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Using Popular Films in History of Mathematics Courses: Reflections from Prospective Mathematics Teachers

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Abstract

This article examines the reflections of prospective mathematics teachers about the use of popular films in a history of mathematics course. Three films are used in the course are Agora, The Man Who Knew Infinity and A Beautiful Mind, describing mathematicians' experiences and struggles in different historical moments. Following the completion of the course, twelve prospective middle school mathematics teachers voluntarily participate in the face-to-face semi-structured interviews. According to the results, popular films are inspirational for prospective mathematics teachers to pursue further mathematical studies and the stories in the films are influential while making future decisions. For prospective mathematics teachers, popular films are also helpful to put mathematicians in context in which their life styles and experiences become more visible. Despite the benefits of watching mathematicians in the films, prospective mathematics teachers reflect on the fact that popular films are coming from a profit-driven sector and they reflect on how the commercial purposes can limit a full comprehension of mathematicians' lives. In the light of the findings, popular films are recommended as productive instructional materials in mathematics teacher education courses while there is a need to reflect on the commercial purposes and disadvantages.

Keywords: History of Mathematics, Mathematics Teacher Education, Mathematicians in History, Popular Films

Introduction

History of Mathematics [HoM] is gained an increased attention by mathematics teacher education research. HoM can provide various learning opportunities for prospective mathematics teachers [PMT] such as providing a historical background for mathematics, promoting PMTs' pedagogical reflection on mathematical concepts and improving their beliefs and attitudes towards teaching mathematics (Furinghetti, 2007). Experiencing the historical construction of mathematics can bring an awareness to the contextual aspects of doing mathematics (Fauvel, 1991) and can enable a consideration of mathematics as an evolving body of knowledge rather than irrefutable and eternal truths (Barbin, 2000). Therefore, several mathematics teacher education programs consider HoM as an elective or required course for prospective teachers in addition to content courses.

There are different purposes of using HoM in mathematics education (Jankvist, 2009). The first one is using HoM as a tool to develop teaching and learning mathematics. HoM as a tool can be considered as an instructional pedagogy for school mathematics. Second, HoM can also be the goal. HoM as a goal focuses on "the development of mathematics in a scientific, technological or societal context of a given time and place" (Jankvist, 2009, p. 252). In this study, HoM is not only considered as a pedagogical tool to improve mathematical knowledge or attitude but also as a goal for PMTs, since the primary focus of the course is to learn historical development of mathematical knowledge. In the sense of HoM-as-a-goal, mathematics history provides an avenue for PMTs to encounter the multiple ways of development of mathematical knowledge by showing mathematicians' actual struggles in approaching and solving the problems (Liu, 2003).

As argued in the HoM literature, visual aids can be one of the ways to learn mathematics history (Fauvel & van Maanen, 2000). Specifically, popular films have the potential to provide an avenue for prospective teachers to explore the struggles and actual experiences of mathematicians in different periods and locations as a way to study the humanistic facet of mathematics history and development of mathematical knowledge. Popular films might be counted as alternatives to the instructional strategies to teach mathematics history such as lecturing, reading or presenting the historical materials. Historical development of mathematical knowledge can be learned and studied through watching popular films that reflect experiences, struggles, and

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opportunities of mathematicians across the history. This paper examines the views of PMTs on the use of popular films as an alternative instructional material in a HoM course that is offered in a mathematics teacher education program in Turkey.

The studies that are relevant to HoM in mathematics teacher education generally focus on improving mathematical knowledge that prospective teachers are going to teach (Arcavi et al., 1987; Clark, 2012; Jankvist et al., 2020; Mersin & Durmuş, 2021), developing positive attitudes, motivation and beliefs towards mathematics (Furinghetti, 2007; Phillippou & Christou, 1998; Zengin, 2018), and providing instructional materials, pedagogical tools, and techniques for teaching mathematics (Jankvist, 2009). A meta-analysis of the HoM literature reveals that the empirical research in mathematics teacher education programs mainly investigates the reflections of PMTs in terms of using HoM as a pedagogical tool to improve their future mathematics teaching practices (Baki & Bütüner, 2018). The overarching trend of the research is that prospective teachers are generally show positive attitude towards using HoM when they become future mathematics teachers (Alpaslan et al., 2014; Dündar & Çakıroğlu, 2014, Sullivan, 2000; Yenilmez, 2011). This indicates that prospective teachers are open to learn HoM and to gain experience in the integration of it into their pedagogical repertoire to improve learning opportunities for their future students (Burns, 2010).

According to Fauvel and van Maanen (2000), there are several ways of using HoM in mathematics education to benefit from learning historical development of mathematical knowledge and they suggest a variety of ways of using HoM through historical anecdotes, primary sources, historical problems, play, and visual materials, including films. However, the review of empirical studies in the context of HoM indicates that small historical anecdotes and mathematical activities are the most commonly used instructional sources and there is a need to find alternative materials (Baki & Bütüner, 2018). To fill that void, popular films about mathematics history are used in the HoM course.

In the literature, one of the productive instructional tools in teacher education courses are popular films are considered as productive tools in teacher education programs, which can increase engagement and critical reflection about the topics of interest when connected conceptually to the content of the courses (Bluestone, 2000; Tan, 2006). For instance, education-themed films can allow prospective teachers to move into worlds of schooling and to analyze the contextual elements in educational situations (Fennell, 2013). Studies report that practicing or prospective teachers consider films are effective tools to concretize abstract historical ideas (Kaya & Günal, 2015), to explore the daily use of science and the role of families in learning science (Güven Yıldırım et al., 2015), and to learn Turkish as a second language by engaging with the dialogues, mimics and affective dimension of the conversations (İşcan & Karagöz, 2016). Similarly, in mathematics education, films can provide a space to encounter the life of mathematicians with attention to the cultural and historical context that they lived and worked in, rather than presenting static images of mathematicians.

Education-themed movies are well-known instructional materials in teacher education. Films are useful to increase academic motivation and develop positive attitudes towards teaching such as building love, value and harmony with students (Kontaş, 2016). In classroom management courses, movies are perceived as beneficial to represent practical situations in addition to the theoretical knowledge (Tofur, 2018). To explore advanced social concepts such as social and cultural habitus of a society, films are considered as bridges to connect theory and practice (Trier, 2002). Films can challenge prospective teachers' beliefs and values about teaching in schools that are different from their own environments by raising points of reflection about learning and teaching and issues in diverse educational communities (Grant, 2002).

Trier (2002) noted that watching popular films to analyze educational concepts or to engage with the content of the course is not without any resistance. That is, although using popular films in teacher education courses is a productive avenue to learn the content, prospective teachers can respond in negative ways when they have no interest in the film or the topic. Further, when films play on the prospective teachers' emotions, the film and its message can be misread. This might undermine the critical reflection that is aimed by the teacher educator (Giroux, 1993) and reproduce naïve beliefs about teaching in urban schools (Grant, 2002). Despite these potential pitfalls of using films, English and Steffy (1997) argued that through watching films, it becomes possible to observe nonverbal discourses such as body language, facial expressions and mimics. That is, films are considered as valuable teaching materials that provide contextual views of the issue that they address. When the content is explored through the life of a film character, it becomes more concrete and relevant to the students (Gregg et al., 1995). If appropriately chosen, films are useful instructional materials for the prospective teachers to reflect and think deeply on an issue (Tan, 2006).

Given the calls and cautions regarding the use of popular films in teacher education and the lack of related research in mathematics teacher education, it is significant to do additional research in different contexts and with different participants. Movies about mathematicians can provide opportunities for PMTs to enter the world of mathematics history. During the course, these three films, which are explained in detail in the methods

section of this article, are discussed as reflective of mathematicians' life stories, chances and barriers in various contexts and in different historical moments. Rather than presenting static images of mathematicians, films can provide a space to encounter with the life of mathematicians with an attention to the cultural and historical context that they did live and work.

The purpose of this article is to explore the reflections of prospective teachers about using popular films in a HoM course. As the review of teacher education literature indicates, films are considered useful materials in teacher education courses. However, there is a lack of research that examines the role of popular films in HoM courses. The empirical research on HoM in mathematics teacher education mainly focuses on the affective aspects on learning mathematics history or inclination to use mathematics history in future teaching (Furinghetti, 2007; Phillippou & Christou, 1998). Another line of HoM research focuses on the development of mathematical knowledge through learning mathematics history (Clark, 2019; Mersin & Durmuş, 2021). These studies rarely attend to the instructional tools to teach mathematics history. One exception is the use of GeoGebra in a HoM course, where prospective teachers report their conceptual learning of mathematics (Zengin, 2018). In addition to this, incorporating popular films into the HoM courses is considered as one of the ways of learning the historical development of mathematical knowledge together with mathematicians' experiences while pursuing their mathematical works. The reflections provided by PMTs give insights regarding how to teach HoM courses effectively in mathematics teacher education programs.

Given there is a scarcity of research that investigates the role of using popular movies in mathematics teacher education, this study aims to contribute to the HoM scholarship with its particular focus on the humanistic facets of doing mathematics in different historical settings: Following research question is asked:

- What are the views of prospective mathematics teachers about using popular films about the life of mathematicians in history of mathematics courses?

Method

Research Design

To respond to the research question of this paper, case study design was used. The fundamental goal of case study research was to explore how people interpret and make sense of their experiences in a bounded environment (Creswell, 2013). It provided both descriptive and interpretive accounts on how people reflect on an issue or a course of action. Since the aim of this paper was to examine the reflections of PMTs about using popular films in the HoM course and it studies shared experiences of multiple individuals for a particular program, case study was chosen as a suitable design, which thematically uncovered how individuals make meaning of an issue based on their perspectives.

Participants and Context

Participants were 12 prospective mathematics teachers [PMTs] who completed an elective history of mathematics course at a large public research university in Turkey. There were nine females and three males. All participants were in mathematics education degree program for middle schools at bachelor's level. Five of them were in their third year and seven of them in the fourth year. Their ages ranged between 20 and 22. Purposive sampling method was used. The criterion for selecting the participants is the completion of HoM course and its requirements. The reason for choosing these PMTs was that they took this elective HoM course, watched the target films as their course requirements, and volunteered to participate in the study.

History of Mathematics Course and the Selection of Popular Films

The content of HoM course included the mathematical knowledge from Ancient Egypt, Ancient Greeks, Mesopotamia, India and Far East countries as well as the works of mathematicians from the Islamic world such as Al-Khwarizmi and Khayyam among others and their impact on the development of Modern Mathematics. The aim of the course is determined as learning the historical development of mathematical concepts across different periods and locations (Higher Education Council [HEC], 2007).

To explore the contextual elements in the life of mathematicians and the humanistic aspects of mathematical knowledge construction processes, three popular films were used as an instructional material. The movies were *Agora*, directed by Alejandro Amenábar (Bovaira & Augustin, 2009), *The Man Who Knew Infinity*, directed by Matthew Brown (Pressman et al., 2015) and *A Beautiful Mind*, directed by Ron Howard (Grazer & Howard, 2001). Agora narrated the life of Hypatia, a woman mathematician, astronomer and philosopher in the fourth century East Roman Empire. The movie focused on the struggles of Hypatia as a woman and her dedication to contribute mathematical knowledge. The Man Who Knew Infinity described the life of an Indian mathematician Srinivasa Ramanujan and his travel to Cambridge University. His mathematical successes despite the social and cultural challenges he faced in the university were portrayed in the film. A Beautiful Mind

was based on the life of an American mathematician, John Nash, who was having difficulties to distinguish between the reality and the fiction and who was also the winner of the Nobel Prize for his unpredictable work on game theory. The story in the film was built upon his struggles both as a mathematician trying to do novel work and as a one who was experiencing mental difficulties.

These three films were selected due to the in depth portrayal of mathematicians' lives, their experiences and challenges in different historical contexts. There are certainly other films that could be related to mathematics history. Popularity is referred as being the product of popular culture. The chosen films did not have to be well-known or top-rated movies. Rather, popularity indicated the wide range of availability and suited to the taste of the general public. These three films were chosen for their portrayal of mathematicians' lives, their experiences, and challenges in different historical contexts.

As suggested by Demircioğlu (2007), worksheets were distributed prior to watching films. In these worksheets, a set of prompt questions was provided for PMTs so that they could focus on the social and situational aspects of mathematical developments of the given historical period. *The examples of these questions are: What were the advantages and disadvantages of Hypatia being a woman while doing math? Evaluate Ramanujan's experiences during his visit to England in terms of his cultural identity. What were John Nash's observations, thoughts and questions as developing his theorem, known as the "Nash equilibrium" in the movie?* Following PMTs watched movies, they were asked to answer the prompt questions, reflect upon the life of the mathematicians as part of the course requirement. One course session was also devised to discuss the issues that PMTs raised about the movies. Since PMTs were assigned to watch three popular films as described above, all in all, three course sessions were allocated for the discussion of the popular films. Nevertheless, PMTs' responses to the questions and discussion sessions were part of the course itself. That is why; these were not included in this study due to ethical considerations.

Data Collection and Analysis

The data of this study was collected through the face-to-face interviews that were conducted with PMTs following they completed the HoM course. Interviews lasted on average 30 minutes, ranging between 25 to 45 minutes. All interviews were audiotaped and then transcribed. The interview questions included how PMTs made meaning of popular films that were about different mathematicians. Further, during these interview sessions, the experiences of mathematicians as humans were unpacked by asking specific questions about the storylines of mathematicians in the films. The overall aim of interviews was to understand how PMTs reflected on the use of popular films in their HoM course. Sample interview questions included: *What are the advantages and disadvantages of watching popular films in HoM courses? How do you think about using popular films in HoM courses? How do popular films help you to learn about mathematics history and the lives of mathematicians?*

Each interview was transcribed verbatim. In basic qualitative research, data analysis consisted of identification of the recurring patterns and themes (Merriam, 2009). In order to find those recurring themes, inductive methods were used for data analysis (Corbin & Strauss, 2008). As the use of popular movies in HoM courses was very rare in the literature, the participants' own words and statements were used to develop codes through open coding (Saldaña, 2013). When deciding the parts of transcripts to code, the analytic focus was given on the instances that PMTs talked about the contextual elements of mathematicians' biographies, advantages and disadvantages of using movies in HoM courses. The coding process gave an initial list of codes such as "inspirational", "struggling as a woman" and "profit-driven industry". Following the coding of each interview, the data were further reviewed to refine codes. Initial codes and corresponding passages were analyzed to generate umbrella themes using constant comparison method (Corbin & Strauss, 2008). For example, initial codes based on participants' own words such as "social and cultural conditions of mathematicians", "cultural difficulties experienced while conducting mathematical work" and "struggling as a woman" were brought together under the umbrella theme, "putting mathematicians in context". These themes were presented in the findings section. To ensure the credibility of the findings, rich descriptive accounts of PMTs were provided. Before presenting the results, coded passages of PMTs were translated into English by the author of this article. PMTs' reflections on the use of popular films were narrated in the themes presented in the findings section.

Results

The purpose of this research was to investigate PMTs' reflections on the use of popular films in HoM courses. According to the analysis, their opinions were concentrated around four main themes. First, popular films were seen as inspirational for doing mathematics and influential in making future decisions. Second, for PMTs, films were helpful materials to put mathematicians in context and to learn the social circumstances of the time. Third, PMTs reflected on the advantages and disadvantages of the use of popular films as an instructional material.

Last, PMTs also identified the possible dangers of the film industry and the limitations of movie plot to learn mathematics history. Each of the findings is presented below with quotations from PMTs under the following themes.

Popular Films as Inspirational for Doing Mathematics

The first theme that emerged from the reflections of PMTs was the perception of the popular films as inspirational for doing and pursuing mathematical work. According to them, the films were stimulating their attention towards the cumulative development of mathematical knowledge, which required an effort. As PMT3 commented:

> *All of the films inspired me, not just mathematics but I again remembered that if I try to do something in any situation, I have to struggle to overcome it. Success is not easy. After every movie, I realized that nothing is easy to obtain. And, in order to do mathematics even one needs to refute the theorems, it is necessary to proceed in cumulatively, based on the theorems in the past (PMT3).*

Despite the obstacles that mathematicians face throughout their life, their successes in mathematics were encouraging. Mathematicians' works in the films were understood by the PMTs in a broader sense such as doing mathematics and contributing mathematical knowledge base. Films inspired PMTs about the perseverance of mathematicians who never gave up working, solving mathematical problems of their time and conducting mathematical research. Below, PMT5 expressed how the movie was effective for them to see that mathematicians in the films never gave up:

> *They [mathematicians] went through a lot thing, but still didn't give up. For example, I would give up. There were many occasions in the films where I thought I could give up. They never gave up. If I were Ramanujan, I would say if my health is getting worse and I would leave. If I were like the one in A Beautiful Mind, I would also leave mentioning my mental issues. I could not overcome it. It really impressed me that they didn't give up. It is very nice not to give up (PMT5).*

The perseverance of mathematicians was influential for PMTs in terms of their own mathematics courses as well as their foregrounding of future mathematics teaching. As PMT5 continued and PMT7 added:

> *I love watching movies anyway. When they are about mathematics and so, they are more interesting for me, I watched the movies with pleasure and wrote my thoughts in full [in the assignments]. As I watched the lives of scientists, my ambition in classes increased and I decided to do as best as I could do for my students in teaching mathematics (PMT5).*

> *The movies impressed me very much. The hero of each movie has a distinct adventure, a distinct struggle. Their goals were common, that was to work for the development in science (PMT7).*

PMTs reflections reveal the appreciation of the work of mathematicians and even as examples of hard work and perseverance. In addition to learning about the life of the mathematicians in different historical moments, PMTs reflected on the ways in which popular films contributed to their personal lives and decisions for future.

Popular Films as Putting Mathematicians in Context

PMTs generally expressed that popular films were helpful to understand the social and cultural circumstances of the time. PMTs were able to put mathematicians in context and they understood the works of mathematicians as inclusive of both mathematics itself and also their living conditions. Below quotations reveal how PMTs described mathematicians' living conditions in detail:

> *The greatest common feature of the mathematicians in the films is that they took big steps for mathematics as they dealt with social, religious, and health-related problems during the period they lived. If we look in detail, they are all faced with the prejudices such as Hypatia being a woman, Ramanujan being an Indian, John Nash being an introvert. At first glance, other people think that they cannot do anything for science and so these people do not help their work (PMT3).*

> *Also, it was good for me to evaluate the historical conditions of the periods where mathematics was developed (PMT10).*

> *Hypatia stood firm against war, religious complexities, and the male scientists of the time. She did not give up her purpose. Ramanujan also tried and succeeded in doing science in an environment where religion and racial discrimination were made. John Nash was not defeated despite the games his own brain played on him, and he struggled hard to complete his work (PMT3).*

Furthermore, popular films about mathematicians enabled PMTs to understand humanistic aspects of mathematical knowledge construction in diverse situations. PMTs commented on the experiences and difficulties of mathematicians while they were doing and contributing to mathematics in the following excerpts.

> *For example, when we watch the movies, Hypatia is really in a very difficult situation within their social and cultural environment. It was an unforgettable thing. In their perspective, there was a mandatory female profile that society imposed on her. And there were situations such as not being able to do it and move forward. But despite that, she was able to succeed (PMT9).*

> *He [Ramanujan] had to go to another country from his homeland. Although his family did not want it, he still went and continued his studies there (PMT8).*

For PMTs, using popular films was valuable to unpack mathematicians' struggles and challenges that they faced. After watching the movies, PMTs were able to empathize with the mathematicians and think about their mathematical success together with their social identities such as being a woman or an Indian. Several PMTs commented on the racial and gendered identities of mathematicians as they were in the process of mathematical knowledge development.

> *After watching the movie, for example… my view of women mathematicians… or I learned that they too can achieve a lot of success or they might have obstacles for different reasons (PMT2).*

> *I think the films were very valuable, as they allowed us to observe the lives, difficulties, ways of thinking and efforts of many mathematicians such as Ramanujan and Hypatia. As a prospective mathematics teacher, I think it enables us to live and think like a mathematician, or to be able to put ourselves in their place (PMT9).*

> *Again, they deal with many difficulties. Especially for Hypatia, for example, it is thought that the only job of women at that time was being a housewife, having children and cleaning the house. For example, she was treated as if ungodly because she was dealing with it [mathematics]. But she continued to work without paying attention to any such things, she was working day and night. She finally achieved the success she wanted. In addition, Ramanujan also left his family back and went to work (PMT11).*

Here, it is important to note that films compared to other tools to learn mathematics history seemed to be more influential for PMTs, particularly because they provided the situated narratives for the mathematical knowledge making processes. The visual narratives were important vehicles to put the life of mathematicians in the history in context.

Popular Films as Instructional Materials to Learn Mathematics History

PMTs mentioned the advantages of using popular films as an instructional material in HoM courses. For them, in general, watching popular films was an effective method of teaching and learning mathematics history, as the movies were interesting, stimulating and beneficial for meaningful understanding. PMT5 and PMT10 expressed their interest in not only watching for themselves but also using the films for their future students when they become mathematics teachers:

> *I definitely think that popular films need to be part of the mathematics history course. If there is a movie suitable for me, if I have time in my school when I become a teacher, I consider using movies. Because in movies you know a lot… it may be because I like it very much, but I also think that it contributed a lot, understanding the general view of those scientists (PMT5).*

> *First, I can easily attract my students to the class. They [students] become curious. Numerical operations usually do not catch the attentions of students. That… talking about those narrative parts… would probably attract my future students (PMT10).*

Furthermore, PMTs compared the use of popular movies with the other approaches such as reading a book or listening to a presentation. PMTs found watching movies was more beneficial for them to learn mathematics history and biographies of mathematicians. Below excerpts indicated how popular films were productive materials for them to learn mathematics history as opposed to other means:

> *Movies are for me, I never forget when I watch them, I always remember. But if we gave presentations, I would really forget [the content] after the presentation. The movie is a little more visual… the presentation is also visual... but the movie appeals more to our feelings. There is a connection. We give something in the presentation, then we pass, we cannot make a connection (PMT5).*

After all, we could read and learn this information from the book, but we try to understand it both by watching and hearing in the film. At least, it is more permanent and I think it is good with respect to getting our attention (PMT8).

I can say that it is more permanent by watching such movies rather than reading the life story by searching it (PMT9).

Besides the advantages, PMTs also mentioned the disadvantages of using popular films as an instructional material. Foregrounding with their future teaching, PMTs were cautious about movies that could be misread by the audience and be frightening for children. These two PMTs in the following quotations highlighted the ways in which popular films might have limitations for their future students.

Some parts were difficult even for me to understand. This may confuse my students (PMT3).

Here are the disadvantages. For example, if I tell the life of Ramanujan to students, they will probably see that a mathematician has not actually made a success in easy ways. So, it might sound a little scary to them (PMT10).

To summarize, PMTs generally think that using popular films in HoM course is an effective and productive instructional source that stimulates their interest in the lives of mathematicians and their knowledge about the contextual elements in mathematicians' lives. Nevertheless, PMTs note that using popular films can be inadequate for especially young age individuals.

Dangers of Film Industry

PMTs reflected on the film industry while expressing their views about the use of popular films in HOM courses. They were aware of the fact that popular films are the objects of a commercial sector. Also, selection of mathematicians for the films could be made in terms of its profit for the sector. PMT1 and PMT10 explained the dangers of commercial purposes in detail:

In order to make the movie, these people need to make money in the industry. They want to make money from the movie. They do not really want to publicize their [mathematicians] lives. This is a little bit troubling... There are perhaps much bigger mathematicians whose lives should be publicly visible (PMT1).

For example, Pythagoras has also achieved great success in the field of mathematics, but considering that the film was made for commercial purposes, the difficulties Pythagoras faced in his life may not be interesting enough for the audience and not worth watching. For this reason, producers may want to focus on the lives of people they think will make them a lot of money (PMT10).

In addition to PMTs' views about the popular films as originated in a commercial business, they mentioned the movie plots as dramatizing the biographies of mathematicians in order to catch the attention of the audience and to increase the profits. Some of their reflections on this issue are presented below:

For those who have a movie… the film needs a story. Yes, after all, watching the life of a regular person does not give anyone pleasure. All of them [mathematicians in the films] had difficulties in general. Their lives were not progressing easily by saying "look, I found a theory, oh I accepted it too". There was war, there was a disease, there were religious differences in the life of Hypatia, there were riots related to this and so on (PMT3).

The mathematicians whose films we watch are usually those who have encountered situations that would prevent and restrict them from doing mathematics and still continue to do mathematics without giving up and have achieved great success in the field of mathematics (PMT10).

The reason they are famous is that they have sad stories rather than theories. That's why these people are getting popular. Otherwise, although Cahit Arf is much more successful than them, many people do not even know the name of Cahit Arf. It has to have a sad story. You know ... The film industry should be able to sell that story (PMT1).

These quotes from PMTs indicate that they are aware of the fact that popular films are part of a profit-driven industry, which limits the issues of accuracy for the sake of commercial interests. Instead of unconscious watching of the life of mathematicians in the history as represented by the film producers, PMTs did also exhibit a critical eye on the movies.

Discussion and Conclusion

This study explores the reflections expressed by PMTs about the use of popular films in mathematics history courses. In the HoM course where PMTs watch popular films as part of the requirements, they gain the chance

to learn about the obstacles and opportunities that mathematicians experience in different historical moments. PMTs are generally inspired by the perseverance and hard work of the mathematicians who play in the movies. Popular films serve as an effective instructional tool for PMTs to learn HoM as a goal rather than as a tool to improve mathematics teaching and learning (Jankvist, 2009). Through popular films, PMTs become involved with the humanistic side of doing mathematics as they engage with the life of mathematicians more closely and they are inspired by the particular characteristics as role models. As Fried (2001) notes, one of the reasons for integrating the HoM into mathematics education is providing historical role models for students. Similarly, PMTs consider the mathematicians in the popular films as role models for themselves, especially when they mention their future decisions such as studying mathematics further or doing the best despite the hard conditions of life. In this sense, a popular film can be used to develop a historical awareness of mathematics and the socio-cultural context in which mathematics has been developed (Tzanakis & Arcavi, 2000). These indicate that using popular films about mathematicians is a way to learn the contextual aspects of the historical development of mathematical knowledge.

When HoM attends to the work of mathematicians in the construction of mathematical knowledge, one can recognize the work of others, respect and value different contexts, needs, and purposes, and realize the contribution of each civilization to the field of mathematics (Grugnetti & Rogers, 2000). In this regard, popular films are seen as helpful and effective instruments to learn the social and cultural context in which mathematicians work (Fauvel & van Maanen, 2000) and according to the findings of this study, PMTs seem to agree with this. For PMTs, the minute details as presented in the movies unpack the historical conditions that mathematicians experience. This enables PMTs to recognize the success of mathematicians together with their social identities such as being a woman or an Indian. In contrast to the images of mathematics as cold, abstract and value-free, movies help PMTs to focus on historical development of mathematical knowledge, as negotiated with social and cultural identities of mathematicians. That is, watching popular films of mathematicians who have diverse racial and gendered identities expands PMTs' conceptions of mathematical work together with social circumstances. This expansion can potentially enable an affirmation of social identities and the intricate relationship with doing mathematics.

For PMTs, popular films are productive instructional materials to learn mathematics history. With the help of the movies, they learn about how mathematicians contribute to the body of mathematical knowledge. Through movies, mathematicians' experiences and dynamic ways of reasoning together with their social context are emphasized. Popular films about mathematics history can reveal the actual struggles of human beings in diverse contexts while solving and engaging with mathematical problems. Hence, through the help of the popular films about mathematicians, PMTs conceives the dynamic processes of mathematical knowledge development (Grugnetti & Rogers, 2000).

Further, PMTs compare watching popular films with other instructional approaches in the HoM course. Similar to what is generally found in the literature (English & Steffy, 1997; Kontaş, 2016; Tofur, 2018), PMTs consider popular films are more advantageous for visualizing and narrating the context. Specifically, they have the opportunity to watch mathematicians as actual people as well as their feelings and struggles in solving the problems. As they argue, films as providing long-lasting learning opportunities than the other instructional tools in the HoM course such as presentations of historical periods or reading books about mathematics history.

PMTs also express the use of popular films in their future mathematics teaching. Despite the benefits, PMTs mention that popular films might not be suitable for school-age children. Their tensions are mainly built on their assumptions that the movies could be misread or frightening due to their story plot and contexts consisting of wars, social conflicts and illnesses. Further research is needed to examine the use of popular films in school mathematics and how experienced teachers perceive the suitability of using popular films in mathematics classes for children.

Given these merits of learning historical development of mathematical knowledge and contextual aspect of the mathematicians' lives, PMTs of this study do not watch the films without any critical thought. In the interviews, they comment on the fact that popular films are made in a profit-based industry. Similarly, Kaya and Günal (2015) find that history teachers are also critical about the rating concerns of historical TV series while teaching history. As commercial products, these materials can overwhelmingly dramatize the story or portray a deficient view of the history by only focusing on dramatic stories to gain more audience and so, more profit can be made. Hence, when using popular films or series in teacher education courses, it is important to reflect on how the stories are fictionalized and dramatized for commercial purposes.

As an implication of this study, popular films can be recommended as one of the ways to open up the conversation about who the mathematicians are and how they develop mathematical knowledge in different times and spaces. When used with supportive educational activities, mathematics teacher educators are

encouraged to use popular movies in their mathematics history courses in order to provide contextual insight into the social and cultural aspects of the historical development of mathematical knowledge.

Having said the implications, it is important to note that this study is limited to the participants, the HoM course, and the three films that are used as an instructional material. Therefore, the conclusions above are bounded with this particular study. Further research is needed to explore the use of popular films in HoM and other teacher education courses with additional movies.

References

Alpaslan, M., Işıksal, M., & Haser, Ç. (2014). Pre-service mathematics teachers' knowledge of history of mathematics and their attitudes and beliefs towards using history of mathematics in mathematics education. *Science & Education*, *23*(1), 159-183. https://doi.org/10.1007/s11191-013-9650-1

Arcavi, A., Bruckheimer, M., & Ben-Zvi, R. (1987). History of mathematics for teachers: The case of irrational numbers. *For the Learning of Mathematics, 7*(2), 18-23. https://www.jstor.org/stable/40247891

Baki, A., & Bütüner, S. O. (2018). A meta-synthesis of the studies using history of mathematics in mathematics education. *Hacettepe University Journal of Education, 33*(4), 824-845. https://doi.org/10.16986/huje.2018036911

Barbin, E. (2000). Integrating history: Research perspectives. In J. Fauvel & J. Van Manen (Eds.), *History in mathematics education—The ICMI study* (pp. 63-90). Kluwer Academic.

Bluestone, C. (2000). Feature films as a teaching tool. *College Teaching 48*(4), 141-146.

Bovaira, F. & Augustin, A. (Producers) & Amenábar, A. (Director). (2009). *Agora* [Motion Picture]. Focus Features.

Burns, B. A. (2010). Pre-service teachers' exposure to using the history of mathematics to enhance their teaching of high school mathematics. *Issues in the Undergraduate Mathematics Preparation of School Teachers, 4*, 1-9.

Clark, K. (2012). History of mathematics: Illuminating understanding of school mathematics concepts for prospective mathematics teachers. *Educational Studies in Mathematics, 81*(1), 67–84. https://doi.org/10.1007/s10649-011-9361-y

Clark, K. (2019). History and pedagogy of mathematics in mathematics education: History of the field, the potential of current examples, and directions for the future. In U. T. Jankvist, M. Heuvel-Panhuizen, & M. Veldhuis (Eds.), *Eleventh Congress of the European Society for Research in Mathematics Education* (pp. 29–55). Utrecht University.

Corbin, J., & Strauss, A. L. (2008). *Basics of qualitative research.* Sage.

Creswell, J. W. (2013). *Qualitative inquiry & research design: Choosing among five approaches* (3rd edition). Sage Publications

Demircioğlu, İ. H. (2007). Tarih öğretiminde filmlerin yeri ve önemi [The place and importance of films in history teaching]. *Bilig, 42*, 77-93.

Dündar, S., & Çakıroğlu, M. (2014). Why should the mathematics history be used in mathematics education, *Eğitimde Kuram ve Uygulama*, *10*(2), 522-534. https://dergipark.org.tr/en/pub/eku/issue/5460/74069

English, F., & Steffy, B. (1997). Using film to teach leadership in educational administration. *Educational Administration Quarterly*, *33*(1), 107–115. https://doi.org/10.1177/0013161X97033001006

Fauvel, J. (1991). Using history in mathematics education. *For the Learning of Mathematics, 11*(2), 3-6. https://www.jstor.org/stable/40248010

Fauvel, J., & van Maanen, J. (Eds.). (2000). *History in mathematics education—The ICMI study*. Kluwer Academic.

Fennell, H. (2013). Reel stories of teaching: Film and teacher education. *Action in Teacher Education, 35*(5-6), 445-461. https://doi.org/10.1080/01626620.2013.846762

Fried, M. (2001). Can mathematics education and history of mathematics coexist? *Science & Education, 10*, 391–408. https://doi.org/10.1023/A:1011205014608

Furinghetti, F. (2007). Teacher education through the history of mathematics. *Educational Studies in Mathematics*, *66*(2), 131–143. https://doi.org/10.1007/s10649-006-9070-0

Giroux, H. A. (1993). Reclaiming the social: Pedagogy, resistance, and politics in celluloid culture. *Counterpoints*, *1*, 35-58. https://www.jstor.org/stable/45136431

Grant, P. A. (2002). Using popular films to challenge preservice teachers' beliefs about teaching in urban schools. *Urban Education*, *37*(1), 77-95. https://doi.org/10.1177/0042085902371006

Grazer, B. & Howard, R. (Producers) & Howard, R. (Director). (2001). *A beautiful mind* [Motion Picture]. Universal Pictures.

Gregg, V., Hosley, C., Weng, A., & Montemayor, R. (1995, March). *Using feature film to promote active learning in the college classroom.* Presented at the 9th Annual Conference on Undergraduate Teaching of Psychology: Ideas and Innovations. (Eric Document 389 367).

Grugnetti, L. & Rogers, L. (2000). Philosophical, multicultural and interdisciplinary issues, in J. Favuel & J. Van Manen (Eds.), *History in mathematics education—The ICMI study*, (pp. 39-62), Kluwer Academic.

Güven Yıldırım, E., Köklükaya, A., & Selvi, M. (2015). Öğretim materyali olarak 3-Idiot filmi ile öğretmen adaylarının günlük hayatta fenin kullanımı ve eğitimde aile rolü üzerine görüşlerinin belirlenmesi [Determination of candidate teachers' opinions on science in everyday life and family role in process of education with 3-Idiots movie as a teaching material]. *Trakya Üniversitesi Eğitim Fakültesi Dergisi*, *5*(2), 94-105. https://dergipark.org.tr/en/pub/trkefd/issue/21482/230219

Higher Education Council. (2007). *Eğitim fakültesi öğretmen yetiştirme lisans programları [Education faculty teacher preparation bachelor's programs]*. Retrieved from https://www.yok.gov.tr/Documents/Yayinlar/Yayinlarimiz/egitim-fakultesi-ogretmen-yetistirme-lisans-programlari.pdf

Jankvist, U. T. (2009). A categorization of the ''whys'' and ''hows'' of using history in mathematics education. *Educational Studies in Mathematics*, *71*(3), 235–261. https://doi.org/10.1007/s10649-008-9174-9

Jankvist, U. T., Clark, K. M., & Mosvold, R. (2020). Developing mathematical knowledge for teaching teachers: potentials of history of mathematics in teacher educator training. *Journal of Mathematics Teacher Education*, *23*(3), 311-332. https://doi.org/10.1007/s10857-018-09424-x

İşcan, A., & Karagöz, B. (2016). Yabancı dil olarak Türkçe öğretiminde konuşma becerisi kazandırmada filmlerin kullanımı. [The use of films to help students gain speaking ability in teaching Turkish as a foreign language]. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, *20*(4), 1265-1278. https://dergipark.org.tr/en/pub/ataunisosbil/issue/26966/283397

Kaya, R., & Günal, H. (2015). Tarih öğretmenlerinin muhteşem yüzyıl dizisi özelinde tarih konulu film ve dizilerin öğretimde kullanımına yönelik görüşleri [Views of history teachers on the use of history-themed movies and TV series in teaching in the context of The Magnificent Century]. *Türk Tarih Eğitimi Dergisi*, *4*(1), 1-48. https://doi.org/10.17497/tuhed.185614

Kontaş, H. (2016). The effect of an education-themed movie on the academic motivation of teacher candidates and their attitude towards teaching profession. *Journal of Education and Training Studies*, *4*(6), 93-103. https://doi.org/10.11114/jets.v4i6.1483

Liu, P. (2003). Do teachers' need to incorporate the history of mathematics in their teaching? *Mathematics Teacher*, 96(6), 416-421.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation, (3rd edition)*. Josey-Bass.

Mersin, N., & Durmus, S. (2021). Effects of the enriched history of mathematics course on prospective mathematics teachers. *International Journal of Curriculum and Instruction*, *13*(1), 635-668.

Philippou, G. N., & Christou, C. (1998). The effects of a preparatory mathematics program in changing prospective teachers' attitudes towards mathematics. *Educational Studies in Mathematics*, *35*, 189–206. https://doi.org/10.1023/A:1003030211453

Pressman, E. R., Young, J., & Thomas, J. (Producers) & Brown, M. (Director). (2016). *The man who knew infinity* [Motion Picture]. Warner Bros.

Sullivan, K. M. (2000). *Pre-service secondary mathematics teachers' attitudes about the history of mathematics* (Order No. 1399933). Available from ProQuest Dissertations & Theses Global. (230757606).

Tan, C. (2006). Philosophical reflections from the silver screen: Using films to promote reflection in pre-service teachers. *Reflective Practice, 7*(4), 483-497. https://doi.org/10.1080/14623940600987080

Tofur, S. (2018). Use of educational movies in classroom management courses: A metaphorical study. *Turkish Online Journal of Qualitative Inquiry, 9*(4), 389-411. https://doi.org/10.17569/tojqi.423738

Trier, J. (2002). Exploring the concept of 'habitus' with preservice teachers through the use of popular school films. *Interchange, 33*(3), 237-260. https://doi.org/10.1023/A:1020941318001

Tzanakis, C., & Arcavi, A. (2000). Integrating history of mathematics in the classroom: An analytic survey. In J. Fauvel, & J. van Maanen (Eds.), *History in mathematics education, The ICMI Study* (pp. 201–240). Kluwer Academic.

Yenilmez, K. (2011). Matematik öğretmeni adaylarının matematik tarihi dersine ilişkin düşünceleri [Views of prospective mathematics teachers about history of mathematics course]. *Pamukkale University Education Faculty Journal, 30*, 79-90. https://dergipark.org.tr/en/pub/pauefd/issue/11113/132873

Zengin, Y. (2018). Incorporating the dynamic mathematics software GeoGebra into a history of mathematics course. *International Journal of Mathematical Education in Science and Technology, 49*(7), 1083-1098. https://doi.org/10.1080/0020739X.2018.1431850