

A New Answer for the Question of How We Will Make Mathematics Attractive: Cinema

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Abstract: The aim of this study, which was designed as a case study, is to examine the possible effects of watching a math-themed movie on students' attitudes, beliefs, emotions, and, math anxiety in math class. The research was carried out with 12 students who were enrolled in the 6th-grade in a public school in Konya. Two different math-themed movies (The Man Who Knew Infinity, Fermat's Room) screened to the participants for the intervention, which lasted seven class hours in one week. The data of the study collected through semi-structured interviews conducted with 12 students. After content analysis, the data of the research classified under five categories (self-confidence in mathematics, necessity of mathematics, ways to be successful in mathematics, math anxiety, and fun) and it was found that watching math-themed movies have a positive affect on students' attitudes, beliefs, emotions towards mathematics, and, math anxiety. So in this paper, a promising, novel and, practical education way introduced for increasing positive beliefs, emotions, and attitudes towards mathematics and decreasing math anxiety.

Keywords: Attitude towards mathematics, Math-themed movie, Math anxiety, Beliefs, Cinema, Secondary-school student

1. Introduction

Recently, a considerable literature has grown up around the theme of attitude towards mathematics and math anxiety. Many recent studies have focused on new ways and approaches for increasing positive attitudes towards mathematics of the students and decreasing the math anxiety. According to Demirel (1993) attitude is a "learned tendency that pushed people to show certain behaviors towards certain people, objects, and situations". Attitudes have affective, behavioral, and cognitive dimensions. The cognitive dimension determines information, belief, and opinions about the object to attitude, affective dimension determines senses such as liking, not liking, and rejection, the behavioral dimension determines actually behaving (Pehlivan, 1997). In the learning environment, it is known that there is a strong correlation between attitudes and academic achievement. Neale (1969) describes the attitude towards mathematics as "an individual's tendency to like or dislike mathematics, to engage in or escape from mathematical activities, and to believe that he/she will be successful or unsuccessful in maths, and whether mathematics is useful or not (Maqsud, 1998). "Math attitudes" can express many aspects of students' perceptions, beliefs, and mentality about mathematics. Math attitudes and math skills are interrelated. Positive attitudes about mathematics promote mathematics achievement, which in turn encourages even more positive attitudes (Ma, 1997). The students who have negative math attitudes tend to avoid mathematics (Hembree, 1990). Positive attitudes lead to more academic success while negative attitudes cause a decrease in academic achievement (Kalm, 2010). Therefore, students' positive attitudes towards mathematics will increase their success and negative attitudes will decrease their success. This shows how important and critical it is to have a positive attitude towards mathematics.

The terms of quantiphobia (Goldberg & Waxman, 2003), mathophobia (Hilton, 1980), math phobia (Pan & Tang, 2005), and Mathematics Learning Distress (Iossi, 2007) describes nearly the same phenomenon. Despite this diversity, most researchers prefer the term math anxiety for this phenomenon. Math anxiety is defined as an irrational scare which prevents dealing with numbers in daily or academic life and solving mathematical problems (Lazarus, 1974; Richardson & Suinn, 1972). In another definition, math anxiety is defined as fear, anxiety, and irritability state in individuals when they deal with mathematics (Fennema & Sherman, 1976). Math anxiety begins in the first years of study and increases gradually (Jackson & Leffingwell, 1999). A large number of students suffer from math anxiety (Perry, 2004). Math anxiety also leads to negative behaviors such as avoiding mathematics and decreasing mathematics achievement (Hembree, 1990). In addition, the student who is anxious about mathematics also develops this anxiety against his/her teacher and this affects the teacher-student relationship negatively.

Although math anxiety is not hereditary, parents' confidence in their mathematical skills and attitudes affects their children's feelings about mathematics. (Byrd, 1982) In addition to parents, teachers' and peers' views are also effective in increasing or decreasing students' confidence in mathematical skills (Alcı, 2001; He, 2007). Researchers have suggested that there may be several reasons for math anxiety. Lazarus (1974) reported that math anxiety occurred with the interaction of the structure of mathematics, family behaviors, educational factors,

expectations from mathematics, and personal values. Another major factor causing math anxiety is that students are afraid of making mistakes during their mathematics classes (Zakaria & Nordin, 2008). Math anxiety begins in the first years of study and increases gradually. Most of the students suffer from math anxiety (Jackson & Leffingwell, 1999; Perry, 2004). Due to math anxiety, this type of negative attitude towards mathematics is an important factor affecting the emergence of mathematics skills especially in students (Hannula, 2006). For this reason, it must keep in mind that it is of great importance for the subsequent processes that the mathematics education during the school periods and especially during the primary and secondary grades should be arranged in a way that does not cause anxiety for the students (Keçeci, 2011). Personal value, self-confidence, personal opinion, avoidance, cognitive learning styles are the other personality factors related to beliefs, emotions, math anxiety, and attitude towards mathematics (Curtain-Phillips, 1999; Furner & Berman, 2003; Tobias & Weissbrod, 1980). As it is seen, students' attitude and anxiety towards the math course significantly affect their interest, motivation, and success for the lesson.

The math anxiety and the attitude towards mathematics have a negative correlation (Peker & Mirasyedioğlu, 2003; Tuncer & Yılmaz, 2016) and affect each other. Negative attitudes cause students to raise their math anxiety and eventually fail in this course. The prejudices of the students against the mathematics lesson make them think that mathematics is difficult. Also, children's math attitudes can be (unintentionally) influenced by the negative viewpoints of adults with whom they interact. For example, children whose parents have negative attitudes towards mathematics are more likely to be exposed to math anxiety (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). Another factor affecting students' achievements is teachers. Teachers' attitudes, behaviors, and beliefs, especially against primary and secondary mathematics lessons are significant factors that affect students' attitudes towards mathematics (Kulm, 1980; Beilock, Gunderson, Ramirez, & Levine, 2010). Therefore, the most important task belongs to teachers. One of the most important objectives of mathematics teachers should be to ensure that their students develop positive beliefs, emotions, and attitudes towards mathematics and reduce their math anxiety levels (Curtain-Phillips, 1999). The teacher should reduce his/her role by giving the students a chance to express themselves more, to be more understanding of failures, to emphasize success, and to develop positive attitudes and emotions by enriching the lessons with mathematics games. Such approaches enable the student to gain self-confidence and to feel less anxiety when dealing with mathematics (Curtain-Phillips, 1999). The literature review shows that if students understand the nature of mathematics and believe that they can achieve it, their attitude towards mathematics, beliefs, emotions, and math anxiety would change positively.

The mathematical powers of the students have a significant effect on their success levels in mathematics lessons. The National Council of Teachers of Mathematics (NCTM) in the USA defined mathematical power in 1991. Mathematical power includes the ability of students to make exploring, conjecturing, and reasoning, to solve non-routine problems, establishing relationships between the ideas that mathematics covers and other mental activities, communicating about mathematics, and communicating via mathematics. Also, mathematical power plays an important role in the development of self-confidence and willingness to conduct research, the ability to use and interpret numerical and figural information in the process of problem-solving, and decision making. Students' attitudes, interests, flexibilities, and prejudgments also affect the realization of mathematical power (NCTM, 1991: 12). According to the National Assessment of Educational Progress Unit (NAEP) in the USA, mathematical power is characterized as a student's overall ability to gather and use mathematical knowledge through exploring, conjecturing, and reasoning logically; solving non-routine problems; communicating about and through mathematics; and connecting mathematical ideas in one context with mathematical ideas in another context or with ideas from another discipline in the same or related contexts (NAEP, 2003:35). Also, Ryan (1998) describes the concept of mathematical power as the ability to reveal mathematical relationships, logical reasons, and to use mathematical methods effectively. Mathematical power is an ability which students are responsible for their thoughts about mathematics and it is revealed by the positive change in their belief that they are expected to be successful in mathematics (Rachlin, 1998). A different important aspect of mathematical power is that the student can put forward an idea without being dependent on the teacher (Greenwood, 1993). Mathematical power has an important role in students' attitudes towards mathematics due to their mathematics achievement levels.

According to Einstein, the formulation of a problem (only mathematical or experimental skills) is more important than the solution to the problem. Learning environments and course plans are also very important. They must create an opportunity to connect real life and the learnings in lessons. In this way, by using art, students can develop a positive approach to mathematics with a better grasp. For example, the drama approach has a significant effect on attitudes towards mathematics (Sözer, 2006; Kayhan, 2012). The visual arts adapted to mathematics lessons positively change the attitudes towards mathematics (Granger, 2000; Özder, 2008). Additionally, in the literature, studies present the relationship between music and attitude towards mathematics (Beer, 2008; Ayotola & Adedeji, 2009; Tezer & Kıvanç, 2012). Kaşkaya, Ünlü, Akar, Sağırılı, and Özturan (2011) analyzed the effect of school and teacher-centered movies in the teaching profession and their perceived self-efficacy of teacher candidates. Obtained data analysis revealed that educational movies affected students' attitudes meaningfully towards the teaching profession and their perceived self-efficacy positively. Arts can be powerful tools to develop

and shape emotions and attitudes. So, the seventh art (cinema) can affect the beliefs, emotions, attitudes towards mathematics and, math anxiety.

According to Cohen (1999, cited in Trier, 2002), films have such a kind of potential energy to carry relatively thoughtful and deeper influences than texts. The movies reveal something that we cannot notice easily, even if we notice, we cannot mention easily. Written texts and verbally conveyed thoughts and information may not create enough motivation for people. In addition to these, cinema can shape the emotions and thoughts of people through visual, auditory stimuli and regular editing that it has. Indeed, the term cinematic elevation refers to the ability of movies to promote sacrifice. The audiences display a more self-sacrificing attitude, inspired by the power, virtue, favor of the character he/she sees on the screen (Niemic, 2012). Schnall, Roper, and Fessler (2010) found in their study that displaying the self-sacrificing behavior of another person increased positive cinematic assessment, and this provided a measurable increase in the self-sacrificing behavior or benevolence of audiences. In addition to this finding, it has been concluded that this increase in many researches provides a basis for the development of many positive social behaviors (Aquino, McFerran, & Laven, 2011; Cox, 2010; Landis et al. 2009; Schnall & Roper, 2012). A close term, cinematic admiration, is how audiences shape their personal development in a determined way by using movies or a target behavior is brought to the audience. This admiration is influenced by talent or a character that audiences observe in the movie and cause a strong motivation to change personal development or target behavior in that direction (Algoe & Haidt, 2009; Niemic, 2012). It is possible to explain the emergence of such behaviors with Bandura's (1977, 1986) social cognitive theory. One of the ways that children learn is to model the behavior of parents, teachers, peers, or characters in movies.

Movies are used in education as well as psychotherapy studies named cinema-therapy (Berg-Cross, Jennings, & Baruch, 1990). The movies recommended by this method allow the patient to understand and find solutions to their problems without feeling threatened and under pressure (Dermer & Hutchings, 2000). When using movies as a therapy method, it is critical to evaluate both the strengths of movies and to identify and determine well-matched movies and match them with the patient. Then it is essential to create a discussion environment to make the desired behaviors or personal development stronger and more permanent. Using movies to help children with broken families to define and discuss their feelings is a good example of this situation (Marsick, 2010). Emotions and attitudes are acquired by learning. For the cinema industry, creating emotional changes in audiences is an indispensable instrument. Music, slow-motion scenes, facial expressions, and fiction intended to create the emotion that is tried to be processed dictate these emotions to the audience. According to Zillman's (1988) concept of mood management, almost all movie choices aim to increase satisfaction or positive effect. Even horror movies will be chosen for pleasure in releasing or unraveling tension. However, these are short term impact changes after watching the movie. But movies can also promote long-term impact and eventual behavioral changes (Zilman, 1998). Fredrickson, Cohn, Coffey, Pek, and Finkel (2008) states that the positive emotions of the person cascading upward as a spiral, and those current or instant positive emotions can be transformed into positive sources for the needs in future difficult times.

Entertainment-Education (E-E) means to place educational messages in the entertainment environment and is another type of education that can be realized through cinema (Singhal & Rogers, 2002). This method uses movies as a means to disseminate ideas that can lead to social and behavioral change. It is possible to see this widely in Hollywood. With a fiction made, it is possible to create imaginary heroes that people will try to resemble and the desired type of changes in society can be created by giving to real people superhuman missions. Children learn in part from their observations about the behavior of their parents, peers, and teachers', from the books they read and from the movies they watch. The effort, perseverance, fearlessness, and determination of the movie character who plays a role model by admiration, deeply affect them. Cinema is a very effective way to develop positive behavior and attitude (Singhal & Rogers, 2002). We believe that movies and the admiration for the characters in the movies with high mathematical power may affect the beliefs, emotions, attitudes towards mathematics and, math anxiety of the students.

2. The Aim of Research

Considering the relationship between attitudes towards math, math anxiety, math achievement, and the effect of movies on humans' social and behavioral change; it's believed that movies and the admiration for the characters in the movies with high mathematical power may affect math anxiety of students and their attitudes, beliefs, and emotions towards mathematics positively. In the literature, there is not a single study investigating the effects of watching math-themed films on students' math anxiety, attitudes towards mathematics, beliefs, and emotions. Therefore, this study aims to investigate the effects of math-themed movies on 6th-grade students' math anxiety, attitudes towards mathematics, beliefs, and emotions.

3. Method

3.1. Research Design

This study was designed in the case study design which is one of the qualitative research methods. The case study is a research method that enables researchers to examine a case or event, by answering How? and Why? questions (Yıldırım & Şimşek, 2018). Finding out how and why mathematics-themed films affect students' math anxieties, beliefs, emotions, and attitudes towards mathematics have been the factor determining this preference.

3.2. Research Group

The convenience sampling method used in the study and the intervention group of the study consisted of 12 students enrolled in 6th grade in a public school in Konya in the 2017-2018 academic year. The mean age of students was 11.3 years. (SD= 0.4). Convenience sampling, which is included in random sampling methods defined as obtaining the data from a sample that can be easily accessed by the researcher (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2015).

3.3. Intervention and Data Collection Process

The researchers examined ten different movies and two school psychological counselors for the process and two of them were chosen by consensus. The criterias determined by Yıldız and Ürey (2014) are used in the selection of the movies. Required permissions were taken from the local distributors who have the broadcasting rights of the movies which would be screened for the study. In case of the possible negative effects of the movies to be watched by students on their personal development, the movies were watched by three different school psychological counselors by considering the age-appropriateness and their potential psychological and physical effects. The scenes which were not suitable as a result of the expert opinions (sexuality, brutality, etc.) were pixelated or removed from the movies.

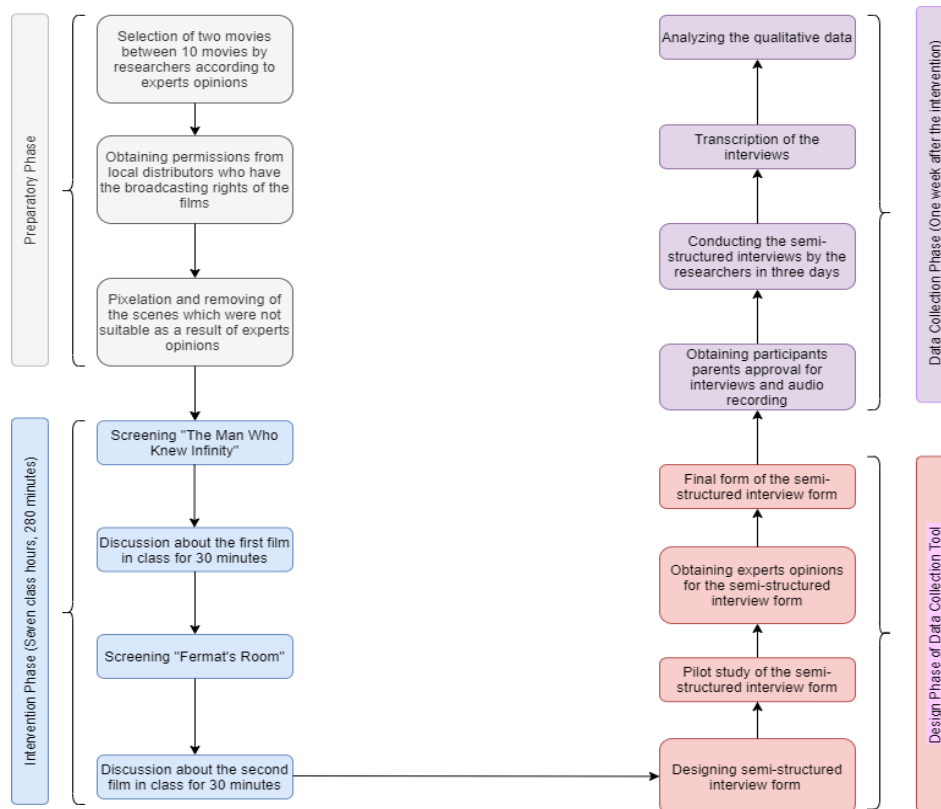


Figure 1. Design of the research

Afterward, selected two movies were shown to students. The plot of the first film (The Man Who Knew Infinity) is “the story of the life and academic career of the pioneer Indian mathematician, Srinivasa Ramanujan, and his friendship with his mentor, Professor G.H. Hardy” (IMDb, 2015). The second movie called Fermat’s Room (La habitación de Fermat) is about “four mathematicians who are invited to solve an enigma. Once there, they're locked in a mechanically shrinking room and given one minute to solve each puzzle via cellphone while also figuring out why they're there.” (IMDb, 2007). In the movies, the sections that the students might find difficult to understand were explained during the intervention by their teacher. Following the end of both films, the students were provided with the opportunity and talk about each other to explain their ideas by allowing a discussion environment for about 30 minutes. Neither researchers nor their teachers made directive interventions in

discussions about movies. The intervention phase completed in a week and lasted seven class hours (280 minutes) in total.

Also, one week later, 30-minute interviews with 12 students were conducted by the researchers using semi-structured interview forms designed by the researchers. In this study, the semi-structured interview method which is one of the qualitative research data collection methods was preferred. This technique can be seen as a more appropriate technique for educational research due to its flexibility as well as standardization (Ekiz, 2003). The fact that each participant answered the questions independently in the interview form without being affected by each other, and that there was a certain level of flexibility and standard at the center of the method was a factor determining this preference. The interviews were held in the same school where the practice is executed. The interviews were recorded at the initial stage of the analysis (358 minutes) with the approval of the participants' parents. The parents of all 12 students and students were informed about the process in detail. The questions prepared by the researchers before the interview were tried to be asked to all the students in the same order, with the same words and voice tone that would remind the same meaning, and there were no limitations on the answers given to the questions. However, due to the features of the semi-structured interview method, which was chosen as the data collection method, some probe questions were asked to enable participants to explain and clarify their answers. In Figure 1, the design of the research and the data collection process are presented visually in detail.

3.4. Data Collection Tools

In order to collect qualitative data, semi-structured interviews were designed by researchers after the literature review and intervention. The semi-structured interview form is focused on the effects of the math-themed movies on students' opinions about mathematics and their beliefs and attitudes towards mathematics. In the process of developing the qualitative data collection tool, two different experts (Psychological Counseling and Guidance field expert, Mathematics Education expert) were asked to examine the interview form (respectively one of the experts has a Ph.D. and the other one has a post-graduate degree). Besides, the suitability of the language used in the form was provided by taking the opinions of a specialist in Turkish Language Teaching. The feedback obtained from the semi-structured interview form which was designed as a measurement tool, compared with the experts and after the necessary edits were made, the suitability of the language was taken into consideration again and the necessary edits were made by taking the opinions of the expert in the field of Turkish Language Teaching. A pilot study was conducted with a student after the application. As a result of the pilot study, experts and researchers agreed that the form was appropriate. The pilot study was used to construct interview questions and was not given in the findings section as results.

3.5. Data Analysis

Content analysis involves collecting data, which resembles each other, around certain concepts and categories for bringing them into a form that the reader can easily understand and include the processes of evaluation and interpretation. The four-stage qualitative content analysis method was used in the data analysis of the study (Yıldırım & Şimşek, 2018):

- (1) Data coding
- (2) Category determination
- (3) Arrangement and definition of the data according to codes and categories
- (4) Interpretation of the results.

The interviews recorded in the first step of the analysis were transferred to an Office program (68 pages) and read several times. The variational method was used in data analysis. Codes created by two independent researchers were compared with those created by the researchers who conducted this study and necessary arrangements were made. The categories were determined by considering the focused items and questions while preparing the interview form. Then, verbatim quotations were made to show the opinions of the participants under the nature of the content analysis. The factors such as multiplicity (different views), explanatory (suitability to the category), diversity, and extreme samples were taken into consideration during data presentation (Ünver, Bümen, & Başbay, 2010). The notes of the interviews are given in quotation marks in the results section and the codes given in the parentheses indicate which student stated the note (S1, S2, S3, ..., S12).

3.6. Validity and Reliability

In qualitative research, validity is defined as the accuracy and reflection of scientific findings. Reliability is defined as the consistency of scientific findings (Golafshani, 2003; Yıldırım & Şimşek, 2018). To increase the validity and reliability of the study, some precautions were applied by the researchers. The data collection tool of the study, prepared in line with the experts' opinions and pilot study.

The interviews were recorded at the initial stage of the analysis with the approval of the participants' parents and transferred to an Office program and read several times. The parents and students were informed about the process in detail. The interviews were held in the school where the practice is executed. Thus, the participants were tried to be felt comfortable and familiar. The questions prepared by the researchers before the interview were tried to be asked to all students in the same order, with the same words and voice tone that would remind the same meaning, and there were no limitations on the answers given to the questions.

The interviews were recorded in the first step of the analysis with the participants parents' approval and transferred to an Office program and read several times. The variational method was used in data analysis. Codes created by two independent researchers were compared with those created by the researchers who conducted this study. The consistency rate between coders is 89% according to the Miles and Huberman (1994) formula. The intervention, study group, and the data collection process were tried to be described in detail. Detailed descriptions were provided by verbatim quotations from participants.

3.7. Ethics, and the Role of the Researchers

During the research process, scientific ethical principles were meticulously followed. The identities of the participants were kept confidential and the participants were reported with their assigned codes. Required permissions were taken from the local distributors of the movies. The movies were watched by three different school psychological counselors by considering the age-appropriateness and their potential psychological and physical effects. The scenes which were not suitable as a result of the expert opinions (sexuality, brutality, etc.) were pixelated or removed from the movies. Besides, this study was conducted with the 20.10.2020 dated and 2020-19 numbered permission of “Necmettin Erbakan University Social and Humanistic Sciences Scientific Research Ethics Committee.

The movies and intervention process were planned by all three researchers. One of the researchers works as a math teacher and cinema club consultant at the school where the intervention was carried out. However, another researcher conducted the interviews.

4. Result

The codes and categories obtained as a result of the content analysis and the verbatim quotations from students about these categories are given below. The notes of the interviews are given in quotation marks and the codes given before the quotations indicate which participant stated the note. During the analysis process, some of the answers given by the participants were associated with more than one code. Due to this situation, the frequencies and the number of participants may not be consistent in the tables in the result section. The categories and codes prepared according to the opinions of the participants are given in Figure 2 as a diagram.

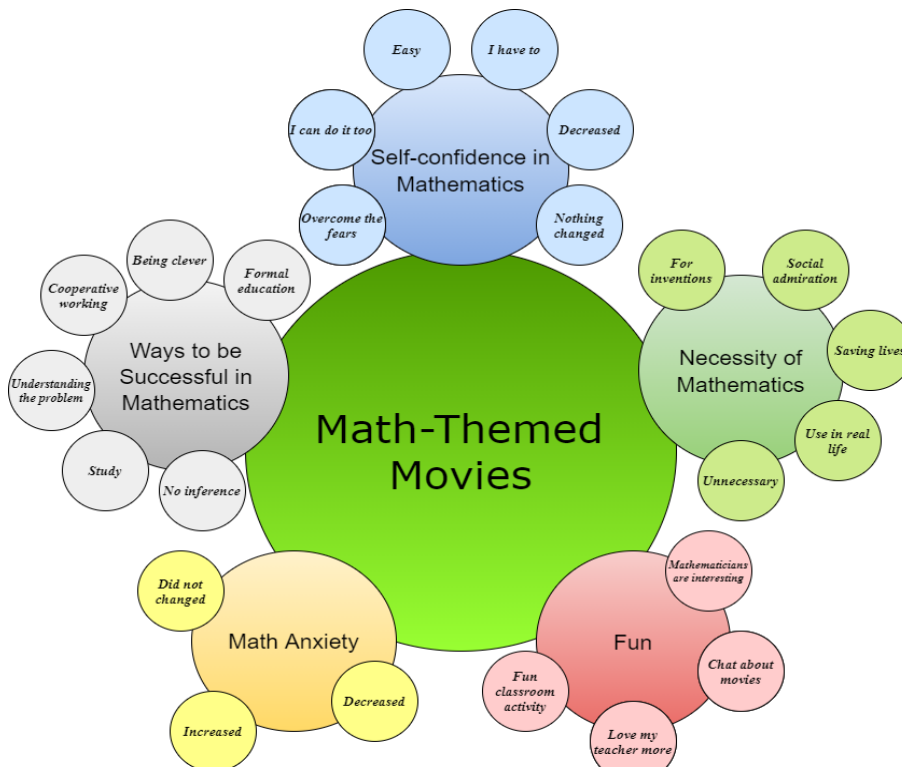


Figure 2. Categories and codes about watching math-themed movies

4.1. Self-confidence in Mathematics

According to the semi-structured interviews conducted with the participants, eight of the participants stated that their beliefs that they would be successful in mathematics were strengthened. Two of the participants stated that their self-confidence about mathematics decreased. As a result of the content analysis of the semi-structured interviews carried out with the participants, six codes were created under the category of "Self-confidence in Mathematics". Those codes and their frequencies are given in Table 1.

Table 1. Codes and frequencies determined under the category of self-confidence in mathematics

Category	Codes	Frequencies (f)
Self-confidence in Mathematics	Overcome the fears	1
	I can do it too	4
	Easy	1
	I have to	2
	Decreased	2
	Nothing changed	2
	Total	12

When the codes created under the category of "Self-confidence in Mathematics" presented in Table 1 were examined, it was seen that the opinions of the participants were mostly classified under the codes "I can do it too", "I have to", "decreased" and "nothing changed". Some verbatim quotations and interpretations about the quotations are given below.

S6: *"I'm afraid of mathematics, but if you have to do it and your life depends on it, you have to overcome your fears. I believe I can beat mathematics now."*

S7: *"...doing mathematics is the way to be successful. I can do it and become a genius."*

When considering the answer of S6, "I believe I can beat mathematics now.", it is clear that his anxiety about mathematics decreased. It seems that he accepted the fear of mathematics and decided to overcome it. Similarly, S7 stated that the path to success is through mathematics success.

S3: *"I thought mathematics was something that could not be solved. But in the first movie (The Man Who Knew Infinity) he dealt with mathematics even when he was sick. If he can do it when he is even sick, I can do it too."*

It is seen that S3 was strongly influenced by the discussion of mathematics with Hardy even in Ramanujan's sickbed and his continued working in the hospital and this increased his self-confidence in mathematics.

S1: *"...Sometimes I have questions that I cannot solve. It has arisen from my thoughtfulness or sometimes, I do not care because it is simple, not that I cannot..."*

It was observed that S1 liked mathematics before the application and due to his self-confidence in this subject, his anxiety level was low and his confidence in mathematics did not change negatively or positively.

S4: *"... that Indian man was so smart I could not be as smart as he is. Mathematics is a piece of a cake for him, but it is difficult for me..."*

When S4's opinions were examined, he decided that characters in movies could make mathematics because they were very smart and he believed that he could not make mathematics because he was not smart as much as characters were.

S8: *"... Four mathematicians gathered and were trying to solve the questions, how could I do..."*

It is seen that S8 thought mathematics was very hard because even the characters in the movies failed although they were very smart. He stated that his self-confidence in being successful in mathematics decreased.

S2: *"...I have to understand if the walls are shrinking..."*

In application, the second movie named Fermat's Room was displayed. In the movie, four mathematicians remain closed in a room and they are requested to solve interesting math problems, sent them by an unknown person, at a certain time. When the time is up, the walls of the room move and the room narrows. Mathematicians argue about who this mysterious person is and try to solve the given problems cooperatively. S2 stated that he had to overcome mathematics when he had to.

4.2. Necessity of Mathematics

According to the content analysis of the obtained data, five codes were created under the category of "Necessity of Mathematics". Those codes and their frequencies are presented in Table 2.

Table 2. Codes and frequencies determined under the category of necessity of mathematics

Category	Codes	Frequencies (f)
Necessity of Mathematics	For inventions	1
	Social admiration	7
	Saving lives	1
	Use in real life	3
	Unnecessary	1
	Total	13

Almost all of the students stated that their opinions about the necessity of mathematics changed positively. One student stated that their opinions about the necessity of mathematics did not change and it is still unnecessary for him. When the codes created under the category of "Self-confidence in Mathematics" presented in Table 2 are examined, it is seen that most of the participants stated that if they were successful in mathematics, their "social admiration" by society would increase. Three participants stated that mathematics can be "used in real life". One student stated that mathematics can be used "for inventions" and one stated that mathematics can be used in "saving lives". Some verbatim quotations and interpretations about the quotations regarding the category are given below.

S3: *"Mathematics was a lesson which is meaningless for me and I learned it only to get good grades in school. My thoughts about mathematics became better after this movie. I had never thought mathematics could save lives..."*

It is noteworthy that S3 stated, "Mathematics was a lesson which is meaningless for me and I learned it only to get good grades in school". It is seen that after the application, he started to ascribe different meanings to mathematics and he understood that his life could change through mathematics.

S8: *"... In the movie (The Man Who Knew Infinity) which the room narrows, the man who made the popcorn machine could invent the device because he is a mathematician. Mathematics is used even in this. "*

S8 stated that it was very interesting to use mathematics even for making new inventions.

S1: *"You can be held in esteem due to your mathematic ability even if you are from another continent and have not any features. This is very interesting because I never thought that math would bring such a benefit."*

S1 stated that he thinks that his position in social life can change via mathematics.

S3: *"A man can take mathematics away to the far end of the world. He was even exposed to discrimination because he is Indian and his religion was different, but he showed that he was a good mathematician at the end, and he was accepted..."*

It is noteworthy that S3 deduced that mathematics can gather people from different cultures, religions, and nationalities and that it can make positive changes in social life through the mathematical power acquired. He stated that these situations had a positive effect on his thoughts about mathematics.

S7: *"In the second film (Fermat's Room), I saw interesting and difficult problems with the use of Mathematics in daily life, and I saw that their solutions are related to daily life too..."*

In S7's mind, math problems are no longer abstract and he understands that they are in the flow of life. Unlike other participants, S4 stated that his thoughts on the necessity of mathematics did not change.

S4: *"Mathematics is still an unnecessary lesson for me. I think it is not necessary for my life..."*

4.3. Ways to be Successful in Mathematics

According to the content analysis of the obtained data, six codes were created under the category of "Ways to be Successful in Mathematics". Those codes and their frequencies are presented in Table 3.

Table 3. Codes and frequencies determined under the category of ways to be successful in mathematics

Category	Codes	Frequencies (f)
Ways to be Successful in Mathematics	Cooperative working	1
	Formal education	4
	Being clever	3
	Understanding the problem	1
	Study	2
	No inference	4
	Total	15

As a result of the semi-structured interviews, eight students stated that they found new ways to be successful in mathematics. The remaining four, on the other hand, could not make inferences from the films to be successful in mathematics. When the codes created under the category of "Ways to be Successful in Mathematics" presented in Table 3 were examined, it was understood that four participants believed that they need a "formal education" at school for being successful in mathematics. Three of them stated that "being clever" is the only way of being successful, two of them believed they could achieve success by "studying". Some verbatim quotations and interpretations about the quotations are given below.

S1: *"Before watching the first movie (The Man Who Knew Infinity), I had thought that to deal with mathematics, intelligence is enough. I figured out that I am too clever by half. I learned that the study is important and I need to listen to the lessons better to understand mathematics."*

S7: *"...The first movie was a bit boring, and it was ridiculous. No one can learn mathematics on their own without school."*

Interestingly, S1 stated that only intelligence is not enough to do mathematics and that he learned the necessity of listening to the teacher and studying. In the movie, The Man Who Knew Infinity, Srinivasa Ramanujan, a famous Indian mathematician, is accepted to Cambridge University with the invitation of a famous mathematician Godfrey Hardy. Hardy met Ramanujan who came to England, is very impressed by this genius man who is unaware of even the simplest modern proof concepts. However, after Hardy stated that Ramanujan should take a formal mathematics education and their discussions on this subject, it was observed that the student was impressed by Ramanujan's education process and his continuous working on his room every evening and he made the conclusion that only the intelligence, without getting a formal education, would not be enough for being successful in mathematics. Also, S7 believes that people cannot learn mathematics on their own and need a formal education.

S2: *"... I can't understand the problems. I can solve it if someone tells me, I find it difficult to understand by myself. That's why I have got in my stomach when I see a problem. It seems it is easy to understand. If you do not understand it, you cannot solve it. ... I started to enjoy solving problems."*

S2 stated that he had difficulty in understanding the problem, which is the first of the problem-solving steps. Therefore, he stated that he developed a negative attitude towards problems. However, this negative attitude that he developed has evolved positively after the movie.

S1: *"Intelligence is required to be successful in mathematics. That's why I must be gifted that's the only way."*

S1 believes that his math ability cannot be improved. It must be innate or requires high intelligence.

S4: *"...they solved those difficult problems by working together. The way to success may be through working together. I can do the same with my friends from my class..."*

S4 stated that he could be successful in mathematics by working in collaboration with his classmates.

4.4. Math Anxiety

As a result of the data analysis collected through semi-structured interviews, three codes were created under the category of "Math Anxiety". The codes and the frequencies of this category are given in Table 4.

Table 4. Codes and frequencies determined under the category of math anxiety

Category	Codes	Frequencies (f)
Math Anxiety	Decreased	7
	Increased	2
	Did not changed	3
	Total	12

In the analysis of the codes created under the category of "Math Anxiety" given in Table 4, it was seen that the students could not reach a consensus on math anxiety. Seven of the students who participated in the interview stated that their math anxiety "decreased", three of them "did not change" their opinions, and two of them were more concerned. Some verbatim quotations and interpretations about the quotations are given below.

S7: *"I can solve mathematics but I used to fear if I make a mistake. I did not want to give my paper without checking the operations twice or three times in the exams. I solve twice the questions even if I am sure. It is not necessary to push myself too much. It's not the end of the world (laughs). So you have to be a little relaxed."*

S7 stated that he was constantly concerned that he had made a mistake, even when he was certain of the accuracy of the solution in mathematics exams and check the solutions recurrently, but his anxiety about making mistakes decreased.

S4: “... I scared more of mathematics after the movie. But I was surprised that mathematics was interesting enough to be the subject of movies.”

S8: "Man in the movie (The Man Who Knew Infinity) which took in old time was super intelligent, even he could not solve somethings, I could never solve. Four mathematicians gathered and were trying to solve the questions, how could I do? Even if you did not explain, I would not even understand the questions. I am not good at this subject..."

When S4’s and S8’s opinions were examined, they decided that characters in movies could do mathematics because they were very smart and he believed that he could not do mathematics because he was not as smart as the characters were and his self-confidence in mathematics decreased.

S1: "I have never afraid of mathematics... Movies did not generate fear or concern in me. Mathematics is still a joyful and easy lesson for me”

It was observed that S1 loved mathematics before the application and due to his self-confidence in this subject, his anxiety level is low.

4.5. Fun

As a result of the analysis of the opinions of participants, four codes were created under the category of “Fun”. Those codes and their frequencies are presented in Table 5.

Table 5. Codes and frequencies determined under the category of fun

Category	Codes	Frequencies (f)
Fun	Fun classroom activity	12
	Love my teacher more	2
	Chat about movies	4
	Mathematicians are interesting	3
	Total	21

All of the participants stated that they found the application fun. Four participants stated that they liked “chatting about movies” with their friends, three participants found “mathematicians interesting” and two of them stated they “love their mathematics teacher more” now. Some of the verbatim quotations from the answers of some students about the category and interpretation of these quotations are given below.

S10: “As I watch such kind of movies, I think my interest in mathematics will increase. They do not show movies in lessons, if we watch such kinds of movies occasionally that would be great...”

S1: “...We also did not waste our time and solved so many problems with our teacher. I love my teacher more now. Why are these movies not being broadcast on television?”

S10, who finds the movies attractive, believes that math-themed movies increase his interest in mathematics and want to watch such movies in school and at home. Similarly, S1 stated that watching movies were fun and his relationship with his mathematics teacher was strengthened.

S9: “Movies, which are relevant to the lesson and have an exciting scenario, make lessons beautiful and funny. But at the end of the movies, my ideas about mathematics did not change much. ”

S9 stated that he liked the films but did not affect the ideas about mathematics.

S7: “... the second movie endeared me math more. The movie tells how mathematics can sometimes save lives. Mathematicians are interesting human beings. I would like to watch this movie again...”

S7 stated that Fermat’s Room has endeared mathematics to him. Action, tension, and mystery in the movie attracted student’s attention. The heroes of the second movie are saved from a difficult situation by using mathematics. It is thought that this situation may have contributed to S7’s positive attitude towards mathematics. The first film was boring for the student, and it was not convincing for him that Ramanujan became skilled by himself in mathematics.

S2: “From now on, I want to watch movies like that in lessons because it was fun, and it was also fun to solve the questions in the movie and it was also nice to chat with my friends about the movies...”

Considering the S2’s views above, he stated that he felt a high level of anxiety when faced with the problem since he had difficulty in understanding the problems. However, he stated that after the movies he started to believe that he could overcome this anxiety. Also, he enjoyed chatting about films with his friends.

5. Discussion & Conclusion

The results of the study revealing the opinions of students on watching math-themed movies presented under five categories and shown in Figure 2.

- (1) Self-confidence in Mathematics
- (2) Necessity of Mathematics
- (3) Ways to be Successful in Mathematics
- (4) Math Anxiety
- (5) Fun

The effect of the movies can affect the beliefs and attitudes of the audiences (Aquino et al. 2011; Cox, 2010; Landis et al. 2009; Schnall & Roper, 2012). Similarly, the findings of this study showed that math-themed movies can have a positive effect on students' beliefs, emotions, attitudes towards mathematics, and math anxiety. This effect is similar to the results of Kaşkaya et al. (2011) study. Besides, the effects of drama (Sözer, 2006; Kayhan, 2012), music (Beer, 2008; Ayotola & Adedeji, 2009; Tezer & Kıvanç, 2012) and visual arts (Granger, 2000; Özder, 2008), on attitudes towards mathematics and math anxiety are known. Also, it can be said that the seventh art (cinema), has a similar effect.

According to the analyzes of the semi-structured interviews, ten of the participants' beliefs on being successful in mathematics were strengthened. Two of the participants stated that their self-confidence about mathematics decreased, almost all of the students' opinions about the necessity of mathematics changed positively. Besides, eight students found new ways to be successful in mathematics. The remaining four, on the other hand, could not make inferences from the movies to be successful in mathematics. Seven of the students who participated in the interviews stated that their math anxiety changed positively, three of them did not change their opinions, and two of them were more concerned. The main reason for this concern seems to be the high intelligence levels of the characters in the movies. So, the students started to think that they can not be successful in mathematics due to their intelligence levels. Nevertheless, as it is seen this intervention can be a promising way to decrease math anxiety. All of the participants stated that they found the application fun and enjoyed watching math-themed movies.

Considering the statements of participants, it is clear that the movies provided a positive “cinematic elevation” (Algoe & Haidt, 2009; Niemiec, 2012) for the students because of the cinematic admiration they experienced. Similarly, Kaşkaya et al. (2011) found that educational movies affected teacher candidates' attitudes towards the teaching profession and their perceived self-efficacy positively. The students were fascinated by the mathematical power of the characters in the movies and this positively influenced their beliefs, emotions, attitudes towards mathematics and, math anxiety. According to Singhal and Rogers (2002) movies are very effective way to develop positive behavior and attitude. In addition to the findings obtained above, watching math-themed movies in the classroom has created a fun environment in the classroom and has become an activity that all students enjoy. Discussing with their teachers about mathematical concepts and problems that they do not understand has increased the students' interest in mathematics.

Based on the statements of the participants, it was understood that this intervention positively affected students' attitudes to the course and their relations with their teacher. It is also understood that for many of the students, mathematics has become a fun lesson that is used in everyday life rather than a collection of difficult to understand symbols and processes. In addition, the images of the students about mathematicians are cold, inaccessible genius were changed, and they began to show a more sympathetic attitude towards mathematicians. According to Zillman's (1988) concept of mood management, movies can promote long-term impact and eventual behavioral changes. It is thought to be positive that such activities should be included in the annual plans or organized as an activity by the mathematics clubs to be established in schools.

For the process, the researchers examined ten different movies and two of them were chosen. The necessary permissions of movies were obtained from their distributors in Turkey and movies were montaged in line with two expert's opinions due to concern that movies may harm children's personal development. This situation makes difficult the implementation of such an activity. The movies that were accessed by researchers are not suitable for all age groups. It is thought to be positive that determination of this kind of suitable movies examining by Ministry of National Education (MEB) and in case there is not any suitable movies, making this kind of movies by the cooperation of Ministry of Culture and Turkish Radio and Television Association (TRT) and shown to the students via EBA (Educational Informatics Network).

The results of the research should be considered within the limitations of the study. Due to the length of the intervention and execution of the research in the active academic year, the intervention was limited by two films. Considering the results and limitations of the study, the following recommendations have been developed for researchers, educators, and policymakers;

The research was conducted on only one grade and gender. However, further studies may focus on different grades and genders. Besides, quantitative studies can be done to measure this change. Similar studies can be conducted to examine the effects of watching math-themed movies on different emotional dimensions of mathematics education, and similar studies can be carried out for other courses.

Attitudes of the students towards mathematics and math anxiety can be positively changed by showing math-themed movies at the beginning of the school year. Including such activities in annual plans or organizing them as an activity by the math clubs to be established in schools is thought to have positive effects.

This kind of math-themed movies can be shot with the cooperation of the Ministry of National Education, Ministry of Culture, and TRT (Turkish Radio and Television Association) and shown to the students via EBA (Educational Informatics Network).

In this paper, watching math-themed movies as a promising, novel and, practical way is introduced for increasing positive beliefs, emotions, and attitudes towards mathematics and decreasing math anxiety.

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