ARTICLE

MATHEMATICS AND CINEMA THROUGHOUT 25 YEARS: SOME INTERPRETATIONS

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ABSTRACT: The paper consists of qualitative research that aims to analyze cinematographic works that explore Mathematics in their plots. To do so, we sought to understand the origin and development of media as information technology tools, in order to trace back the establishment of cinema as a storytelling mechanism – also recognizing its functionalities. After refined searches on the internet, we found 23 movies that feature scientists' concepts and/or stories in the realm of Mathematics, released in a 25-year interval (between 1997 and 2021). These movies were viewed, classified, and analyzed according to three categories: Mathematics as background; Mathematics as a narrative tool; and mathematicians. The analysis brings a variety of mathematical approaches and references, and, as a result, we concluded that watching fictional stories, as well as those based on real events, can help us to better understand who the mathematical revolutionaries portrayed were and/or how Mathematics can interconnect with the cinematographic art, building engaging narratives while also demonstrating the versatility of this area of knowledge.

Keywords: technologies, digital media, cinebiographies, movies, Mathematics.

MATEMÁTICA E CINEMA AO LONGO DE 25 ANOS: ALGUMAS INTERPRETAÇÕES[1]

RESUMO: O trabalho consiste de uma pesquisa com abordagem qualitativa, cujo objetivo é analisar obras cinematográficas que exploram a Matemática em seus enredos. Para isso, buscamos compreender a origem e o desenvolvimento das mídias enquanto ferramentas tecnológicas da informação, com o

intuito de remontar ao estabelecimento do cinema como um mecanismo de contação de histórias – reconhecendo também suas funcionalidades. Após buscas refinadas na internet, encontramos 23 filmes que apresentam conceitos e/ou histórias de cientistas no âmbito da Matemática, lançados em um intervalo de 25 anos (entre 1997 e 2021). Esses filmes foram vistos, classificados e analisados de acordo com três categorias: Matemática como pano de fundo; Matemática como ferramenta narrativa; e matemáticos(as). A análise traz uma variedade de abordagens e referências matemáticas e, como resultado, concluímos que observar histórias fictícias, bem como as baseadas em acontecimentos reais, pode nos ajudar a compreender melhor quem foram os revolucionários matemáticos retratados e/ou como a Matemática pode se interligar com a arte cinematográfica, construindo envolventes narrativas ao, também, demonstrar a versatilidade que esta área do conhecimento possui.

Palavras-chave: tecnologias, mídias digitais, cinebiografias, filmes, Matemática.

MATEMÁTICAS Y CINE A LO LARGO DE 25 AÑOS: ALGUNAS INTERPRETACIONES

RESUMEN: El trabajo consiste en una investigación cualitativa, cuyo objetivo es analizar obras cinematográficas que exploran las Matemáticas en sus tramas. Para ello, buscamos comprender el origen y desarrollo de los medios de comunicación como herramientas tecnológicas de información, con el fin de remontarse al establecimiento del cine como mecanismo de narración, reconociendo también sus funcionalidades. Después de búsquedas refinadas en internet, encontramos 23 películas que presentan conceptos y/o historias de científicos en el campo de las Matemáticas, lanzados en un intervalo de 25 años (entre 1997 y 2021). Estas películas fueron vistas, clasificadas y analizadas según tres categorías: las Matemáticas como telón de fondo; las Matemáticas como herramienta narrativa; y los matemáticos. El análisis trae una variedad de enfoques y referencias matemáticas y, como resultado, concluimos que observar historias de ficción, así como aquellas basadas en hechos reales, puede ayudarnos a entender mejor quiénes fueron los revolucionarios matemáticos retratados y/o cómo las matemáticas pueden interconectarse con el arte cinematográfico, construyendo narrativas atractivas al mismo tiempo que demuestran la versatilidad que tiene esta área del conocimiento.

Palabras clave: tecnologías, medios digitales, biopics, películas, Matemáticas.

INTRODUCTION

This paper addresses the relationship between Mathematics and cinema, based on the analysis of cinematographic works that explore Mathematics in their plots. The motivation for choosing this theme was outlined by the author's interest in both subjects, to make them talk to each other, seek their relationships, as well as recognize the potential of the research presented here.

Before we talk about cinema, about how some plots involving Mathematics are constructed through specific narrative breakdowns, we will try to understand a little of what established the seventh art as an important tool for dialogue and understanding reality.

The seventh art is a term that we often use to refer to cinema; having its invention at the end of the 19th century, we saw that it "quickly evolved into an artistic genre of its own, joining the other six, traditionally considered: literature, architecture, painting, sculpture, music and dance" (SOUTO, 2013, p 19).

Cinematographic works have plots, that is, the story that will guide both the events and the characters included in it. The lessons learned by the protagonists and supporting characters should bring a kind of reflection on their choices and the consequences that occurred through them. Memories, chronicles, past, present, and future are some of the relationships that we can easily find in any movie, which, together, form the backbone of what we call narrative.

Among the types of plots available, we find those that seek to recreate a real story, based on facts cataloged through the information available regarding a specific historical event or person; we also find those that aim to conceive something new, relying on the fiction headed by both the director and the screenwriter working on the established work (NOVA, 1996).

It is fair to say that cinema was only possible due to the technological development that, over the years, advanced from one creation to another. The fact that this text explores the concept of technologies a little refers to the creation and consolidation of media as powerful information tools, among which cinema is present.

This study consists of research in the area of Education, in which cinematographic works that explore Mathematics to formulate their plots are studied. As a purpose, we seek to find the relationships between Mathematics and certain world cinema productions covering 25 years, delimited between 1997 and 2021. Thus, directing this study, we raise the following guiding question: What can we observe in movies with mathematical plots released over the 25 years between 1997 and 2021?

The text begins with a section on technology, media, and cinema, with a discussion on the advancement and importance of technologies over time, with emphasis on cinema, the main medium explored here. In the subsequent section, relationships that cinema can play with Education are presented. Next, there are the details of the production of research data, as well as the analysis and considerations about cinematographic works that, in one way or another, use Mathematics to formulate their plots.

TECHNOLOGY, MEDIA, AND CINEMA-TOPICS

We need to realize that, since the beginning of time, mastery of some types of technologies, as well as mastery of certain information, can distinguish human beings from others (KENSKI, 2003). It was what made us differentiate and learn over the decades, helped by technological creations that always aimed to make our lives easier. Kenski (2003) highlights, as part of his argument, that "technology is power" (p. 16), based on a specific field of vision, focused on the achievements of many human conceptions; and that, through the use of technological innovations that are increasingly powerful, humanity seeks to expand its domains and wealth.

Regardless of the time, we tried to find information, creating an eternal cycle of knowledge evolution. In this sense, Kenski (2003) argues that "the links between knowledge, power, and technologies are present in all times and all types of social relations" (p. 17) and, having established this, we could find them, for example, in encyclopedias, dictionaries, books, magazines, newspapers, always presenting information from the perspective of their creators, such as authors and editors (KENSKI, 2003). This makes us think about how messages are transmitted to us, always starting from a specific point of view.

Over the years, inventions have also evolved. "The technological development of each era of civilization marked culture and the way of understanding its history" (KENSKI, 2003, p. 20). Thus, it is fair to say that these inventions were consequences of the way of thinking, as well as of the dreams idealized by the people behind the thoughts, so that, with each new historical contribution, they enriched the culture of their descendants who would deal with them in a more personal, becoming accustomed, since birth, to such respective revolutionary interferences in their lives. This is exactly what Kenski (2003) adds when he says that these discoveries served to advance the cultural heritage of human beings.

Now discussing communications, whose relationships have been and are still practically united, we can see that new means of communication increase access to information for people; newspapers, magazines, cinema, and video, among others, are broad media, with enormous social penetration (KENSKI, 2003).

In other words, communication can occur in the most varied ways: it is present in the news we consume through journalistic media, in the music we listen to daily, in the books we read, in the movies we watch, among countless other examples. Along with them, we are conditioned to consume information directly or indirectly, building thoughts and knowledge through osmosis or with consciousness. This is the power of communication.

When we read a book, we are influenced by the author; when we watch a movie by the director; and so on. Thus, Kenski (2003) says that "announcers and artists play important roles in forming the opinions of listeners and spectators" (p. 29). They are the ones who direct us to think as we think, and to act as we act; such as parents and children, teachers and students.

In line with the aforementioned argument, Souto (2013) states that the historiographic narrative is loaded with intentions, reflecting the historian's point of view by targeting specific interlocutors; in this way, the dissemination of certain worldviews can be ideologically compromised.

It's easy to relate to what we like. So, when it comes to cinema, we can say that, in contact with a relatable presentation, a captivating sound, and energetic visual poetry, parts of our fascination gain strength, reverberating in our expressive attention. "The images and sounds brought together provoke our senses and emotions" (KENSKI, 2003, p. 39).

However, even though we have media as an ally in the way we consume certain content, we need attention because, in a way equivalent to the reframing of other types of communication, some may prove to be more "effective" than others. With the programming of a television channel, for example, we consume the content that is imposed on us, without many opportunities for choices – only those linked to the stated schedules. In a medium like the internet, the viewer becomes completely the owner of what they consume, having, in practice, their voice in personal decisions.

Having a latent history of participation in the most varied types of technological tools throughout human history, we can also see how the media have walked together, with latent interference; there has been a radical transformation of knowledge since the rise of information technology, now even more present in the relationships we have daily. However, it takes more than presence, it takes the ability to master them and use them most appropriately and coherently as possible.

Given the interference we have in the digital age, it is reiterated that humanity is made up of techniques that extend and modify reasoning; that is, individuals are constantly transforming these techniques (BORBA, 2001).

As every technology evolves in its way or is replaced by another more advanced one, throughout history, what we seek to do now is to overuse what we have at our disposal, the technological media of the internet and computers, so that, in the future, we can shape and configure it more perfectly and efficiently.

However, it is fair to say that technologies are not transformed solely by factors linked to humanity, since the construction of knowledge can be analyzed through a collective that involves both humans and non-humans (BORBA, 2001). In a reality that is increasingly technological and thirsty for evolution, it is necessary to analyze and invest in techniques and processes that go beyond those required by us. Continuously, "the role that the media has as non-human actors in changing the possibilities that these collectives have to build knowledge" (BORBA, 2001, p. 142) is also continually emphasized.

With new technologies established, we see the relationship between human beings and media as an important and innovative learning tool. Therefore, when consuming content that is increasingly enjoyable to us, we need to work on what is being done and what could become made "from the possibilities offered by the availability of this new media" (BORBA, 2001, p. 143).

The cinema media, like others, works in most cases to enhance general human knowledge, dealing with important aspects that, in one way or another, end up becoming essential. Souto (2013, p. 19) tells us that

> Science and culture, especially relating to the Western world, are often portrayed in cinematographic productions. The seventh art, a symbol of modernity, has become an extraordinary instrument of communication, spreading knowledge, circulating new ideas, disseminating, and at the same time, building cultural values. The various institutions and social practices in different eras and societies have constantly been an object of interest to film production teams. In particular, much of his production has focused on projecting images about science.

Using this prerogative, we have some types of specific productions to inform and entertain the viewer, providing them with a relevant portion, for example, of a historical event, or even of a historical personality. Some movies propose reconstructions of discoveries, inventions, and experiments,

in addition to biographies of scientists and representations of science that are present in the social imagination (NOVA, 1996; SOUTO, 2013).

D'Ambrosio (2013) highlights that cinema can be seen as an efficient strategy for teaching Mathematics, as it highlights and reinforces the importance of the mathematical idea as a human science, filled with strong cultural roots.

Movies, as part of the media concept, actively work to convey information about certain ideas, often helping to develop human knowledge. When it comes to films about Mathematics, Souto (2013, p. 14) mentions that

> This focus comes from the perception of science as a sociocultural product of humanity, and as such, associated, at each historical moment, with the configurations of power relations at local and global levels. In this sense, the use of films aims to create an environment that stimulates reflection and debate around the issues that permeate the production and dissemination of mathematical knowledge.

However, movies do not prove to be powerful information tools just for mathematical knowledge. Thus, also in line with Souto (2013), cinematographic works address themes that contribute to the dissemination of knowledge in general.

> The set of social, scientific, philosophical, and religious structures, plus the intellectual and artistic manifestations that characterize a given society, when portrayed in multiple genres, make films a valuable instrument for studying culture and the history of science. (SOUTO, 2013, p. 20).

In conjunction with the specific vision of the person who portrays the story narrated, we also have the deficiencies caused by the lack of certain information; whether they were lost over the years, or whether they were hidden, so that they would not become known to those who would later have access to the particular fact told.

Souto (2013) mentions that history is made through memories and reminiscences, at the same time that it has lapses and forgetfulness. Therefore, our interest must dialogue with both production and historical contextualization. In this way, the author also states that memory, considered the raw material of history, is structured through memories and forgetfulness, in a continuous recreation of the present. Thus, in the records that memory keeps for history, there is no linearity or accuracy.

CINEMA AND EDUCATION

Continuing the discussion, Ribeiro Junior (2011) argues that, as we are surrounded by electronic media that carry a huge range of audiovisual information, we are constantly bombarded with increasingly intense references, through an increasingly faster process. Bringing the discussion to the school environment, the author mentions that the school is not the supreme holder of Education, as, in the era of the information society, digital media, mainly linked to audiovisual, become training agents, directly influencing the process of young people's learning.

We can say that audiovisual culture has great potential for transformation in schools, especially when used well. This is what Ribeiro Junior (2011) tells us, while he also discusses that the school, immersed in new challenges and new realities, needs to reinvent itself and can no longer remain oblivious to the developments of the information age. Therefore, it is necessary for the media to play a leading role in school activities, and not for it to appear merely as a misused complement.

Bringing this discussion more into the cinematic sphere, Fantin (2014) mentions that, since the beginning of the last century, some researchers have commented on the possible relationship between cinema and Education. However, although there is a great demand for renewed school experiences, with cultural events and informal practices, Brazilian schools still seem to be far from having an educational practice that uses cinema in its curricular proposals. "The character of a resource or teaching tool alternates with the unintentional or unplanned character, in which the strong use of films in improvisation is evident, as a replacement for teachers or activities" (FANTIN, 2014, p. 49).

Therefore, although cinema has great potential to be related to some content worked on in the classroom, adverse factors can hinder the progress of possible proposals.

Through contact with the many stories that permeate the movies, the viewer, student, or teacher, can, according to Fantin (2014), have contact with a series of significant cultural experiences, developing their critical capacity through the messages and also the engravings worked on by the production. There is, therefore, the argument that "it is possible to construct meaning from any film, which would act as a device for discussion and expansion of repertoire" (FANTIN, 2014, p. 51).

Through their studies, Galego and Pereira (2020) mention that the development of mass media, such as cinema, created the need for images of human populations in their cultural manifestations. By bringing the possibility of working on cinema into the classroom, the authors state that there is a great attraction for film productions, since access to them, as well as public investment policies in audiovisual, benefit the relationship between cinema and school.

These authors also state that cinematographic language can be incorporated into school studies as a pedagogical mechanism that goes beyond traditionality, precisely because it is illustrative and instructional material; for this to be enhanced, taking advantage of its various possibilities, it can be used to teach one or more content.

According to Galego and Pereira (2020), when working with cinema for teaching, one may have the opportunity to use audiovisual resources attractively, generating attention and good results; In line with this, when watching a particular film, students can be educated to criticize, analyze and interpret information worked on by the diverse contexts of productions, being included, obviously, not as a form of pure and uncompromising entertainment, but rather as a valid justification for learning.

METHODOLOGY

Considering that the objective of this work is the study of cinematographic works that involve Mathematics in their plots, given the vast potential that these movies can have for the exploration and dissemination of mathematical knowledge, the work is based on qualitative research. According to Goldenberg (1999), it is not a numerical representation of data but rather a deepening of the understanding of a group, which requires flexibility from the researcher to collect this data and analyze it.

To select the movies, we considered twenty-five years, covering the period between 1997 and 2021, and as we did not find a specific website, or location on the internet, to carry out the research, we carried out a refined search on the internet using the keywords key: mathematical movies, movies that contain Mathematics, biopics of mathematicians, Mathematics and cinema. To ensure that no works that satisfied our objective were left out of our work, we were in constant search for movies over a continuous period of three years, browsing through blogs and websites specializing in cinema and mathematics.

Initially, the delimitation of our time frame was 22 years, going from 2000 to 2021; however, we expanded our research spectrum to a longer period, allowing other works to be included, while also updating it to the year in which we were established. Therefore, we decided to work with a new period, going from 1997 to 2021.

With the names of the cinematographic works, the next step was to watch the films, carefully observing each detail that enriched our research, and analyzing how they explore Mathematics in their plots. In line with Souto (2013, p. 21), we seek to understand

> the development of Mathematics in different social and cultural contexts, also considering its relationship with the development of other forms of knowledge. Films provide us with other ways of 'seeing' events that have occurred or imagined, often leading us to situations and environments that we could not even imagine.

During this process of searching for and watching the movies, we selected 23 works that met our objective, and the films found were:

Chart 1 – Selected movies and their respective release years.

Movie	Ano
Contact Director: Robert Zemeckis	1997
Good Will Hunting Director: Gus Van Sant	1997
Pi Director: Darren Aronofsky	1998
October Sky Director: Joe Johnston	1999
A Beautiful Mind Director: Ron Howard	2001
National Treasure Director: Jon Turteltaub	2004
Proof Director: John Madden	2005
The Da Vinci Code Director: Ron Howard	2006
Number 23 Director: Joel Schumacher	2007
Flatland Director: Ladd Ehlinger Jr	2007
La Habitación de Fermat Directors: Luis Piedrahita, Rodrigo Sopeña	2007
National Treasure: Book of Secrets Director: Jon Turteltaub	2007
21 Director: Robert Luketic	2008
Ágora Director: Alejandro Amenábar	2009
An Invisible Sigh Director: Marilyn Agrelo	2010
Moneyball Director: Bennett Miller	2011
The Imitation Game Director: Morten Tyldum	2014
X + Y Director: Morgan Matthews	2014
The Man Who New Infinity Director: Matthew Brown	2015
The Accountant Director: Gavin O'Connor	2016
Hidden Figures Director: Theodore Melfi	2016
Gifted Director: Marc Webb	2017
Adventures of a Mathematician Director: Thor Klein	2021

Source: Prepared by the authors.

Subsequently, with each film seen, we met and developed discussions about previous analyses of the movies, addressing more general points about the stories, mainly linked to their plots. Considering that the exercise of communication and interpretation carry together our theories and worldviews (MORAES, 2003), we began to make a summary of each production, highlighting the information related to the fulfillment of our research objective.

As qualitative research seeks to deepen the understanding of the phenomena it investigates based on a rigorous and careful analysis of information (MORAES, 2003), we set out for categorization, using the inductive method which, according to this author, involves building the categories through a process of constant verification and comparison between data, leading to groupings of similar elements. These sets of close-meaning elements constitute the categories.

Therefore, through this inductive process, three categories of analysis emerged, which we present in the next sections: movies with Mathematics as a background; movies that use Mathematics as a narrative tool; and movies about mathematicians.

FILMS WITH MATHEMATICS AS A BACKGROUND

In this section, movies that, in some way, with Mathematics as a backdrop to their stories are discussed. To achieve this, the productions were organized in order of release.

Movie: Contact (1997)

Contact tells a complex, passionate, and wonderful story that mixes desires, belief, and science, conceiving an intelligent plot of extreme relevance to its time and today, creating a timeless work full of meanings and teachings, while still venturing through an excellent and profound chronicle about humanity, extraterrestrials and the figure of God. Based on a novel of the same name, written by Carl Sagan (1934-1996), to whom the production is still dedicated, the film perfectly balances the real and the fantastic, using numerous scientific concepts ingrained in the accurate imagination behind the script.

The Mathematics appearing in the film is centered on the message captured by humans, in a code that traveled distances across the Universe until it was intercepted. Like a kind of Morse Code, the waves come together, with spaces of time that symbolize pauses. After a thorough analysis, scientists conclude that the message comes in a format that idealizes prime numbers. The ciphers behind the message lead humanity to the knowledge of some secrets about the Universe and other profound information, even beyond terrestrial understanding. One of the countless lessons that the viewer can learn is that, regardless of their devotion, whether to belief or science, it is possible to find a middle ground through the nuances, since the figure of man and the figure of God, being real or not, are not very far away.

Movie: Good Will Hunting (1997)

Good Will Hunting tells the troubled journey of a troubled young man, whose rebellion controls much of the action when his magnificent intellectual gifts are discovered by a university professor, who observed a high capacity to establish himself as one of humanity's greatest geniuses. The problem, as subtly mentioned above, is that he has several emotional and behavioral problems, creating scenarios surrounded by confusion and delinquency, making him a controversial individual, capable of hurting, upsetting, and even violating people due to his fragile and shaken emotions.

As for the Mathematics worked on by the plot, we have, in addition to mentions of famous mathematicians and theorems, some references to Real Analysis and Combinatorial Analysis. However, there is also a more comprehensive citation related to matrices, Graph Theory, focusing on the work of Joseph Fourier (1768-1830), and also the Cayley Formula, which concerns the mathematician Arthur Cayley (1821-1895). Throughout the plot, we follow a series of resolutions and structures of mathematical problems, with the appearance of situations involving series, and geometry, among many other examples. Everything, of course, is handled with extreme ease by the protagonist.

Movie: Proof (2005)

Proof narrates a troubled journey of overcoming and mourning, while secrets and mysteries are developed through the main figures who accompany the plot. The adventure goes around the recent death of Robert, a brilliant mathematician who had suffered for years from severe mental disorientation, which caused his gifts to be subjugated by those around him. Cared for by one of his daughters, Catherine, in his final years, he was able to accompany her in several attempts to carry out major studies in the same area to which he had dedicated much of his life. The girl, as brilliant as him, had dedicated herself to learning at college for a long time, never having; however, the chance to develop a great contribution, so her studies were paralyzed due to the difficulties in completing them, as well as the need to take care of his father.

The movie focuses on narrating Catherine's truncated and mysterious reasoning when she finally manages to make a valuable mathematical discovery. As the name suggests, it constitutes a great numerical proof, an impressive finding worthy of a genius mind.

Movie: An Invisible Sigh (2010)

An Invisible Sigh tells the story of an extremely introverted and shy young woman who has the opportunity to teach Mathematics to a class of children. Forced by her mother, as well as driven by a psychological problem developed by her father, the character ventures into a classroom experience that promises to change her life; or, at least, make her see the world and the people around her in a different way.

Movie: Moneyball (2010)

Moneyball narrates an exciting and incredible journey about an American baseball team turning around its decline, achieving great success by betting on the rationality of certain signings, which have a purely mathematical bias. The story addresses a very firm and innovative stance on a sport that, for a long time, only relied on emotion and luck when played, creating a new way of seeing and practicing it. The way things are worked throughout the narrative is really interesting since the plot has a connection with reality. The events in the movie are inspired by a real story, which was highlighted in sports history as one of the biggest milestones of the competition.

With a turbulent start, the Oakland team begins the season with problematic results, which could call into question all the planning outlined by management. Over time, however, Mathematics proves to be infallible, showing that the decisions made may not have been, in the end, as bad as everyone imagined. Although it did not win the championship that season, the team proved to be an experiment that aroused immense attention and enthusiasm from sports lovers at the time, proving that, sometimes, it does not need to be reduced to mere chance because, sometimes, logic and mathematics can help achieve great things, even when dealing with activities as unpredictable as baseball.

Movie: X+Y (2014)

X + Y, a curious name for a film, tells the story of a shy boy who has a severe degree of autism. Passionate about Mathematics since childhood, he discovered a great logical competition that attracts fanaticism and participation from young people around the world. When accompanied by a teacher, the protagonist seeks to fulfill his dream of being awarded in the aforementioned competition, showing capable of great things – not to impress the world, but to feel good about himself. Very influenced by patterns of organization and logic, his life is shaped by Mathematics, seeing the world around him constructed through notions of the area that, in different ways, embrace and calm him.

Throughout the story, the film features several dialogues and varied situations that evoke Mathematics, portraying conversations and even relationships between the characters. Furthermore, we have mentions of some past mathematicians, such as Srinivasa Ramanujan (1887-1920), Issac Newton (1643-1727), Godfrey H. Hardy (1877-1947) and Bertrand Russell (1872-1970). With a captivating

adventure and human, relatable characters, X+Y is, above all, a movie that goes beyond its mathematical subjects, it is a journey about love, trust, and support. It demonstrates that, although the universe of numbers is exact and sometimes immutable, human feelings and relationships are not.

Movie: The Accountant (2016)

The Accountant is an American movie that mixes action and suspense, with a non-linear narrative, which deals with the past and present simultaneously, while, along with the story, we can understand and relate the arc of the protagonist and supporting actors. In the end, they demonstrate, for the most part, at least one narrative connection. The adventure presents us with some references to Mathematics, as well as the mathematical universe, focusing on mentions of Carl Friedrich Gauss (1777-1855) and Lewis Carroll (1832-1898), for example – while, through the information worked in the story, it reads with Financial Mathematics as a key point in the accountant's development, whose focus brings the adventure to life.

Mathematics is present in history in direct and indirect ways. As we follow a specific service of the protagonist, we have contact with her more explicitly. Even if not directly explored by the narrative, we have the appearance of interest rates, dividends, as well as other calculations related to Financial Mathematics. There is also space for a mention of the way the human brain works when formulating fictitious numbers, here used in a context in which the protagonist tries to think with the mind of the person who embezzled money from the contracting company, formulating some false data to operate in the official reports of profit and expenditure.

Movie: Gifted (2017)

Gifted tells the moving story of Frank and Mary Adler, two people of very different ages, whose life journeys were delimited by a terrible tragedy. Frank is Mary's maternal uncle, responsible for taking care of her since she was very little. After the suicide of his sister, Diane Adler, who left him in her care, he finds himself obliged to take care of her upbringing, seeking to provide her with a childhood and a normal life (something Diane never had).

Like her mother, Mary has always demonstrated a high cognitive capacity, standing out in the area of Mathematics by proving to be an impressive child prodigy. At the age of nine, she had already read, understood, and studied in depth various materials involving advanced calculations and complex theorems – thus, the contents aimed at her age were simple challenges.

As it is a movie with a decisive mathematical approach, we have some concepts and references linked to the area appearing frequently for example, the Trachtenberg Method, the Navier-Stokes Equations, quotes from Srinivasa Ramanujan (1887-1920), mentions of more basic problems linked to calculus and the 23 mathematical problems still unsolved in the 20th century listed by David Hilbert (1862-1943).

Some interpretations of the analysis of movies that have Mathematics as a background

The movies in this category are aligned with both the commitment to telling a real story and the imagination of fictional approaches, conceiving new stories for viewers to enjoy. Some of them share certain particularities, even though they have different histories and contexts.

In *Gifted* (2017), *X+Y* (2014), and *Proof* (2005), we see the stereotype of the antisocial and "problematic" genius being established, having characters who live with various emotional and physical weaknesses, compromising their sense of reality, the well-being of their emotions and also their sanity.

In the first movie, a child prodigy needs to live with the great skills inherited from her mother, an ancient mathematician who, in addition to making a great contribution to the field, met a fateful end when she took her own life. Mathematics, indirectly, acted as the culprit for the decision, after having dedicated a large part of its existence to trying to prove a famous problem. In the second movie, we have an autistic teenager who, to better deal with his feelings, finds a way in Mathematics, focusing on his particular vision that unites everything and everyone in perspectives that relate to knowledge in the area.

In the third movie, we see that Mathematics, although it has been a great ally in the past, was the cause of a man's profound madness; something that, in a way, may have been transmitted to the daughter, who begins to suffer some hallucinations, seeing herself on the verge of madness. Thus, we note that, at the same time as a blessing, Mathematics can be the doom for these protagonists and supporting characters, even though they do not know exactly what effect it will have on their lives.

Good Will Hunting (1997) and *The Accountant* (2016) work on mathematical geniuses in a slightly different way. In addition to their great skills with accounts, the main characters in the movies have a great commitment to other activities. In the first movie, we see a young troublemaker who has an enormous aptitude for other knowledge such as Law and Literature. As the owner of a high-level photographic memory, he is inspired by a professor/psychologist who can make him see the beauty of life and the most varied mundane situations, providing the opportunity to help him find in his career and himself. The second movie is about a mathematician deeply experienced in accounting, extremely methodical and quick in his calculations and services; However, in addition, he still has a high skill in handling weapons and fighting, performing two types of work: with his fist and with his mind. Both films use Mathematics (and knowledge, in general) as an opportunity to improve and evolve the characters' states, giving them the chance to ascend to a better and more dignified life.

We also have *The Man Who New Infinity* (2011), *Contact* (1997), and *An Invisible Sigh* (2010), which work on Mathematics as an important factor for victory and personal and human achievements. The first movie shows us the power of numbers and statistical analysis, even linked to something that many consider uncertain and unpredictable: sports. The second movie works with Mathematics as a form of intergalactic communication, establishing it as the universal language of the Cosmos, something that humanity needs to go through the most varied stages of evolution. The last movie brings Mathematics to the direct development of the plot, trying to show the viewer, as well as the characters in the story, that discipline can be transformative, building relationships between generations of acquaintances and strangers.

MOVIES THAT USE MATHEMATICS AS A NARRATIVE TOOL

In this section, we discuss movies that, in some way, use Mathematics as a narrative tool, using it as the basis for the performance of their respective plots. To achieve this, the productions were organized in order of release.

Movie: Pi (1998)

Pi tells the crazy journey of a disturbed mathematician who sees the world based on mathematical patterns and structures. The story is confusing and full of allegories that transform it into a plot whose meanings can be different, depending on who watches it. The very organization of events, which seems more like a dream than anything else, and does not respect much sense or linearity, appears as a disturbing proposal to leave the viewer uncomfortable during each small narrative decision. The production arouses curiosity and a series of possibilities regarding its true intention. Maybe it means everything, or maybe it means nothing.

The movie is about the idea of God communicating with worldly creatures through mathematical approaches, leading some to believe that a grand message was sent through a specific sequence of numbers. *Pi* can garner great admiration from the viewer or great contempt. It is a movie with several layers, which may need to be seen more than once to try to be understood or resolved. In the end, regardless of the message one may take away from the story, one thing becomes clear: just like the valuable discoveries, the venerable achievements, and the advanced inventions, nothing is as simple as it seems. It takes a lot of effort and patience to face whatever fate has prepared for you, whether or not you follow a logical organization of events, or an exact vision of them.

Movie: National Treasure (2004)

National Treasure narrates the adventure of American historian Benjamin Gates, whose skills go beyond historical knowledge and also walk the line of cryptography and steganography. In the journey of generations of his family, known (and discredited) for hunting treasures, the youngest of the Gates finally walks towards the pompous downfall he dreamed of.

The movie is full of curious and charming challenges, which often surprise attentive audiences, although not all of them involve Mathematics. The majority, perhaps, are endowed with a necessary sense of imagination, as well as historical knowledge, in which the protagonists use their intuitive sagacity to acquire what they desire. That is why, certainly, the historical aspect is so fundamental to the knowledge of these characters. However, at times, the secrets found use numbers and logic to guide those interested in observing them. Among the various enigmas present in the narrative, we can highlight cryptography, riddles, the Ottendorf Code, and steganography as the main ones.

Movie: The Da Vinci Code (2006)

The Da Vinci Code tells the story of Robert Langdon and Sophie Neveu, who find themselves united to uncover one of the biggest conspiracies in human history, big enough to change everything we understand about Christianity: the whereabouts of the Holy Grail. The key to the mystery is hidden in famous works by the ancient polymath Leonardo da Vinci (1452-1519), former leader of the Priory of Sion and one of the many guardians of this ancient secret, whose clues to its solution require great reflective and mathematics. Only the "worthy" could have access to the information contained in the riddles.

The mathematics behind the story mainly involves cryptography, although some other aspects are covered. During the plot, Langdon, an expert in ancient codes, images, and languages, uses his wit to gain access to the information he needs. Many of the mysteries and challenges proposed by the narrative are not based on calculations but rather follow the intuition, imagination, and cognitive capacity of the protagonists. However, most of the mathematical games explained throughout the mishap demonstrate systems of historical figures based on reality.

Movie: Number 23 (2007)

Number 23 tells a curious, confusing, and unexpected story about enigmas. We are introduced to Walter Sparrow, a man who, in addition to working with animal control, appears to be an ordinary citizen at first, without any concerns other than conventional ones. Walter is married and shares his life with Agatha, the mother of his son Robin, a family for which he appears to care more than anything – even putting himself in the background to please them.

Between an ordinary experience and private dramas, whose grandiloquence does not escape the banal standards of irrelevance, Walter is faced with an adventure full of twists and turns and discoveries about himself and a mysterious figure, present in a book (with the same name as the movie) whose authorship will be able to change everything he understands about reality. The plot seeks to relate the number 23 with different events and people, creating a general narrative about sacrifices, destructions, and universal fates, that is, if we force some reasoning, we can find the number in the most varied places. In this way, it does not matter that we arrive at it through addition, division, multiplication, subtraction, clear and clear appearances. Just as we cannot escape our destiny, we cannot escape the digits.

Movie: Flatland (2007)

Flatland is one of the most fun, curious, and different plots in the selection of movies worked here. In free translation, we can read its name as Planolândia, an interesting two-dimensional world where different beings of the same format (or smaller) live. Through its peculiar soil, we can find squares, circles, triangles, straight lines, and other individuals who lead their lives in a similar way to ours. They have jobs, occupations, government representatives, family, and tax responsibilities. The difference is that

everything, from the most insignificant to the most important detail, is done and treated in two dimensions – at least for now.

Planolândia, a mysterious home where the many geometric figures of that universe live, appears to be a curious place that holds great secrets from the beginning of the adventure. The production walks through a wonderful lesson on dimensions, covering the first to the third, while still flirting with the superior ones, leaving the viewer with the main message of the story: questioning the present, dreaming about the future, and configuring one's evolution, through discoveries and considerations.

Movie: La Habitación de Fermat (2007)

La Habitación de Fermat tells the story of five specific people, all with some specific involvement with each other, some of whom are dedicated to the study and learning of Mathematics and/or logical reasoning. The plot unfolds like a mysterious novel that is certainly inspired by detective literature, creating a series of situations that seem more like an adaptation of the works of author Agatha Christie (1890-1976), even though the qualities are incomparable.

The viewer is introduced to a series of secrets and twists that happen little by little. The truth is that all the remnants are trapped in a deadly room, which shrinks through four hydraulic presses, creating a desperate environment. To get out of there, they must solve some mathematical problems that will test their respective logical abilities. Mathematics present in history, in addition to its referential character, such as mentions of theorems and thinkers in the field, takes the form of problems and challenges, one more interesting than the other. Not to mention that, for each codename chosen for the characters, there is also a very macabre explanation, which dictates one of the surprising revelations of the plot.

Movie: National Treasure: Book of Secrets (2007)

National Treasure: Book of Secrets continues the adventures of Benjamin Gates, presenting a new wave of cryptographic concepts that, above all, have the power to bring good entertainment to the viewer.

This new chapter in the franchise is full of exciting and clever challenges, although not all of them involve pure Mathematics as a basis. Historical knowledge, especially that of the protagonist, is again present in a considerable way, while the slight cognitive ability makes the characters complete reflective tasks with precision, even the most difficult ones. Imaginative abilities also appear, as in the previous movie, although logical reasoning is highlighted more frequently.

Cryptography is present in this new adventure, as well as its derivations, with emphasis on the Playfair Cipher, which was created in 1854 by Charles Wheatstone (1802-1875) and gained its name because its use was later promoted by Lord Lyon Playfair (1818-1898). In the plot, we also see the use of steganography, when discovering messages in such a way that other people cannot even perceive them.

Movie: 21 (2008)

21 narrates an interesting and fun adventure, full of cool and notable moments for the selection presented here. We follow Ben Campbell, a young dreamer who aims to study medicine at Cambridge University. However, he is missing two possibilities in his life story: either an impactful and noteworthy event that makes him stand out among other candidates, or three hundred thousand dollars to cover all the costs of studying on the course.

The movie has a light and sometimes unpretentious atmosphere, even though, in several moments, it explores tense situations, focusing on twists and turns and notable events in the world of Las Vegas casinos. We noticed direct and indirect references to Mathematics, with an emphasis on statistics and counting. However, advanced concepts are also discussed, with mention of some mathematicians, such as Isaac Newton (1643-1727), Joseph Raphson (1648-1715), and Augustin-Louis Cauchy (1789-1857).

Some interpretations of the analysis of the movies that use Mathematics as a narrative tool

The movies in this category, regardless of their particularities, focus on structuring a plot based on the solution and/or use of Mathematics and/or logical reasoning so that the characters can go from one point to another, developing through their respective bows. With developments that address fictional events, we see that the protagonists and supporting characters often need to resort to wit to continue their adventures, while they still focus on narrative structures that, in many ways, dialogue with Mathematics.

In *Flatland* (2007), geometric beings need a lot of reflection to discover the secrets of their world, as well as others, with Mathematics present in absolutely all events in the film, from the simplest to the most complex. In *Pi* (1998), a mathematician under the stereotype of a "crazy" person seeks to see the world around him in the same way that his mind and ideas seem to work: based, almost entirely, on mathematical, logical, and/or thoughts filled with references to numbers. In Number 23 (2007), Mathematics is no longer seen as the solution to all problems, but rather the cause of them; the protagonist, based on an insane vision and given over to conspiracies, begins to see patterns that, in different ways, are linked to the number that gives the adventure its name, embarking on a dangerous web of events that seeks, above everything, to continue creating relationships between Mathematics and certain mundane situations, even if in an absurd way.

In *National Treasure* (2004), *National Treasure: Book of Secrets* (2007), and *The Da Vinci Code* (2006), the plots are organized in such a way that, through a lot of cryptography and imagination, the narratives happen. Without basic or in-depth knowledge of it, the characters would not be able to reach their respective and desired bonuses. In the case of Fermat's Room (2007), the protagonists' lives depend on solving the problems highlighted by the chamber that keeps them prisoners, with Mathematics as a barrier and resource at the same time, in a shrewd use of numerical exercises. In *21* (2008), to escape trouble and persecution, the characters need to use logic, as well as luck, to remain firm in disputes in the casinos. Between life, death, prizes, and relics, individuals use quick thinking to escape the stages of plot development, while the stories progress with firm ties to Mathematics.

Although Mathematics acts as a narrative tool in all the films that permeate this category, it is used in different ways, even when they have certain similarities (such as treasure hunting). It is seen as a solution to problems and challenges, as the basis for a dense plot full of social discussions, or even for the creation of conspiracy theories, to amuse the viewer.

It is also worth paying attention to the fact that, in 2007, we had a huge number of releases, since most of the productions listed in this category debuted during this period.

MOVIES ABOUT MATHEMATICIANS

In this section, movies that talk about mathematicians are discussed. As they are biographical productions, each one is related to the life story of the particular figure it shows, even if they have certain particularities – such as movies that talk about wars. To achieve this, the productions were organized in order of release.

To write additional content referring to some details of the lives of the mathematicians mentioned, the biographies section of the MacTutor platform was used[2].

Movie: October Sky (1999)

October Sky tells the story of a young dreamer who, after the launch of Sputnik 1, in 1957, falls in love with rockets, realizing the great desire to be able to build one one day. For this to be possible, however, he will need to overcome a series of challenges that go beyond the students, related to the steps and knowledge necessary for the task.

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[2] Available at: https://mathshistory.st-andrews.ac.uk/. Access on: August 2022.

Although it is not a revolutionary adventure, with unprecedented events and lessons, the production does well to play it safe, based on the life story of a real figure: the former NASA space engineer, and writer, Homer Hickam (1943-). A little about his youth is narrated throughout the minutes of the production, showing how he, accompanied by some colleagues, managed to achieve, through studies and Mathematics, a desired prize at the National Science Fair, held in the city of Indianapolis.

Movie: A Beautiful Mind (2001)

A Beautiful Mind narrates part of the engaging trajectory of John Nash (1928-2015), a respected mathematician who gained the world's spotlight when he won the 1994 Nobel Prize in the area of Economic Sciences. Nash had a troubled life: he suffered from schizophrenia during a crucial stage of his youth, causing damage to his professional occupations, his marriage, and his mental health. The movie takes us to some of these turbulent points, which do not necessarily accurately reflect the historical facts they cover, but allow the viewer to understand, at least, who this man was and why he was important.

John Nash's excellent conduct in his studies made him make important contributions to Mathematics. Two of the main ones are Game Theory and Nash Equilibrium. While in Game Theory the main objective is to extract results from the operations arranged, the Nash Equilibrium consists of a scenario where, in a situation of dispute between two or more players, precious information is obtained regarding the behaviors that equalize the results. Thus, observing the situation of the members, we would form a consideration regarding the possible conduct adopted by them.

John Nash became one of the winners of the Nobel Prize in Economic Sciences in 1994, immortalizing his great merit. It is mentioned at the end of the production that his theories influenced American national commerce, as well as local labor relations and even some discoveries in evolutionary biology.

Movie: Ágora (2009)

Ágora seeks to narrate part of the history of the ancient mathematician Hypatia (370-415), whose knowledge, in addition to Mathematics, also followed the lines of Philosophy and Astronomy. We follow her journey through the ancient city of Alexandria, where she shares a home with her father, Theon (335-405). Hypatia's story is remembered for her prominence about other women of the time, as Theon allowed her to remain single, helping her to acquire a higher education, and dedicating entirely to her studies and teaching.

When walking through different types of knowledge, Hypatia probably had great inspiration for the future achievements she would achieve, given the intellectual influence that her progenitor had. Allowed not to get involved with men, in a relationship, at the time, of stunning submission, Hypatia dedicated her life to science, having a large part of her knowledge formation built through prestigious schools in the city of Athens. He had always been taught Neoplatonic thinking.

The movie also outlines a possible new event marked by the passing of Hypatia: a premature discovery of something essential to human knowledge. In the adventure, she is established as the first intellectual to discover that the translation route of planet Earth is given by an elliptical orbit – something that the narrative emphasizes again at the moment of her death, representing a beautiful and at the same time tragic symbolism. The discovery, as said just before the final credits, ended up being formulated around one thousand and two hundred years later, by astronomer Johannes Kepler (1571-1630).

Movie: The Imitation Game (2014)

The Imitation Game tells the story of mathematician Alan Turing (1912-1954) during his long journey to decipher the codes of the German Enigma machine, a German army tool used in World War II for secret communications between strategic leaders and soldiers. Recruited by the United Kingdom government, Turing was helped by some colleagues, with whom he initially had many problems getting along, who shared, in a certain way, the same knowledge as him; together, they joined forces to achieve the goal. Known as the Father of Computing, the mathematician proposed the creation of a revolutionary

machine; the only one, in its conception, capable of solving the encryption proposed by the German apparatus. At that time, the importance and influence of artificial intelligence on humanity's actions began to be increasingly discussed.

Unlike many old problems, pranks, and codes, Turing and the rest of the team of decoders working at Bletchley Park realized that, without the benefit of an unprecedented apparatus, it would be humanly impossible to decipher the secret messages that the Nazis produced daily. Appropriating statistics and probability, those in charge designed a machine capable of analyzing the configurations that emerged from the codes and, in this way, deciphering the meanings they held. Both Enigma and Bomba had their stories filled with a lot of Mathematics, having inventors who certainly mastered this area of knowledge.

Alan Turing also published, in 1950, a highly focused study on artificial intelligence. In his initial proposal, he wanted to prove that a machine, although it possessed the behavioral capacity of a human mind, could behave and look like one. To prove this theory, he developed a small test, based on a children's game, where players had fun pretending to be other people. Thus, he made men exchange answers both with other men and with machines, without their knowledge. The more correct answers a computer had, without raising suspicions that it was not another human being, the more identical it would be to a human. The test was called the Imitation Game by him.

Movie: The Man Who New Infinity (2015)

The Man Who New Infinity tells the troubled and curious story of the Indian mathematician Srinivasa Ramanujan (1887-1920), owner of a brilliant mind who, throughout his existence, was responsible for discovering several formulas and solving various problems with them, hitherto unknown. Ramanujan's life story proved to be a milestone in the history of Mathematics, because, although he proved to be a genius for calculations and discoveries, he made them, for the most part, without academic training. After publishing a research work focused on Bernoulli Numbers in the Journal of the Indian Mathematical Society, in 1911, Ramanujan finally gained recognition and notability for his studies and began to stand out in India as a genius in Mathematics, gaining great knowledge in Madras.

After exchanging letters with the mathematician Godfray Harold Hardy (1877-1947), demonstrating his great cognitive ability for algebra, Ramanujan migrated to England, becoming, over the years, one of the main collaborators at the University of Cambridge. The movie tells his troubled journey during the five years he experienced at university, going through emotional problems, racism, and several moral dilemmas.

Movie: Hidden Figures (2016)

Hidden Figures narrates the difficult trajectory of three strong and determined black women, Katherine Johnson (1918-2020), Mary Jackson (1921-2005), and Dorothy Vaughan (1910-2008), all mathematicians and/or engineers, who spend their respective existences in the 1960s in the United States, a time of immense prejudice, worked here with a focus on racism and machismo. Through an exciting and, at the same time, dramatic narrative, the three seek to carry out their work with excellence, aiming to be noticed and, of course, respected for their great gifts and capabilities.

The movie´s atmosphere is built around the tension of the space race, fought as a competition between the Soviets and the Americans. Through it, they sought to see who had the greatest space power, capable of taking the first man off the Earth and, later, to the Moon. Mathematics is present in the movie in the form of formulas, theorems, and mentions of some mathematicians and scientists, such as Albert Einstein (1879-1955) and Leonhard Euler (1707-1783).

Movie: Adventures of a Mathematician (2021)

Adventures of a Mathematician narrates an important part of the life of scientist Stanislaw Marcin Ulam (1909-1984), known worldwide as the man responsible for solving the problem that made possible the construction of the Hydrogen Bomb, considered one of the most powerful and possibly disastrous

weapons humanity has already conceived; something capable of surpassing, in comparison, the damage of Atomic Bombs.

In the movie, we follow the dramas and some relationships developed by Stan throughout his contributions to the United States government, as one of the main and most capable mathematicians who worked on the Manhattan Project, created by the Los Alamos National Laboratory in New Mexico, developing a process that sought mathematical solutions with the help of random numbers linked to a certain statistical sampling, which was profoundly used to create software for assembling computers.

Some interpretations of the analysis of films about mathematicians

Through each movie, we can extract certain singularities present in the stories, even if, in many ways, they are different, with particular details and life trajectories without much relation – with their respective details linked to the elaboration of the script, the approach to the characters and even the vision behind the direction for the stories. As they are biopics of mathematicians and/or mathematicians, the movies rely on a certain commitment to reality, seeking to portray situations with the greatest possible historical accuracy. However, as it is an artistic medium that aims, above all, to adapt a story for a limited duration, structured in an ordering of dialogues and scenes, it is possible to notice that some details about these trajectories undergo modifications.

The representation of the majority suffers from a stereotype that has long been linked to "geniuses": they are antisocial, arrogant, have great difficulty relating and communicating with other people, end up being initially discredited and sometimes misunderstood, and still acquire striking features that are different from what can be considered "normal"; as in the cases of mathematicians established by *A Beautiful Mind* (2001), *The Imitation Game* (2014) and *The Man Who New Infinity* (2015). Each one has a different journey and struggle, although, deep down, they want to achieve only one thing: recognition and/or achievement – they were people who studied hard to get to where they are.

The stereotype of "weird", "clumsy" and "crazy" seems to orbit the cinematic incarnations of portrayed scientists, as if it were an absolute truth about people who dedicate themselves to science, discoveries, and great intellectual revolutions. Even though addressing the theme is linked only to the mathematical scope, there seems to be a commitment from the filmmakers to this image. This can, in many ways, distance or bring together the general public, who, in their eagerness to know the life story of a particular scientist, find themselves capable of creating affection through identification, surprise, or even pity. However, the opposite can also occur, causing the viewer to move away from the idea or possibility of wanting to look like them. If we carefully analyze the details provided by each production, we will realize that this choice is intentional; There seems to be a romanticism built around the figure of the "problematic" genius, establishing itself so much in the popular imagination that, even when it is not an adaptation of real events and characters, it is present.

It is interesting to reflect on the image that the mathematician ends up showing to people outside of studies in the area, or even internally. They are seen and portrayed as alien and/or arrogant, hated by the majority, but who, to the detriment of their genius, have their "flaws", which are often disregarded. After all, as highlighted by most productions, genius must require this type of behavior. It is also possible to notice that there is a certain pattern that permeates all the stories analyzed: there are always mentions of other geniuses who, in one way or another, seem to move and even inspire the protagonists and supporting characters. We can notice that certain names appear frequently throughout the journeys of the characters in this category, used as a driving force for the formation of the figure whose life is narrated.

However, although this stereotype is present in some stories, it is not present in all incarnations. As is the case, for example, with *Adventures of a Mathematician* (2021) and *October Sky* (1998), here, the mathematicians have their problems, but, above all, they do not have much difficulty relating to other people. The first is established as someone charismatic and charming, with dilemmas cloistered by an appearance that seeks to sustain a "mask" of concerns, while the second addresses students at a school, with shy behaviors inherent to their teenage ages, working on innocence and dreams.

Another fundamental fact to be noticed is how mathematics gains its deserved prominence in the productions aimed at them; we see a historically reliable description of their difficulties, in which,

in most cases, their abilities, skills, and aspirations were massacred by machismo and misogyny; as is the case with *Ágora* (2009) and *Hidden Figures* (2016). In addition to being protagonists, female support groups also have strength and representation, as in *A Brilliant Mind* (2001) and *The Imitation Game* (2014), helping in the construction and discoveries that permeate the narratives exposed through the adventures.

It is also important to highlight the presence of war in most movies in this category, appearing as an engine for the development of the plots, to inspire the protagonists and supporting characters in their respective revolutionary acts. We see the appearance of ancient wars, as well as some more current ones, which marked the 20th century – such as the First and Second World Wars, as well as the Cold War.

FINAL CONSIDERATIONS

In this paper, we seek to understand and analyze cinematographic works that, in one way or another, use Mathematics to formulate their plots. From the observations made and recorded here, we can draw some conclusions regarding the main objective of the work, considering the details provided and the studies produced.

With three categories, the 23 movies had their respective stories described, drawing parallels with the parts of Mathematics they convey. Initially, we noticed that the categories had a balanced amount of production. In the first, dealing with movies that have Mathematics as a background, we had a total of eight productions; in the second, dealing with movies that use Mathematics as a narrative tool, we also had a total of eight productions; and, finally, in the third, dealing with movies about mathematicians, covering their respective biopics, we had a total of seven productions. Along with the summaries and analyses, we have created a database for those who want to know what we cover, intending to make public the large production of cinematographic works with plots focused on Mathematics that we have had in recent times, some of which may be unknown to many people.

We conclude that each movie, although addressing common themes and sharing the aforementioned categories, follows its story in its own way, always having the director/screenwriter's vision as something unique. Those movies that deal with real stories sometimes make some concessions so that the journey can be told in a reduced and organized duration, while those movies that deal with fictional stories get it right, in short, by creating a plot worthy of attention and interest by the spectators. Observing fictional stories, as well as those based on real events, can help us better understand who the mathematical revolutionaries portrayed were and/or how Mathematics can interconnect with cinematographic art, building engaging narratives while also convincing viewers of its versatility. that this area of knowledge has.

To be able to analyze these works in a precise and satisfactory way for our objectives, bringing a series of discussions and interesting observations to make, and being able to broaden the horizon of readers-spectators who wish to find, perhaps, a more immersive and detailed about the stories of the movies covered, we discussed each film, reporting their stories, as well as their characters, while an investigation took place, observing the variety of approaches and mathematical references they contained.

Finally, immersed in this paper, we reflect on a detail that may have gone unnoticed by some. In one of the productions presented, we see that a certain number seems to orbit the most varied situations, finding present in the most unusual places. Although unintentionally, throughout this research, we arrived at a particular number of selected works, which, interestingly, also fit into the conspiracist vision adopted by the aforementioned story. We might even think that this is nothing more than a coincidence. However, even in the most unpredictable of them, certain nuances can make us believe that mere chance does not exist. In total, we analyzed 23 movies… could this be another sign?

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Author 2 - Coordinator of the work, active participation in the development of the research, data analysis, and review of the final writing.
Author 3 - Coordinator of the work, active participation in the development of the research, data analysis, and review of the final writing.

All authors read and approved the final version of this article.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this article.