International Journal of Education & Literacy Studies
ISSN: 2202-9478
www.ijels.aiac.org.au

Understanding Mathematics Perception through Drawing: An Online Interpretative Phenomenological Analysis (OIPA) Study

Aygen Koç Koca*

Faculty of Education, Adıyaman University, Adıyaman, Turkey

Corresponding author: Aygen Koç Koca, E-mail: akoc@adiyaman.edu.tr

ARTICLE INFO

Article history
Received: June 29, 2023
Accepted: September 22, 2023
Published: October 31, 2023
Volume: 11 Issue: 4

Conflicts of interest: None
Funding: None

ABSTRACT

In this study, it is aimed to reveal the images formed in the minds of high school students about the concept of mathematics with the help of their own expressions and drawings. In this qualitative study, the core of 100 high school students' experiences of math was examined with a holistic approach using Online Interpretative Phenomenological Analysis (OIPA). In order to obtain in-depth information about the concept of math from the participants, the purposeful sampling method was used. It was paid full attention to ensure that the participants were high school students. The data were obtained by using the OIPA form, which allows students to create stories and drawings about the concept of math. The data obtained were analyzed in three stages by the researcher and an expert psychologist. As a result of the analysis, it was seen that there were deficiencies in students' mathematical literacy in situations such as understanding the role of mathematics in daily life and using it to solve real life problems. Additionally, the students expressed the concept of math using 18 different main themes, most of which contained negative strong emotions. Students associated math most frequently with the themes of life (44%) and difficult math language (38%). The students associated math least frequently with the themes of hate (5%) and unimportant (5%). On the other hand, students explained the math domain with individual factors (74%) the most and exosystem (15%) the least. In line with the results obtained in the study, a few recommendations were made.

Key words: Mathematics, Online Interpretative Phenomenological Analysis, Perception Of Mathematics, Teaching Math, Mathematical Literacy

INTRODUCTION

Education plays an important role in the process of preparing individuals for life. Mathematical science has a high impact on the development and guidance of the lifelong education process by revealing human talents (Ibrokhimovich & Mirzaxolmatovna, 2022). In fact, by providing a systematic and logical flow of thought, education contributes to the ability of the mind to solve daily life problems through generalizations (Baykul, 1999) by abstracting what the mind receives from the environment (Umay, 1996). The structure of mathematics that facilitates human life contributes to pioneering many sciences and developing technology. The fact that mathematics is the basis of computers, which are used in every branch of science and profession today, is an example of this situation. In this context, it can be said that mathematics is a discipline that is needed in areas that employ mental thinking skills in many areas of daily life.

The science of mathematics has become crucial in terms of providing an infrastructure for activities open to development over time and its impact on solving daily life problems. This situation has been reflected in education programs, and this provided mathematics an important place in schools. Thus, it is aimed to develop high-level cognitive skills such as systematic and critical thinking and problem solving in individuals with the help of mathematical thinking skills (Boyraz, 2020). This development, which aims to develop mathematical literacy in the cognitive context, shows that the learning and teaching of mathematics, which takes place at every point of life, is a science that needs to be studied (Alkan, 2019). Mathematical knowledge gains meaning by transforming daily life problems into skills through mathematical relationships. This is possible through the development of mathematical literacy, which enables people to solve problems in daily life activities where they face challenges (Janah et al., 2019). In order for students to reach mathematical skills effectively, procedural and conceptual knowledge is explored gradually (Ergen & Durmuş, 2022) by associating it with other disciplines (Snead et al., 2022). This contributes to the development of mathematical literacy and many vital skills that students use in daily life, such as verbal communication, reasoning, democratic life, social life or teamwork. However, although it is directly related to daily life, mathematics is among the disciplines that are considered difficult

Published by Australian International Academic Centre PTY.LTD.

http://dx.doi.org/10.7575/aiac.ijels.v.11n.4p.297

to learn by many people today (Yeniel, 2019). One of the reasons for this situation is that mathematics is difficult for students because it is a self-consistent discipline (Civelek et al., 2003). This negative attitude and prejudice against learning makes mathematics difficult to learn and even prevents learning (Ma & Xu, 2004; Tatar et al., 2008).

Although being difficult for students is one of the factors that prevent learning mathematics, it would not be correct to say that this is the only factor. The social and familial structure in which individuals live is also an effective factor in the formation of mathematics fear and anxiety. Fears and anxieties developed against mathematics are closely related to learning (Heyder et al., 2020). In fact, the negative attitude of the society and the family towards mathematics can be a factor in the learner's negative attitude over time (Thomas & Furner, 1997). This negative situation causes mathematical literacy not to reach the desired level (Niss & Jablonka, 2020). On the other hand, teacher attitude (Schaeffer et al., 2021), ineffective teaching methods (Kossybayeva et al., 2022), and lack of basic mathematical skills are among the factors affecting attitude towards mathematics (Szczygieł, 2020).

Research in the field of mathematics education shows that students perceive mathematics as a challenge that they face throughout their lives (Barakaev et al., 2020; Hendriana et al., 2022; Richland et al., 2012). For this reason, various studies have been carried out to determine the source of this perception (Sajan et al., 2022; Stella, 2022). In these studies, it can be said that metaphor analysis through written expressions is considered as a powerful method (Blom et al., 2022; Khatin-Zadeh et al., 2023). However, since there are limited studies on the subject in the literature, it is thought that deeper investigations should be conducted on the formation and functioning of students' perceptions towards mathematics. In this study, it was aimed to visualize and make sense of students' inner worlds about the concept of mathematics through their written expressions and drawings that they themselves created. Therefore, in this study, the Online Interpretative Phenomenological Analysis (OIPA) method developed by Tanhan and Strack (2020) and adapted into Turkish by Tanhan (2020) was used to examine in depth the perceptions of the high school students in Turkey towards the concept of mathematics.

Online Interpretative Phenomenological Analysis (OIPA)

This method is one of the innovative analysis methods developed by Tanhan and Strack (2020) and adapted into Turkish by Tanhan (2020) in order to use the traditional Interpretative Phenomenological Analysis (IFA) approach more effectively. The fact that factors such as time, material and communication resources can be used more effectively in OIPA compared to other methods allows a rich study to be conducted in terms of the situations investigated in which more factors can be examined by easily reaching various participants. For this reason, it is more advantageous than the traditional IPA on which OIPA is based (Tanhan, 2020; Tanhan & Strack, 2020).

When the literature is examined, it is seen that the OIPA is generally used to analyze the data (e.g., participant's perspective, thoughts, story) accompanying the photos collected with Online Photovoice (OPV) (Doyumğaç et al., 2021; Özkan & Tanhan, 2023; Seydooğulları, 2023; Subasi et al., 2023; Tanhan, 2020; Tanhan et al., 2021; Tanhan & Strack, 2020). In addition, the researchers who developed OIPA stated that it can also be used in the analysis of the data shared verbally or in writing by the participants, whether or not there is visual data (Tanhan, 2020; Tanhan & Strack, 2020). These researchers recommend the use of the OPV rather than traditional IPA and/or content analysis. In her master's thesis, Kizilay (2022) examined the attachment approaches of adults, for the first time without collecting visual data meaning without using OPV, but using the key and quite comprehensive and meaningful SHOWED questions of OPV; you can see SHOWED questions in the method section of this paper. Then she analyzed the data collected using OIPA.

Since OPV has many advantages over the traditional photovoice method (Wang & Burris, 1997) and OIPA has many advantages over the traditional IPA, both OPV and OIPA have recently been used by different researchers in various subjects (e.g., Armiyau et al., 2022; Doyumğaç et al, 2021; Genc et al., 2022; Ozkan & Tanhan, 2023; Öğülmüş, 2021; Subasi et al., 2023; Tanhan, 2020; Tanhan et al., 2021; Tanhan & Strack, Tümkaya et al., 2021). All of these researchers emphasized in their studies that OIPA provides a more effective, practical and useful framework than traditional methods.

In OIPA, participants are asked to present their perspectives on the research topic verbally or in writing, with or without a visual. The purpose of using visuals is to reveal representations that will help other people to see and make sense of the participant's inner world with the help of visuals (Tanhan, 2020; Tanhan & Strack, 2020). Thus, the internal voices of the participant are made visible. However, the participant's or participants' perspective on the research topic can also be addressed with OIPA without visualization (Kızılay, 2022; Tanhan, 2020; Tanhan & Strack, 2020). The current study differs from the studies conducted so far using OIPA (e.g., Doyumğaç et al., 2021; Özkan & Tanhan, 2023; Tanhan et al., 2021). In all the OPV studies mentioned above, participants first took one or more photographs to convey their perspectives and then expressed their perspectives using key and meaningful SHOWED questions. The researchers then analyzed these perspectives using OIPA. This current study differs significantly from all previous OPV or OIPA papers in that participants drew the visuals themselves. When used with OPV, OIPA allows the use of pre-created images or images taken within the scope of the research with the help of cameras. When OIPA is used only in the analysis of participants' verbal or written perspectives without the use of visuals (Kizilay, 2022; Tanhan, 2020; Tanhan & Strack, 2020) the richness of research visualization can be missed (Tanhan, 2020). Compared to other classical analysis methods, the OIPA adds depth to the research in terms of time, cost and participant diversity. However, the fact that

the participants can use ready-made images also allows them to use any photograph that does not fully reflect themselves. The fact that the participants were over the age of 18 in previous studies also affected the use of ready-made visuals in those studies. To overcome this disadvantage of the OPV method, it was decided to use hand drawings that represent the participants' own inner worlds and imaginations. Thus, it was thought that the participants would be able to reveal their feelings and thoughts more strikingly. It was also thought that the impact area of the OIPA, which is quite easy, practical and economical to use, would expand. For this reason, in the current study, it was decided to determine the participants' feelings and thoughts about the concept of "mathematics" by examining them in depth with the help of their own drawings.

Research methodologies used in online environments, such as the OIPA method, provide great convenience to researchers in terms of the continuity of scientific studies, especially when face-to-face interviews are impossible due to the worldwide pandemic. The advantages of the OIPA methodology during the pandemic have been discussed in detail by many researchers (e.g., Armiyau et al., 2022; Doyumğaç et al., 2021; Genc et al., 2022; Özkan & Tanhan, 2023; Subasi et al., 2023; Tanhan, 2020; Tanhan & Strack, 2020). Although not directly related to OPV or OIPA, when the literature on education is examined, it is stated that online education applications contribute to more successful results in the majority of the studies (Ananga & Biney, 2017; Neuhauser, 2002; Paul & Jefferson, 2019). In this respect, it is thought that the use of an innovative, economical and practical technique such as OIPA in understanding the perceptions towards mathematics will make a significant contribution to the related literature.

In this study, it was decided to conduct the study through face-to-face interviews instead of the online interviews recommended in OIPA in order to create a warm and sincere environment with the participants. Face-to-face was chosen due to the participants' young age and to prevent their drawings of mathematics concepts from being affected by a different stimulus. In this face-to-face respect, although the study presents a framework that is closer to the traditional IPA, it has the characteristics of the OIPA in terms of the type of questions asked and the type of data collected (e.g., SHOWED questions, visualization) and the way the data analysis is handled to reveal common themes. In other words, the themes in the study were not determined by the researcher as in the IPA; it was handled in the form of the participants creating their own themes as suggested in the OIPA.

In this current study, OIPA was followed in all other stages except face-to-face data collection. Thus, it was ensured that the emotions and thoughts of the participants were handled with the themes that emerged directly in line with their own views without being affected by any stimuli.

As explained in detail in the method and analysis section of this study, the researcher followed OIPA (Tanhan, 2020) and received its training in order to use OIPA as effectively as possible with a new perspective. The researchers received supervision from the OIPA developer (Tanhan, 2020) in the whole process. It is thought that this situation provides a more objective evaluation in the study.

METHOD

Since this study aims to determine the images formed in the minds of the high school students about the concept of "mathematics", the study has qualitative research characteristics. In order to examine the students' views on the subject in depth, Online Interpretative Phenomenological Analysis (OIPA) method, which aims to effectively address the current situations, was used in the study. In the current study, OIPA method, which is adapted from the Interpretative Phenomenological Analysis (IPA) method (Tanhan, 2020; Tanhan & Strack, 2020), was adapted and used in this study to provide a holistic description of the essence of students' experiences of the concept of mathematics.

Participants

One hundred high school students participated in this study. The researchers (Tanhan, 2020; Tanhan & Strack, 2020), who developed the OIPA, recommended at least 100 participants for a reliable analysis. However, they stated that this number may decrease as the age decreases and in subjects where it is difficult to find participants. These researchers also stated that 100 is already a very good number for qualitative research. Participants were selected on a voluntary basis using purposive sampling method. Purposive sampling envisages the selection of information-rich situations in the context of the purpose of the study (Patton, 1997). For this reason, the study was conducted with the high school students who had enough experience with the concept of mathematics and who could express their feelings and thoughts through drawing. Thus, the participants were selected among 11th grade equal weight and numerical students. Fifty eight percent (n=58) of the participants were male and 42% were female (n=42). Sixty two participants (62%) were studying in the equal weight department and 38 participants (38%) were studying in the numerical department.

Data Collection Tools

In this study, the data on the images formed in the minds of the high school students about the concept of mathematics were obtained by following the "drawings" made by the students and the SHOWED questions in OPV or OIPA as suggested by the researchers (Tanhan, 2020; Tanhan & Strack, 2020). In the study, OIPA was used to determine the students' stories about the concept of mathematics and to analyze these stories. Before starting data collection, time was spent with all the students and the aims of the study were explained to them. The participants and their parents were also informed about the subject, and their consent was taken. The data collection process consisted of two main stages: demographic information (Part 1) and the form for understanding the perception of mathematics with the OIPA (Part 2).

1st Section: Demographic Information

In the first part of the data collection, information on the demographic characteristics of the students was collected. Thus, answers were sought to questions such as gender, grade level, age, and department of the students participating in the study.

2nd Section: OIPA Form to Understanding the Perception of "Mathematics"

This section consisted of the following five steps.

1st step: first words/concepts that come to mind

At this stage, the students are asked to express the first word or words that come to mind when they think of the concept of mathematics.

2nd step: drawing/picture preparation

At this stage, students were asked to draw a representative visual that defines, symbolizes or describes these words that came to mind when they thought of mathematics in the first step. They were told that their own drawings were believed to be more valuable than photos taken or downloaded from internet. However, they were asked to be careful not to partially or fully draw any real human beings in their drawings and not to use recognizable elements that belong to the private property of third parties.

3rd step: adding a whole meaningful paragraph-story-perspective that includes showed questions

At this stage, students were asked to express their drawings in writing. In other words, they were asked to add a story/comment to their drawings to make them more understandable. It was stated that a comprehensive and whole story including SHOWED questions would prevent misunderstandings by the researcher and make their drawing and story more meaningful. Because even though a picture/photograph tells a lot on its own, a well-written comment will contribute greatly to the picture/photograph coming to life. In order to make this situation more understandable, it was suggested that they use the SHOWED questions. However, instead of using (answering) the questions one by one, they were asked to create a meaningful paragraph that could answer the questions as one part. Since these comments will be used in the analysis of the study, the students were warned to take care not to include identifiable personal information when writing comments. SHOWED questions are used to create a more effective and meaningful story. When these stages are followed, it is aimed to prevent different interpretations of the participant story written and to hear, feel and convey the interpretation more effectively. The SHOWED questions are as follows:

S: What do you ***S*EE** in your drawing about mathematics and anything related to it?
H: WHAT IS **HAPPENING** in the drawing (briefly describe/describe the drawing)?
O: How does what is happening in the drawing relate to **YOU** (either as an individual or as a community)?
W: WHAT(S) is enabling or causing this situation or factors to occur?
E: What are you **EXPERIENCING** (bodily sensation, emotion, thought, behavior) while you are making the drawing and writing this now?
D: When you think about all of this - your drawing and your story about the concept of mathematics - all of us (math teachers, mental health professionals, peers, research and service organizations, administrators, and others) **WHAT CAN WE DO** to make mathematics in your life more meaningful?

4th step: summary words: please use at least three summary word groups and no more than 10 word groups (e.G., "Protecting nature" is a word group)

At this stage, students were asked to think about all the work and processes they had done and to identify words that encompassed and summarized all of them. Thus, through these summary words, themes or metaphors, other people can comprehend their drawing and story in a concise and meaningful way and store it in their minds and hearts more easily. Moreover, they can take useful steps forward from this extracted meaning.

5th Step: Attributing "approach to mathematics" to Systems

At this stage, students were asked to express what factors or systems best describe their thoughts and experiences in mathematics. These systems included individual/intrinsic factors (e.g., feelings, thoughts, behaviors, attitudes, gender, education level); microsystem factors (family, school, peers, physical environment, religious/spiritual resources); exosystem factors (media, neighbors, social services, local governments, local organizations); macrosystem factors (government policies, community values, economy).

Data Analysis: Online Interpretative Phenomenological Analysis (OIPA)

In this study, the study was conducted through face-to-face interviews in order to create a warm and sincere environment with the participants and to prevent their drawings of the concept of mathematics from being affected by a different stimulus. In the elicitation of the stories, the SHOWED questions as suggested (Tanhan, 2020; Tanhan & Strack, 2020) and the OIPA (Tanhan, 2020) were followed in terms of the way the main themes were analyzed. In other words, the themes in the study were not determined by the researcher as in traditional IPA; it was handled in the form of the participants creating their own themes as suggested in OIPA. Thus, it was ensured that the emotions and thoughts of the participants were handled with the themes that emerged directly in line with their own views without being affected by any other researcher bias. The researcher, on the other hand, combined the themes put forward by the students as

suggested in OIPA themes (Tanhan, 2020; Tanhan & Strack, 2020) and ensured that the main were formed. It is thought that this situation provides a more objective evaluation in the study.

In this study, since the visuals formed in the minds of the high school students about the concept of mathematics were based on the themes and drawings obtained from the participants through the OIPA form, the data were analyzed following OIPA. The data set was analyzed jointly by the researcher and an expert psychologist in order to make in-depth meaning and interpretation of emotions such as hate, love, anxiety, motivation, etc. that may arise in students' views on the concept of mathematics. This also increased the validity and reliability of the study. Thus, the themes that the participants put forward with their own expressions about the concept of mathematics were evaluated and grouped in a holistic manner with the help of their drawings. Main theme groupings were made in line with the themes identified by the participants (Section 1: Step 4: Summary Words). When it was not clear to the data analysts which main theme to place the theme that the participants stated about the concept of mathematics, the stories written by the participants and the visuals they drew were used. At least three different theme groupings were made for each participant.

Finally, in the analysis, when it was determined that the theme groupings were not expressed by 3% or more of the total number of participants, they were included in the closest theme group by interpretation (as suggested by Tanhan, 2020; Tanhan & Strack, 2020). Thus, the data analyzers made main theme groupings three times. With the analysis, the expressions that students used in common in the visuals they drew for the concept of mathematics and their explanations about the visuals were evaluated with a holistic approach.

FINDINGS

In the study, the images formed in the participants' minds about the concept of "mathematics" were examined with the help of their own expressions and visuals. In the first stage of the data collection process, information about the demographic characteristics of the students was collected. Thus, it was determined that the participants were studying at the 11th grade level, the majority of them were male, their average age was 16, and they were mostly studying in a major that gives equal attention to all courses rather than heavily stressing science or verbal courses.

In the second stage of the study, the students' perceptions of the concept of mathematics were examined through their own stories and drawings using OIPA. OIPA consists of five steps. With the help of the first four items of the form, data on students' own drawings and explanations of the concept of mathematics were obtained. As a result of the analysis of the data obtained, the final number of main themes was 18. When the data were first analyzed, 43 themes emerged. The themes that were not expressed by 3% or more of the total number of participants were included in the closest theme group by interpretation. For example, the theme of "hope" that emerged in the first analysis was combined with the theme of "a step for the future" in the second analysis. Thus, the number of themes decreased to 31. The themes that were not expressed by 3% or more of the total number of participants in the second analysis were reanalyzed and included in the closest theme group by interpretation. Students' drawings and stories about the concept of mathematics were taken into consideration during these processes. Thus, as a result of the third analysis, the total number of themes was reduced to 18 and the analysis was finalized. The themes obtained are presented in Table 1.

When Table 1 is examined, it is seen that the high school students associated the concept of "mathematics" with 18 different themes including strong emotions. Tanhan (2020) suggested coding under at least three main themes if the summary words conveying the perspective of each participant are rich enough to fall under three main themes. This basic principle was followed in all of OPV and OIPA studies (Doyumğaç et al., 2022; Genc et al., 2022; Ozkan & Tanhan, 2023; Subasi et al., 2023; Tanhan & Strack, 2020). Since it was aimed to examine the participants' perceptions of the concept of mathematics in depth, each participant's opinion was handled with more than one code. For this reason, the opinions of each participant are included under three main themes in the table. Thus, a total of 300 coding were made for the study themes. Participants associated the concept of "mathematics" with the themes of life (44%), hate (5%), and unimportant (5%). Most of the participants stated that mathematics is difficult (38%) and a separate language involving numbers, formulas and symbols (38%). In addition, the numbers of those who stated that mathematics gave them happiness (22%) and those who stated that it caused them stress (23%) were quite close to each other. The stories and drawings that attracted attention in the study are analyzed in more detail below by themes.

The theme of life was the theme on which the participants expressed the highest number of opinions (44%). When this theme was analyzed, it was determined that the participants mostly thought of mathematics as life itself. Life here includes the views of "being in life and adding a future to your life". "Mathematics is an open reading of the hidden time in life." [P29], "it is the account control of life and the world." [P30], "It is difficult... it is like a game of life..." [P34], "it is almost in every aspect of life" [P46], "...it is completely in life, it affects the formation of the future...it is necessary for the protection of animals, the environment, nature and us. " [P50], "the key to transformation and progress... it expresses life and me with the harmony of numbers and terms" [P61].

Some of the participants also think that mathematics has a structure that directly affects all situations in life. In this context, P9 expressed the relationship between mathematics and life as follows:

> *For me, mathematics means first the world and then the universe. I think everything has developed with mathematics, from the Lydians finding money and using it in trade to the development of tools used in medicine. For example, if you are a football fan like me, you will see that there is mathematics even in the systems used in football. I think one of the most important ones is the systematics of traffic lights. On the other hand, if we*

Table 1. Main themes related to mathematics concept

	Main Themes	Participants (Total 100 Students)	%
1	Life	44(P3,5,7,8,9,14,16,17,23,26,29,30,33,34,37,40,46,47,48,50,52,53,54,57,59,61,62,64,66,69,71,73,74,75,76,78,81,85,86,87,89,90,94,99)	44
2	Difficult	38(P2,4,6,10,11,13,19,26,27,28,29,31,36,37,38,39,41,43,44,45,47,49,51,54,55,65,66,67,74,87,92,93,94,95,96,22,35,82)	38
3	Numbers, formulas, numbers and symbols (math language)	38(P8,12,17,30,31,35,36,37,39,41,44,48,49,50,52,53,56,58,59,60,66,67,69,73,75,76,77,79,80,83,84,85,86,89,91,97,68,88)	38
4	Stress	23(P25,39,41,42,54,55,70,72,82,93,65,28,32,34,38,40,42,45,49,67,96,4,95)	23
5	Happiness	22(P16,18,57,58,59,60,61,62,63,68,71,86,88,14,24,1,3,24,79,81,94,83)	22
6	A step for the future	18(P6,1,14,20,21,23,74,90,9,17,18,73,10,11,27,97,99,84)	18
7	A situation that requires effort	16(P5,11,12,13,22,24,34,63,69,78,80,89,95,97,99,71)	16
8	Logical	15(P1,12,62,63,64,84,9,91,81,2,5,30,77,78,16)	15
9	Fear	14(P19,32,45,57,65,72,85,87,15,38,40,42,56,83)	14
10	Seeing important	14(P7,48,50,52,58,60,68,75,76,77,88,26,33,79)	14
11	Boring	12(P7,28,46,51,100,20,64,22,43,70,98,32)	12
12	Feeling sad	7(P8,15,51,55,56,92,72)	7
13	Lack of motivation	7(P3,20,93,21,91,96,47)	7
14	Instructor not responsive to the student	7(P4,13,10,15,19,21,44)	7
15	Success	7(P6,18,53,2,33,80,90)	7
16	Seeing math as mandatory	7(P23,31,61,98,100,29,25)	7
17	Hate	5(P25,70,82,92,27)	5
18	Unimportant	5(P6,43,46,98,100)	5

As suggested in Tanhan (2020), each participant provided at least three different summary words and if they were rich enough, they were coded under three main themes

take astronomy, we see that there is an intense use of mathematics there too. Who knows, maybe mathematics will lead us in the search for life in space against the danger of not living on this earth. [P9].

From the ninth participant's explanation, it is understood that the impact of mathematics in today's life has been present from the past to the present. In fact, it is revealed that mathematics concerns many fields (medicine, football, traffic, astronomy) and is integrated with life in today's conditions.

"Mathematics is the beginning of everything. There cannot be life without mathematics. It is used in the whole universe." [P16]. The participant not only associated mathematics with life itself through her expressions and drawing (Figure 2), but also stated that mathematics is a very logical system and gives her happiness. This approach of the participant shows that she has a positive perspective on mathematics. Some of the participants partially separated the existence of mathematics in life and its existence for their own lives. For this reason, some of the data were separated from the life theme and analyzed under the theme of a step for the future (18%). P18 can be shown as an example of this situation.

If we take success as a black background, mathematics is a path that must be traveled to encourage people to succeed with white stripes on that black background. The collection of operations it contains is useful both in our daily lives and in all areas of life. For this reason, I think we should adopt it in all areas of our lives and walk on the bright path with a positive perspective to reach this black ground. [P18]

While explaining mathematics, it is seen that the participant handled it on the axis of life, thinking about his own future. The student stated that mathematics is directly related to success. While explaining this situation, he makes us feel that he thinks that mathematics is necessary for him to be successful in life. On the other hand, he also associated mathematics with happiness and revealed the factors that make up his future. Another remarkable explanation within the theme of happiness was made by the participant 79th.

During my education process, I realized that mathematics is related to numbers and symbols. Being able to do mathematics using these symbols is so beautiful and meaningful... I mean, it really makes you feel very happy. As long as you can do it, you become hungry for knowledge. [P79]

It is understood from the statement made by the participant that he considers mathematics important and feels happy when he succeeds through numbers, symbols and formulas. In the study, it is seen that most of the students stated that mathematics is a course that is conducted using numbers, symbols and formulas (38%). In the analysis, it was determined that 21 students in this theme associated this situation with the theme of happiness and 17 students thought that this situation caused mathematics to become boring.

Students who thought that mathematics was boring usually expressed these thoughts along with other negative emotions. *"There are plenty of formulas. It doesn't help anything.*

It is a complete waste. It makes me unhappy and depressed. I mean, I get stressed." [P70]. *"Mathematics tires the brain because both questions and subjects are difficult. Some math questions are even brain-burning. But I have to learn this unimportant subject."* [P100], *"Mathematics is one of the biggest obstacles to my university dream. The more I try to overcome it, the more stressed I get because it is very difficult for me. It is very boring."* [P28], *"I want to gain knowledge in mathematics. I push myself. I try. It requires effort, but it is extremely boring."* [P22], *"I cannot get rid of it even if I travel from continent to continent and from country to country. I encounter it everywhere and I think I am the only one who doesn't know it, which gives me anxiety and fear. It is a very repulsive lesson, but I still can't get it out of my mind."* [P32], *"I have no interest in mathematics because we have always seen it since we were little. I want to be an agricultural engineer, so I need to learn it. But I have no motivation."* [P20], *"When I think of mathematics, I think of a complex, difficult and boring lesson. I feel sad because it forces me a lot."* [P51], as can be seen from the explanations, most of the students who found mathematics boring also associated mathematics with negative emotions such as stress, hatred, seeing it as unimportant, compulsory, difficult, requiring effort, fear, lack of motivation and feeling sad.

Only participant 64 stated that although mathematics is boring, it is related to life and makes sense. *"We cannot have a profession without being able to do mathematics. As such, it affects our lives a lot. Yes, it is a very logical course, but not everyone has to understand everything."* [P64].

It was observed that most of the students who had teacher-related problems explained the meaning of mathematics for themselves with similar negative emotions. Thus, it was determined that some of the students (7%) who addressed mathematics by referring to the problems caused by the instructor also associated mathematics with themes such as difficult, boring, requiring effort, feeling sad, and fear. *"It is quite difficult, but it can be done with effort. I got a bit discouraged because of a teacher who treated me badly."* [P13], *"My teacher always told me that I couldn't do it and I got discouraged from mathematics."* [P10], *"Some teachers discouraged me from working hard. Therefore, I am undecided whether I can do it."* [P15], *"Mathematics is a difficult exam for me. Mathematics is always difficult for me as long as it is in my life. The formulas go around my head, but they don't enter my brain. I have a lot of difficulty because I do not get enough support from my teachers."* [P19], *"To solve my math problem, we should start from the basics. Because I was not guided correctly by my teachers*." [P44]. The picture drawn by the participant 21st in this theme is striking (Figure 3).

It can be said that the participant perceives the world mathematically. When his own explanations are taken into consideration, this perception becomes evident as a challenging situation rather than a positive inference. *"I did not get enough support from my teacher, which hinders my future. Life revolves around an incredible wheel. As a matter of fact, it continues with its difficulties. Mathematics is a part of life and a necessary branch in the world."* The participant

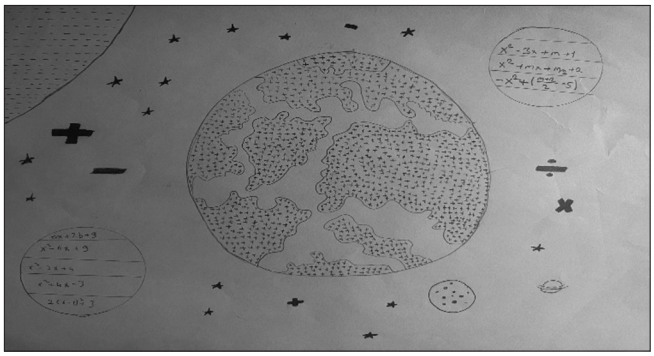

Figure 1. Participant 16's hand drawing of the concept of mathematics AQ1

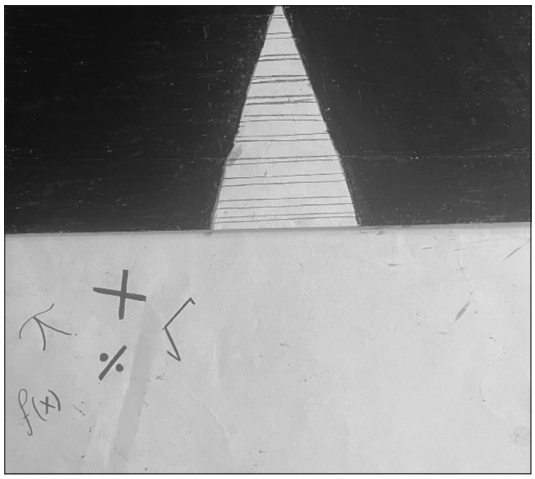

Figure 2. Participant 18's hand drawing related to the concept of mathematics AQ1

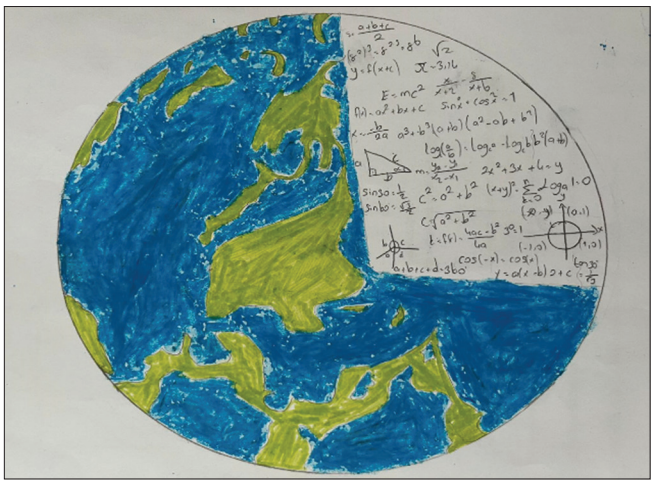

Figure 3. *Hand drawing* of the participant 21st related to the concept of mathematics

stated that he did not receive enough support from her teachers and this situation affected him negatively. In the picture he drew, it is seen that mathematics is related to the world. This situation can be explained in the sense that the student has positive feelings towards mathematics. Because the student can reveal how important mathematics is. However, the student probably lost his motivation towards the mathematics lesson due to the reasons arising from the teacher.

Table 2. Attributing the field of mathematics to systems

Attributed Systems	Individual	Microsystem	Exosystem	Macrosystem
Number of person and percentage	74 (39%)	66 (34%)	15 (8%)	37 (19%)

The last item of the OIPA aims to obtain a general evaluation of the systems to which the high school students attribute the domain of mathematics. At this stage, students were asked to state which of the individual, microsystem, exosystem and macrosystem domains best explained the mathematics domain for them. It was indicated to the students that they could attribute to more than one system. The findings obtained are as follows.

When Table 2 is examined, it is seen that the students mostly associate mathematics with individual/personal factors such as emotions, thoughts, behaviors and attitudes. Microsystem factors including family, school, peers and physical environment ranked second. Macrosystem factors such as government policies, community values and economy ranked third. Exosystem factors such as media, neighbors, local governments and organizations were ranked last.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study, the perceptions of the high school students about the concept of mathematics were tried to be determined with the help of a five-step OIPA form and their own drawings. Thus, it was determined that the main themes related to the concept of mathematics were listed as follows: Life (44%), Difficult (38%); Numbers, formulas, numbers and symbols (math language) (38%), Stress (23%), Happiness (22%), A step for the future (18%), A situation that requires effort (16%), Logical (15%), Fear (14%), Seeing it as important (14%), Boring (12%), Feeling sad (7%), Lack of motivation (7%), Instructor not responsive to the students (7%), Success (7%), Seeing math as mandatory (7%), Hate (5%), Unimportant (5%).

From the main themes obtained, it is seen that the students mostly explained the concept of mathematics using negative emotions (difficult, stress, fear, boring, ...). This situation suggests that students have negative experiences and difficulties related to mathematics. Because a person's perception of a subject is formed through experiences. Previous studies also indicate that negative emotions towards mathematics negatively affect mathematics perception (Escarez et al., 2022; Finell et al., 2022). The spiral structure of curricula ensures that students' experiences in mathematics increase as their grade level increases. The increase in the cognitive level of the outcomes may cause students' achievement in mathematics to differ in the process (Meece, 1996). This may have caused negative feelings in students. Therefore, mathematical language and experience should be carefully planned and executed to improve students' mathematical literacy.

On the other hand, the study revealed that teachers were also effective in the formation of negative feelings towards mathematics. Some of the students participating in the study stated that teachers' negative attitudes during the feedback process caused a lack of motivation in them. Students' inability to express themselves sufficiently may have led to the development of negative feelings towards mathematics and failure in mathematics. Thus, in this study, it was determined that students had anxiety problems about the future due to lack of mathematical knowledge. This situation may cause students not to be competent in using mathematical knowledge and skills. The mentioned competence includes situations such as students' inability to understand the problem situation, inability to use mathematics in decision-making, and negative effects on mathematical literacy (Niss & Jablonka, 2020). It is known that students' communication with the teacher affects their attitude towards the course, success and perception (Cassel & Vincent 2011; Papanastasiou, 2002; Wright et al., 1997). Therefore, ineffective communication with the teacher (Asadı et al., 2019; Bozkurt, 2020; Keskin & Özer Kaya, 2020) can be considered as another factor in students' negative experiences and difficulties towards mathematics. This situation can be improved by teachers communicating effectively with students. Teachers should emphasize the good aspects of students, motivate them to succeed, communicate in a way that supports the correct answer, and approach them with love.

It was determined that the students' perceptions of the concept of mathematics were predominantly associated with the main theme of life. In the studies conducted at different grade levels in the literature, it is seen that students associate mathematics with the concept of life (Çağırgan et al., 2021; Ersoy & Aydın, 2017; Markovits & Forgasz, 2017; Olsen et al., 2020). This shows that students perceive mathematics as a way of life beyond seeing it as a course. However, it can also be said that this situation stems from the students' implicit anxiety towards the mathematics course. The fact that students mostly see mathematics as a science that is difficult and has its own mathematical language may be among the reasons for this anxiety. The fact that most of the themes obtained as a result of the analysis focused on interrelated negative emotions strengthens this assumption. The students' past negative experiences are part of their negative perceptions of mathematics. These anxieties in students make it difficult for them to face life and prevent their problem solving skills from being at the desired level. Therefore, measures should be taken to strengthen students' mathematical literacy (Stacey & Turner, 2015) so that they can critically evaluate the flow of information. Mathematical literacy can be developed to address the positive aspects of students from the first years of education.

The findings of the study revealed that the high school students think that because mathematics is difficult, it will directly affect the life they will live in the future and the professions they will choose. From the students' own expressions and drawings, it was determined that this situation

caused intense stress and anxiety in students. There are studies supporting this finding in the literature (Kim et al., 2023). Students' readiness levels, negative mathematics experiences, abstract nature of the course, underdeveloped mathematical literacy, inappropriate methods and techniques used in teaching the course may have had an effect on the development of negative perceptions. Studies show that mathematics is monotonous and incomprehensible to students because it is difficult, and therefore students develop negative perceptions (Szczygieł & Pieronkiewicz, 2022). This perception can be improved by increasing academic success in mathematics and positive emotional experiences towards mathematics.

In the study, it was determined that students associated mathematics with individual factors the most. It can be said that students' distancing themselves from the learning center for various reasons (such as teacher influence, difficulty, etc.) and the negative mood they experience in mathematics learning cause this situation. Studies emphasize that the causes of negative mathematics perception have not been fully determined (David et al., 2022). However, it is known that cognitive operations that jeopardize the ongoing activity in working memory can cause math anxiety and negative perceptions (Ashcraft, 2002). It can be said that individual factors (such as worry, anxiety.,) have an intense effect on cognitive processes. In fact, studies show that a person can form negative perceptions even for irrational reasons (Fadinastasha & Agustin, 2023). Therefore, it can be stated that the fact that students associate mathematics with individual factors the most is consistent with the literature. This shows that there is an urgent need to improve students' negative perceptions of mathematics stemming from individual factors. Because negative perceptions can negatively affect the conceptual understanding of mathematics or mathematics performance (Quintero et al., 2022).

Microsystems such as family, school and peers were the second factor that students associated with mathematics the most. Mathematics anxiety, which causes negative mathematics perception, affects students' attitudes and performances. The study did not examine whether the perception of mathematics differs according to the gender, education level or participation in communication with the child. However, studies in the literature emphasize that especially the mother's education level affects children's mathematics performance and indirectly mathematics perception (Bellon et al., 2022). This shows that macrosystems are effective in the formation of mathematics perception. As a matter of fact, it was also found to be an effective factor in the results of this study. Finally, macrosystems such as government policies and community values and exosystems such as neighbors, media and local governments had the least influence on students' mathematics perceptions. In addition to all these, future researchers can act from a Community-Based Participatory Research (CBPR; Dari et al., 2021; Dari et al., 2023; Doyumğaç et al., 2021; Hauber-Özer et al., 2021; Tanhan, 2020; Tanhan & Strack, 2023; Waegh et al., 2023) approach to collaborate with the families, teachers and students to conduct Online Photovoice (OPV; Tanhan & Erin, 2023; Tanhan & Strack, 2023; Subasi et al., 2023) with different samples to understand facilitators and barriers from the students' experience with mathematics. Subasi (2023a) used OIPA by itself to understand college students' belonging, and in another study, Subasi (2023b) used OPV to collect teachers' post COVID-19's experiences and used OIPA to analyze the data. Therefore, future researchers can use OIPA, OPV, and CBPR to understand the themes emerged related to mathematics in this current research in more details.

REFERENCES

Alkan, V. (2018). A systematic review research:'Mathematics anxiety'in Turkey. *International Journal of Assessment Tools in Education*, *5*(3), 567-592. https://doi.org/10.21449/ijate.445919

Ananga, P., & Biney, I. K. (2017). Comparing face-to-face and online teaching and learning in higher education. *MIER Journal of Educational Studies Trends and Practices*, *7*(2),165-179. https://doi.org/10.52634/mier/2017/v7/i2/1415

Armiya'u, A. Y. U., Yıldırım, M., Muhammad, A., Tanhan, A., & Young, J. S. (2022). Mental health facilitators and barriers during COVİD-19 in Nigeria. *Journal of Asian and African Studies*, 00219096221111354. https://doi.org/10.1177/00219096221111354

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science*, *11*(5), 181-185. https://doi.org/10.1111/1467-8721.00196

Barakaev, M., Shamshiyev, A., O'rinov, X., Abduraxmonov, D., & Ismatov, N. (2020). Problems of Teaching Mathematics in Modernization. *International Journal of Progressive Sciences and Technologies*, *19*(2), 201-203.

Baykul, Y. (1999): *Primary mathematics education.* Ani Printing Press.

Bellon, E., Van Bergen, E., & Dowker, A. D. (2022). Is Parental Mathematics Anxiety Associated with Young Children's Arithmetical Performance?. *Education Sciences*, *12*(11), 812. https://doi.org/10.3390/educsci12110812

Blom, R., Lu, O., & Lu, C. (2022). Mindfully navigating the wind and water: defining the currents of metaphors that interfere with excellence in mathematics education. *Journal of Humanistic Mathematics*, *12*(1), 172-179. https://doi.org/10.5642/jhummath.202201.12

Boyraz, C. (2020). Matematik dersi öğretim programı. M. Gültekin (Ed.), *Cumhuriyet Dönemi İlkokul Programları* içinde (pp. 152-196). Pegem Akademi.

Bozkurt, A. (2020). Koronavirüs (COVİD-19) pandemisi sırasında ilköğretim öğrencilerinin uzaktan eğitime yönelik imge ve algıları: Bir metafor analizi. *Uşak Üniversitesi Eğitim Araştırmaları Dergisi*, *6*(2), 1-23. https://doi.org/10.29065/usakead.777652

Cassel, D., & Vincent, D. (2011). Metaphors reveal preservice elementary teachers' views of mathematics and science teaching. *School Science and Mathematics*, *111*(7), 319-324. https://doi.org/10.1111/j.1949-8594.2011.00094.x

Civelek, Ş., Meder, M., Tüzen, H., & Aycan, C. (2003). Matematik öğretiminde karşılaşılan aksaklıklar. *İnternet Adresi: http://www. matder. org. tr/Bilim/Moka. Asp*.

Çağırgan, D., Karaduman, G. B., & Sönmez, D. (2021). Vısual Analysıs of the Classroom Teacher Candıdates' metaphorıcal Perceptıons Related to the Mathematıcs Course. *European Journal of Education Studies*, *8*(4).

Dari, T., Chan, C., & Del Re, J. (2021). Integrating culturally responsive group work in schools to foster the development of career aspirations among marginalized youth. *Journal for Specialists in Group Work*, *46*(1), 75–89. https://doi.org/10.1080/01933922.2020.1856255

Dari, T., Fox, C., Laux, J. M., & Speedlin Gonzalez, S. (2023). The Development and Validation of the Community-Based Participatory Research Knowledge Self-Assessment Scale (CBPR-KSAS): A Rasch Analysis. *Measurement and Evaluation in Counseling and Development*, *56*(1), 64-79. https://doi.org/10.1080/07481756.2022.2034478

David, A., Rubinsten, O., & Berkovich-Ohana, A. (2022). Math anxiety, self-centeredness, and dispositional mindfulness. *Journal of Educational Psychology*, *114*(2), 393. https://doi.org/10.1037/edu0000550

Doyumğaç, I., Tanhan, A., & Kiymaz, M. S. (2021). Understanding the most important facilitators and barriers for online education during COVID-19 through online photovoice methodology. *International Journal of Higher Education*, *10*(1), 166-190. https://doi.org/10.5430/ijhe.v10n1p166

Ergen, Y., & Durmuş, M. E. (2022). Sınıf Öğretmenlerin Matematik Öğrenmeye İlişkin İnançları ve Matematik Öğretimi Kaygıları Arasındaki İlişki. *Van Yüzüncü Yıl Üniversitesi Eğitim Fakültesi Dergisi*, *19*(1), 65-85. https://doi.org/10.33711/yyuefd.1067779

Escarez Jr, Y. F. D., & Ching, D. A. (2022). Math anxiety and mathematical representations of Grade 7 students. *International Journal of Educational Management and Development Studies*, *3*(1), 166-181.

Fadinastasha, S. S., & Agustin, M. (2023, June). The Effect of Mathematıcs Anxıety on Academic Procratination Moderated With Self-Control Factors in Mechanical Engıneering Students of UPI. In *3rd Borneo International Conference on Islamic Higher Education (BICIHE) 2023* (Vol. 1, No. 1, pp. 302-308).

Finell, J., Sammallahti, E., Korhonen, J., Eklöf, H., & Jonsson, B. (2022). Working Memory and its mediating role on the relationship of math anxiety and math performance: A meta-analysis. *Frontiers in Psychology*, *12*, 798090. https://doi.org/10.3389/fpsyg.2021.798090

Genc, E., Tanhan, A., & Kose, O. (2022). Exploring the facilitators and barriers to maintaining intimate relationships during COVİD-19 through online photovoice methodology. *Journal of Family Issues*. http://dx.doi.org/10.1177/0192513X221113855

Hauber-Özer, M., Call-Cummings, M., Hassell-Goodman, S., & Chan, E. (2021). Counter- storytelling: Toward a critical race praxis for participatory action research. *International Journal of Qualitative Studies in Education*, *36*(6), 1175-1190. https://doi.org/10.1080/09518398.2021.1930252

Hendriana, H., Prahmana, R. C. I., Ristiana, M. G., Rohaeti, E. E., & Hidayat, W. (2022, October). The theoretical framework on humanist ethno-metaphorical mathematics learning model: An impactful insight in learning mathematics. In *Frontiers in Education* (Vol. 7, p. 1030471). Frontiers. https://doi.org/10.3389/feduc.2022.1030471

Heyder, A., Weidinger, A. F., Cimpian, A., & Steinmayr, R. (2020). Teachers' belief that math requires innate ability predicts lower intrinsic motivation among low-achieving students. *Learning and Instruction*, *65*, 101220. https://doi.org/10.1016/j.learninstruc.2019.101220

Ibrokhimovich, F. J., & Mirzaxolmatovna, X. Z. (2022). The most important role of mathematics in primary school. *Galaxy International Interdisciplinary Research Journal*, *10*(3), 652-655.

Janah, S. R., Suyitno, H., & Rosyida, I. (2019). Pentingnya Literasi Matematika dan Berpikir Kritis Matematis dalam Menghadapi Abad ke-21. PRISMA, *Prosiding Seminar Nasional Matematika,* 2, 905–910. Retrieved from https://journal.unnes.ac.id/sju/index.php/prisma/article/view/29305

Khatin-Zadeh, O., Eskandari, Z., & Farsani, D. (2023). The roles of mathematical metaphors and gestures in the understanding of abstract mathematical concepts. *Journal of Humanistic Mathematics*, *13*(1), 36-53. https://doi.org/10.5642/jhummath.BZXW2115

Kim, J., Shin, Y. J., & Park, D. (2023). Peer network in math anxiety: A longitudinal social network approach. *Journal of Experimental Child Psychology*, *232*, 105672. https://doi.org/10.1016/j.jecp.2023.105672

Kizilay, I. (2022). *Farklı bağlanma stillerine sahip bireylerin ilişki deneyimlerinin online yorumlayıcı fenomenolojik analiz (OYFA) ile incelenmesi* [Yayımlanmamış yüksek lisans tezi]. Üsküdar Üniversitesi.

Kossybayeva, U., Shaldykova, B., Akhmanova, D., & Kulanina, S. (2022). Improving teaching in different disciplines of natural science and mathematics with innovative technologies. *Education and Information Technologies*, *27*(6), 7869-7891.

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of adolescence*, *27*(2), 165-179. https://doi.org/10.1016/j.adolescence.2003.11.003

Meece, J. (1996). *Gender Differences in Mathematics Achievement: The Role of Motivation*. In M. Carr (Ed.), *Motivation in Mathematics* (pp. 113-130). Hampton Press.

Neuhauser, C. (2002). Learning style and effectiveness of online and face-to-face instruction. *The American Journal of distance education*, *16*(2), 99-113. https://doi.org/10.1207/S15389286AJDE1602_4

Niss, M., & Jablonka, E. (2020). Mathematical literacy. In S. Lerman (Ed.), *Encyclopedia of mathematics education* (pp. 548–553). Springer. https://doi.org/10.1007/978-3-030-15789-0_100

Olsen, J., Lew, K., & Weber, K. (2020). Metaphors for learning and doing mathematics in advanced mathematics lectures. *Educational Studies in Mathematics*, *105*, 1-17.

Öğülmüş, K., Acikgoz, M. H., & Tanhan, A. (2021). Evaluation of teacher candidates' perceptions about specific learning difficulties through Online Photovoice (OPV) method. *International Journal of Education and Literacy Studies*, *9*(2), 161-169. http://dx.doi.org/10.7575/aiac.ijels.v.9n.2p.161

Özkan, N., & Tanhan, A. (2023). Women's perspectives of sexuality through Online Photovoice (OPV). [Kadınların cinselliğe bakışının online seslifoto ile incelenmesi]. *Eskişehir Osmangazi Üniversitesi Sosyal Bilimler Dergisi*, *24*(2), 194-229. https://doi.org/10.17494/ogusbd.1110733

Papanastasiou, C. (2002). Effects of background and school factors on the mathematics achievement. *Educational Research and Evaluation*, *8*(1), 55-70. https://doi.org/10.1076/edre.8.1.55.6916

Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health services research*, *34*(5 Pt 2), 1189.

Paul, J., & Jefferson, F. (2019). A comparative analysis of student performance in an online vs. face-to-face environmental science course from 2009 to 2016. *Frontiers in Computer Science*, *1*(7). https://doi.org/10.3389/fcomp.2019.00007

Quintero, M., Hasty, L., Li, T., Song, S., & Wang, Z. (2022). A multidimensional examination of math anxiety and engagement on math achievement. *British Journal of Educational Psychology*, *92*(3), 955-973. https://doi.org/10.1111/bjep.12482

Richland, L. E., Stigler, J. W., & Holyoak, K. J. (2012). Teaching the conceptual structure of mathematics. *Educational Psychologist*, *47*(3), 189-203. https://doi.org/10.1080/00461520.2012.667065

Sajan, S., Sasmal, S. K., & Dubey, B. (2022). A phytoplankton–zooplankton–fish model with chaos control: In the presence of fear effect and an additional food. *Chaos: An Interdisciplinary Journal of Nonlinear Science*, *32*(1). https://doi.org/10.1063/5.0069474

Schaeffer, M. W., Rozek, C. S., Maloney, E. A., Berkowitz, T., Levine, S. C., & Beilock, S. L. (2021). Elementary school teachers' math anxiety and students' math learning: A large-scale replication. *Developmental science*, *24*(4), e13080. https://doi.org/10.1111/desc.13080

Seydooğulları, S. Ü. (2023). University students' wellbeing and mental health during COVID-19

an Online Photovoice (OPV) approach. *Journal of Happiness and Health.* Manuscript under review.

Snead, S. L., Walker, L., & Loch, B. (2022). Are we failing the repeating students? Characteristics associated with students who repeat first-year university mathematics. *International Journal of Mathematical Education in Science and Technology*, *53*(1), 227-239. https://doi.org/10.1080/0020739X.2021.1961899

Stacey, K., & Turner, R. (2015). Assessing mathematical literacy: The PISA experience. New York, NY: Springer. https://doi.org/10.1007/978-3-319-10121-7_1

Stella, M. (2022). Network psychometrics and cognitive network science open new ways for understanding math anxiety as a complex system. *Journal of Complex Networks*, *10*(3), cnac012. https://doi.org/10.1093/comnet/cnac012

Subasi, Y. (2023a). College belonging among university students during COVID-19: An Online Interpretative Phenomenological (OIPA) Perspective. *Journal of Happiness and Health*, Manuscript under review.

Subasi, Y. (2023b). Öğretmenlerin COVİD-19 sonrasi sürecini Online Seslifoto (OSF) yöntemiyle anlamak. *EKEV Akademi Dergisi*, Makale hakem sürecinde.

Subasi, Y., Adalar, H., Tanhan, A., Arslan, G., Allen, K. A., Boyle, C., Collet, K. & Lauchlan, F. (2023). Investigating students' experience of online/distance education with photovoice during COVID-19. *Distance Education*, *44*(3), 563-587. https://doi.org/10.1080/01587919.2023.2227140

Szczygiel, M. (2020). Gender, general anxiety, math anxiety and math achievement in early school-age children. *Issues in Educational Research*, *30*(3), 1126-1142.

Szczygieł, M., & Pieronkiewicz, B. (2022). Exploring the nature of math anxiety in young children: Intensity, prevalence, reasons. *Mathematical Thinking and Learning*, *24*(3), 248-266. https://doi.org/10.1080/10986065.2021.1882363

Tanhan, A. (2020). COVID-19 sürecinde Online Seslifoto (OSF) yöntemiyle biyopsikososyal manevi ve ekonomik meseleleri ve genel iyi oluş düzeyini ele almak: OSF'nin Türkçeye uyarlanması. [Utilizing Online Photovoice (OPV) methodology to address biopsychosocial spiritual economic issues and wellbeing during COVID-19: Adapting OPV to Turkish.] *Turkish Studies, 15*(4), 1029- 1086. https://doi.org/10.7827/TurkishStudies.44451

Tanhan, A., Arslan, G., Yavuz, F., Young, J. S., Çiçek, İ., Akkurt, M. N., & Allen, K. A. (2021). A constructive understanding of mental health facilitators and barriers through Online Photovoice (OPV) during COVID-19. *ESAM Ekonomik ve Sosyal Araştırmalar Dergisi*, *2*(2), 214-249. https://dergipark.org.tr/en/pub/esamdergisi/issue/64932/956618

Tanhan, A., & Erin, A., (2023). Online Seslifoto (OSF) yöntemiyle üniversite öğrencilerinin tasavvuf anlayışını keşfetmek [Exploring college students' perception of tasawwuf through Online Photovoice (OPV) methodology]. *Iğdır Üniversitesi Sosyal Bilimler Dergisi*; Manuscript in print.

Tanhan,A., & Strack, R. W. (2020). Online photovoice to explore and advocate for Muslim biopsychosocial spiritual wellbeing and issues: Ecological systems theory and ally development. *Current Psychology*, *39*(6), 2010-2025. https://doi.org/10.1007/s12144-020-00692-6

Tatar, E., Okur, M., & Tuna, A. (2008). Ortaöğretim matematiğinde öğrenme güçlüklerinin saptanmasına yönelik

bir çalışma. *Kastamonu Üniversitesi Kastamonu Eğitim Dergisi*, *16*(2), 507-516.

Thomas, H. & Furner, J. M. (1997). Helping high ability students overcome mathematics anxiety through bibliotherapy. *Journal Of Secondary Gifted Education,* 8(4), 164-179. https://doi.org/10.1177/1932202X9700800403

Tümkaya, S., Kayiran, B. K., Tanhan, A., & Arslan, Ü. (2021). Using Online Photovoice (OPV) to understand youths' perceptions of distance education during COVID-19. *International Journal of Education and Literacy Studies*, *9*(4), 45-60. http://dx.doi.org/10.7575/aiac.ijels.v.9n.4p.45

Umay, A. (1996). Matematik eğitimi ve ölçülmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *12*(21), 145-149.

Waegh, R. D., Teaurere, R., Orams, M., & Lück, M. (2023). Online photovoice to engage indigenous Cook Islands youth in the exploration of social and ecological wellbeing amidst a global disruption. *Frontiers in Sustainable Tourism*, *2*. https://doi.org/10.3389/frsut.2023.1172034

Wang, C., & Burris, M. A. (1997). Photovoice: Concept, methodology, and use for participatory needs assessment. *Health education & behavior*, *24*(3), 369-387. https://doi.org/10.1177/109019819702400309

Yeniel, A. (2019). *Seçmeli matematik uygulamaları dersinin öğrencilerin matematik okuryazarlık düzeylerine ve matematiğe yönelik tutumlarına etkisi ve öğretmen görüşlerinin incelenmesi* (Doctoral dissertation, Necmettin Erbakan University (Turkey).

Author Query???

AQ1: Kindly cite figures 1 and 2 in the text part