponds to the "Advanced" level. Accordingly, it can be said that the sample group is at the "Advanced" level in all intelligence areas in general. The development levels of the students according to their intelligence fields are given in Table 2.

Table 2. *Development Levels of Students According to Intelligence Areas*

Intelligence Areas	DEVELOPMENT LEVEL				
	Very Advanced	Advanced	Moderately Advanced	Somewhat Advanced	Undeveloped
Verbal-Linguistic	2	13	3	0	0
Musical-Rhythmic	4	8	6	0	0
Logical-Mathematical	6	12	0	0	0
Visual-Spatial	5	12	1	0	0
Bodily-Kinesthetic	6	11	1	0	0
Interpersonal	2	10	6	0	0
Social-Interpersonal	6	10	2	0	0
Naturalist	7	10	1	0	0

When Table 2 is analyzed, it is seen that all intelligence areas developed at least at a moderate level in all students who are sampled. In addition, based on Table 2, it can be said that personal-self-directed and musical-rhythmic intelligence domains develop less than other intelligence domains, and mathematical-logical and natural intelligence domains develop more than other intelligence domains.

The findings obtained as a result of the descriptive analysis of the answers given by the students to the questions asking "positive and negative aspects of the mathematics lesson taught with the materials and activities prepared according to the Multiple Intelligence Theory", which are the first two questions of the research, are given in Table 3.

Table 3. *Students' Opinions About Mathematics Lesson Applied to Multiple Intelligence Theory*

Positive Opinions	f	Negative Opinions	f
Funny	18	Noise	10
Easier/Better Learning	13	Spray Paint Scent	8
Remarkable	7	Time Shortage	7
Memorable	6	Many Events at the Same Time	5

Being Active	4	

When positive opinions are examined in Table 3, it is seen that all of the students stated that the lessons were more fun when processed according to multiple intelligence theory, and more than half of the students (f=13) stated that the lessons were more understandable and they learned better and easier. In addition, the students stated that the lessons were more remarkable (f=7) and permanent (f=6) when they were processed according to the theory of multiple intelligence, and that they attended the lessons more actively (f=4). Some examples of the statements of some students who answer the question of what are the positive aspects of the mathematics lesson taught with materials and activities prepared according to the Multiple Intelligence Theory are given below.

> S_{11}: "*I found the math studied before boring. On the other hand, I find maths that are processed in this way fun and enjoyable*."
> S_2: "*These activities helped me to understand mathematics better. I learned the formulas I couldn't memorize with fun thanks to the games. Activities attract students' attention and help them understand better.*"
>
> S_8: "*I think the lessons are more memorable because there are fun activities in the lessons we teach this way.*"
>
> S_5: "*The math lesson we do this way is better. Because it is visual and more fun, it is more catchy.*
> *I have difficulty understanding the mathematics we normally study. But learning by playing games and activities is both fun and easier.*"

When we look at the negative views in Table 3, (f=10),we see that the students complained about the learning environment was louder than before, and they complained about the spray paint smell (f=8) used in material preparation. In addition, some of the students (f=7) stated that the process of preparing materials was difficult and time consuming and the time allocated for the activities was limited. Some students (f=5) stated that they could not attend some activities because more than one activity was held at the same time. Examples of the statements of some students who answer the question of what are the negative aspects of the mathematics lesson taught with materials and activities prepared according to the Multiple Intelligence Theory are given below.

> S_9: "*The classroom environment was very noisy. Since many events are at the same time, I did not have the opportunity to attend some events. The material preparation process was difficult and time consuming."*
> S_4: "*Time was limited and there was some noise. The smell of the paint squeezed into the Egyptian pyramid was very bad. I am very uncomfortable with this.*"
> S_{12}: "*There is a lot of noise in the classroom and everybody is always on the move.*"
> S_{11}: *"While practicing activities, the noise in the classroom was higher than the noise in our normal classroom."*

The third question of the research is "Which activities do you like?", The fourth question is "Which activities do you dislike?" and the last question is "What are the activities you have difficulty with?" The findings obtained as a result of the descriptive analysis of students' answers to their questions are given in Table 4.

Table 4. *Students' Views on Materials and Activities*

Activity Name	I liked it	I didn't like	I had trouble
Conversion Ball	14	1	3
Trigonometric chess	8	3	4
I am solving puzzles	8	1	0
I am singing a song	6	1	0

Hacivat Karagöz Activity	5	3	0
My Gifts in the Pine Tree	4	0	1
I'm Making a Circle from the Tree	4	2	2
My cartoons	3	0	0
Homework skech	3	2	0
Egyptian Pyramid	3	7	0
Finger Account Trigonometry	1	0	0
Preparing a Poster	0	0	0

When Table 4 is examined, it is seen that the students liked the activities of "transformation ball" (f= 14), "trigonometric chess" (f=8) and "I am solving puzzles" (f=8). The most disliked activity of the students was the "egypt pyramid" (f=7) activity. Four students stated that they had difficulty in "trigonometric chess" activity and three students had difficulty in "conversion ball" activity.

Dıscussıon, Conclusıon and Suggestıons

This research was carried out to introduce the teaching process for mathematics course designed according to multiple intelligence theory and to evaluate the students' views on the teaching process. The results, discussion and suggestions reached with the help of findings obtained in this part of research are included.

As a result of this research, it was concluded that the most natural intelligence field was the most developed intelligence field in students, while the least developed intelligence field was the personal intelligence field. Özden (2008) states that when developmental characteristics of children are taken into consideration, as the age increases, the awareness of the individual increases and he knows himself better. Therefore, as the age of the individual grows, his/her self-directed intelligence is expected to increase. Considering that this study is studied with secondary school students, it is a situation that can be expected to be the least developing intelligence field of personal-self-directed intelligence. However, when the relevant literature is examined, the most developed and least developed intelligence areas differ in the sample groups in the studies conducted on multiple intelligence theory. Contrary to this study, Baran and Maskan's (2011) study with 11th grade students revealed that their interpersonal intelligence was more advanced than other intelligence areas in the sample group. This situation is thought to arise from the fact that many factors such as historical-cultural factors, geographical factors, economic factors, familial factors affect the development of intelligence areas. Based on their study, Baran and Maskan (2011) stated that students can be said to be under the influence of external dynamics such as demographic information as well as their Interpersonal. As a matter of fact, looking at the previous studies (Akamca & Hamurcu, 2005; Al-Zoubi & Al-Adawi, 2019), the findings confirm this.

As a result of the study, the students stated that learning was more fun and attention-grabbing with activities designed according to multiple intelligence theory, thus they learned the subject of trigonometry both easier and better and the subject was more memorable. It has been determined that this is beneficial because students learn by living by doing the materials due to their own preparation, but the process of material development and application takes a lot of time and the learning environment is more noisy than before. Başbay (2000) also states that enriching the educational environment with the activities provides both an easier understanding of the subject and the learning activities of the learners. Al-Zoubi & Al-Adawi (2019) also examined students' views on multiple intelligence theory practices, similar to this study, students were actively involved in the lesson, applications encouraged students to learn, that students enjoyed learning. It has been shown that it has become easier. In the light of all these findings, it was concluded that with the activities suitable for multiple intelligence theory, students enjoy learning process, participate more actively in lessons, have the opportunity to use their abilities, therefore learning is easier, the permanence of information increases and students have positive opinions in general terms.

It was concluded that the students liked the "conversion ball" activity the most, the activity they disliked was the "egypt pyramid" and the students had the most difficulty in the "trigonometric chess" activity. It can be said that the dominant intelligence areas that students have with their favorite

applications are generally parallel. Although the most advanced intelligence area of the students is the natural intelligence area, it is thought that the "egypt pyramid" activity in this area is the most unpopular activity because the spray paint smell frequently mentioned in the interview form is disturbing. Again, it can be said that the difficulties of the students in "trigonometric chess" activity arise from the statements in the interview forms because the game is difficult to understand and there is not enough time for this.

Based on the results of the research, it is recommended that the students consider that they may have different intelligence areas and develop enrichment activities while planning education and training. In addition, due to the fact that the material development and application process takes time, the necessary precautions to minimize the undesired situations such as excessive noise and discipline problems that may occur in the classroom due to the fact that they pay attention to this issue, some materials and activities may cause adverse situations such as bad smell and excessive noise. It is recommended to take it in advance. For researchers, different sampling groups, different lessons or different subjects related to multiple intelligence theory can be applied and student-teacher opinions can be examined and research results can be compared.

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