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STEM IN MOVIES: FEMALE PRESERVICE TEACHERS' PERSPECTIVES ON MOVIE "HIDDEN FIGURES"

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Abstract. *Movies are informal teaching tools to make teaching relevant to a diverse group of students. The use of movies may enhance students' interest in science, technology, engineering, and mathematics (STEM). They can be effective tools to build students' interest in STEM fields and raise their awareness of STEM and STEM careers. This study purpose was to identify STEM-related topics in the movie "Hidden Figures" and determine preservice female teachers' views of it. The study sample included 19 female students. A qualitative phenomenological design research method was used. Data were collected using "the Movie Hidden Figures" and a "Semi-Structured Interview" forms. Qualitative data were analyzed using semiotics and content analysis. Analysis showed that Hidden Figures focus mostly on the theme of "gender perception in science" as well as "design process" and "advances in technology." Participants believed that the movie had messages mostly of negative gender perception in science. Despite that, movies emphasized that women can be mathematicians, engineers, and scientists as men. They also stated that gender equality is crucial in education. They also advocated that mathematics and engineering are essential for technological progress and female scientists can play a more active role for achievement.*

Keywords: *gender perception in science, hidden figures, women in movie, preservice teachers, STEM education*

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Introduction

Today, scientific and technological advances (Artificial Intelligence, Big Data, 3D Printer, Virtual Reality, Cyber Security, Artificial Womb, etc.) are becoming an integral part of our lives and changing it dramatically in different areas (health, economy, law, education etc.) (Soylu, 2018). For example, artificial intelligence and cyber security have changed how people perceive law, resulting in the introduction of laws on protection of personal data. These developments have also raised ethical debates on human cloning. Countries, today, need individuals with critical thinking, creativity, problem-solving, communication, and interdisciplinary skills who are capable of surviving in a competitive world because have come to the realization that the key to a strong economy is scientific and technological innovations (Bybee, 2010; Morrison, 2006). In short, scientific and technological advances have brought about drastic changes in numerous fields and promoted countries to revise their education systems. For example, in 2013, the USA released the Next Generation Science Standards to develop innovative skills and to maintain its global economic leadership (National Research Council [NRC], 2012; NGSS Lead States, 2013). Countries, therefore, focus on new educational approaches to turn students into more qualified people demanded by industry. One of those educational approaches is STEM developed in 2001 (Gonzalez & Kuenzi, 2012). STEM is an educational approach that integrates science, technology, engineering and mathematics and relates it to everyday life.

Many countries have implemented STEM in formal and informal education as it is expected to contribute to the development of critical and algorithmic thinking skills and creativity demanded in the twenty-first century (Bybee 2010; Çepni & Ormancı, 2018). STEM also enables students to face real-world problems, encouraging them to find creative solutions to their everyday problems and to develop new products at the end of the process. Another objective of STEM is to increase students' interest in science, mathematics, and engineering (Çepni & Ormancı, 2018). Yıldırım and Türk

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(2018) argue that STEM has been developed because white American students have reduced interest compared to African American, Indian and Chinese descendent students with increased interest in science, mathematics and engineering in the United States. Research also shows that students' interest in science, mathematics and engineering has declined (Dasgupta & Stout, 2014; Hall et al., 2011; Hayden et al., 2011; Tekerek & Karakaya, 2018; Yıldırım & Türk, 2018). Especially, female students have little interest in STEM fields (Yıldırım, 2016). Barton (1998) stated that STEM education programs often ignore how female students learn. For example, STEM fields often focus on high-level intelligence skills such as mechanism, logic, and rationality, but discredit such skills as altruism and collaboration (Diekman et al., 2010; Ross & Gatta, 2009). Women's learning paths are tied to understanding and strengthening the self-relation with others. Therefore, women are more likely to work in areas that promote social relationships. However, men are more likely to work in areas dominated by abstract concepts and physical objects (Maya, 2013). For example, the Society of Women Engineers stated that about 20% of engineering faculty students were women in 2003 (Reinking & Martin, 2018). Another factor making female students less interested in STEM is the fact that girls and boys are assigned different gender roles and tasks from an early age by their parents (Dasgupta & Stout, 2014; Konrad et. al., 2000). At that period, girls are taught about altruism, social skills, and the importance of having a family with children while boys are taught about problem-solving, competition, and exploring the physical world (Konrad et al., 2000). Furthermore, there are a few female role models that work in the STEM fields affecting women's interest in those areas negatively. For example, there are fewer female professors than their male counterparts working in the field of physics in the United States (Ginorio, 1995). Another factor is that gender-based constraints and misconceptions affect women's choice of occupation and prevent them from choosing jobs that would empower them to enjoy leadership and prestige (National Science Foundation [NSF], 2003). The last factor affecting women's interest in STEM fields is parents' educational background and financial status (Fan, 2013). Children grown in low-income families prioritize possible income and job opportunities before they are interested in STEM fields. Various institutions and organizations including UNESCO, GSRI and the Malaysian government focus on increasing female students' interest in STEM fields to increase the number of women involved (UNESCO Asia-Pacific Education Thematic Brief [UAPET], 2016; UNESCO Institute for Statistics, [UIS] 2015). Research also shows that there is a growing interest in STEM among female students (Crawford, 2010).

Countries promote STEM education to meet the challenges of the twenty-first century that require strengthening the workforce in STEM fields and STEM literacy (National Research Council [NRC], 2012). However, integration of STEM into education system to apply in classroom settings is not in desired levels. Teachers are responsible for implementing STEM in classrooms, and therefore, should have sufficient knowledge and skills about it (Türk et al., 2018). Teachers are active elements in formal education. In informal education, written and oral media and movies are used affecting students' interest in STEM fields.

People learn 10% of what they read, 20% of what they hear, 30% of what they see, 50% of what they see and hear, 80% of what they see, hear and say, and 90% of what they see, hear, touch and say (Demirel, 2012). In other words, the focus should be on mass media that appeal to all senses. One of those media tool is movies. Movies provide rich learning environments to make classes entertaining and promote academic achievement (Weinstein, 2001; Woelders, 2007). Movies allow students to learn in a simple and interesting way and to help them develop high-level thinking skills. The movies also provide information about both societies and economic and cultural structures (Chansel, 2003). Movies are, therefore, used as course materials in formal learning environments.

Studies focus on the effect of STEM on variables such as attitude, motivation, and gender equality (Gülhan & Şahin, 2016; Karakaya et al., 2018; Reinking & Martin, 2018; Stoet et al., 2018; Toma & Greca, 2018; Yamak et. al., 2014). Movies have been analyzed based on issues such as gender equality and false scientific knowledge (Barriga et al., 2010; Kalaycı, 2015). No research on STEM in movies and preservice teachers' views of movies has been studied, recently.

Research Originality and Gaps in Literature

There is a small body of research on STEM in movies. However, those studies have three limitations. First, they do not address how gender-based stereotypes in science are portrayed by movies. Second, they do not determine female preservice teachers' views of STEM in movies. Third, they do not look into the repercussions of STEM fields in movies and do not integrate them into classes. Therefore, this is the first study to focus on all those three aspects.

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Significance and Objectives

The aim of the study was to examine STEM fields and to determine female preservice teachers' views of the movie "Hidden Figures". Another aim of this study was to analyze STEM subjects in movies and gender-based career choices in STEM fields. This may be the first study to focus on gender perception in movies, STEM education, gender-based perceptions of STEM careers, and female preservice teachers' views of them. This study would encourage more researchers to study gender equality in movies. Furthermore, this study would raise researchers' and teachers' awareness of gender equality and STEM education and encourage filmmakers to integrate STEM subjects to movies. This study would enable female teachers to teach about the prevalence of gender stereotypes in science and enable Interested parties to take into account gender equality when developing science curricula. In this context, the aim of the study was to analyze the movie "Hidden Figures" in terms of STEM education, to address gender stereotypes in movies, and to determine what female preservice teachers thought about the movie. The main research question was: "How can we analyze the movie "Hidden Figures" in terms of STEM education and what do female preservice teachers think about the movie?". The study sought answers to the following questions:

1. How does the movie "Hidden Figures" depict gender discrimination and highlight the importance of STEM fields?
2. How did participants elucidate the importance of STEM fields after seeing the movie?
3. How did the movie change the way participants viewed gender discrimination?

Research Methodology

Design

This phenomenological study determined preservice teachers' views of the movie "Hidden Figures." Phenomenology is used to collect detailed information from people with experience about a common phenomenon or an incident (Yıldırım & Şimşek, 2011). Phenomenology focuses on how people attach meaning to an event and of what phenomena they are aware (Soydemir, 2015). This study also explored how the movie depicted gender-based stereotypes in science and the role of STEM fields and how it changed preservice teachers' views of gender discrimination and the importance of STEM fields.

Research Process

Preservice teachers received eight weeks of intensive STEM course (4 hours a week), including the following topics: the history and importance of STEM education, STEM integration into teaching, Engineering design process and teaching engineering, Modelling in STEM education, Gender Equality in STEM education, STEM Experience 1: STEM Activity: Designing a Water Rocket, STEM Experience 2: Designing a Satellite and a Telescope, STEM Experience 3: Mathematical modeling of footprint and designing a shoe in instructional technologies and material design to have participants with basic STEM knowledge for study. Movies provide rich learning environments, make classes more fun, and promote academic performance (Weinstein 2001; Woelders, 2007). After STEM education, participants watched the movie all together in the classroom. They were asked to take notes while watching the movie and keep them along with the class. They had a discussion after they saw the movie. Each participant was interviewed at the end of the STEM education. The data were analyzed using content analysis. Figure 1 shows the research process.

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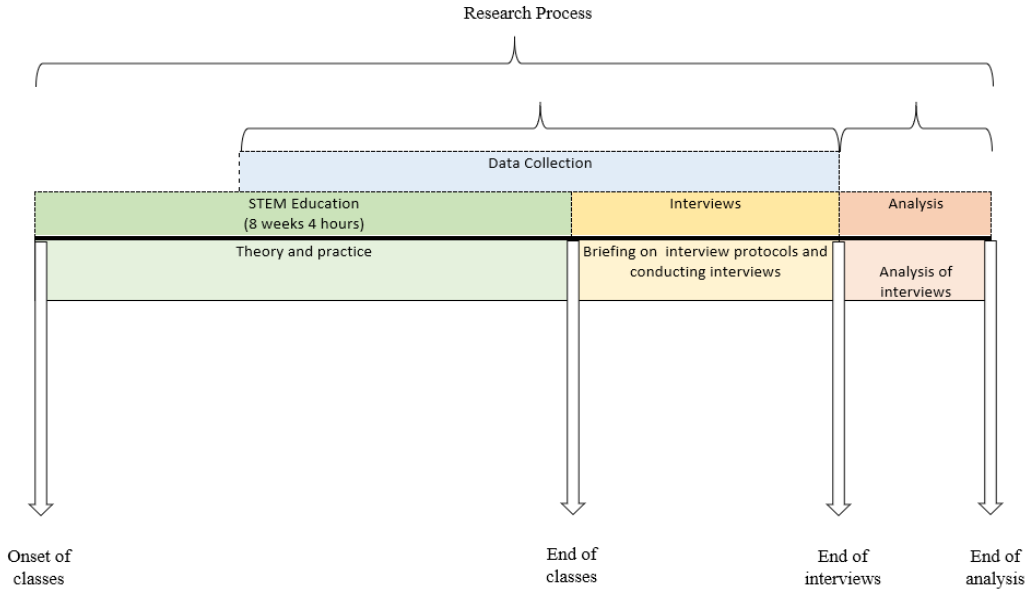
Figure 1
Research Process



Participants

The study sample consisted of 19 female students from the faculty of education at a public university. Participants were recruited using convenience sampling, which is a purposive sampling method with a non-probability methodology. Convenience sampling is a time- and cost-efficient method by which researchers select participants most suited to their research purpose (Balcı, 2015; Patton, 2012). Convenience sampling was chosen for two reasons: (1) the sample consisted of STEM-trained preservice teachers, and (2) preservice teachers agreed to participate. The sample consisted of female preservice teachers for three reasons. First, curricula focus little on women's ways of learning and mostly encourage them to pursue careers in fields where they are expected to make use of social skills (Barton, 1998; Legewie & DiPrete, 2014; Roos & Gatta, 2009). Second, socially constructed gender norms determine the position of women in education (Ceci & Williams, 2010). For example, there is a general misconception that men are better at math than women (Jacobs & Eccles, 1992). Parents focus on their sons' performance more than on their daughters' although girls are as good as boys at math. Therefore, they encourage their sons to study STEM fields (Diekman et al., 2010). This is also evident from the fact that only two out of ten engineering faculty students are women and that the number of male professors is greater than that of female professors in engineering departments of most universities (Ginorio, 1995; Reinking & Martin, 2018). Third, there are few female role models in STEM fields, preventing women from choosing STEM-related jobs that would empower them to enjoy leadership and prestige (NSF, 2003). Students who receive positive feedback from role models are more likely to have high academic performance and be confident and interested in STEM fields. Teachers' personality traits, experiences, media visibility, and personal and pedagogical beliefs also play an important role in students' interest in STEM fields (Christiansen & Knezek, 2017; Franzak, 2002). Cultural beliefs affect female teachers' and preservice teachers' personal experiences. They teach gender stereotypes to their students advertently or inadvertently. This affects female students' interest in STEM fields and their career choices.

Participants received eight weeks of intensive STEM course (4 hours a week), including the following topics: the history and importance of STEM education, STEM integration into teaching, Engineering design process and teaching engineering, Modelling in STEM education, Gender Equality in STEM education, STEM Experience 1: STEM Activity: Designing a Water Rocket, STEM Experience 2: Designing a Satellite and a Telescope, STEM Experience 3: Mathematical modeling of footprint and designing a shoe in instructional technologies and material design to have participants with basic STEM knowledge for study. Participants were coded as T1, T2, T3, etc. to ensure confidentiality.

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Instrument and Procedures

The Movie Hidden Figures

Hidden Figures, directed by Theodore Melfi and released in 2017 is about three African-American women, Katherine G. Johnson, Dorothy Vaughan and Mary Jackson, who work for NASA. The movie highlights their problems, gender repression, and the importance of mathematics and engineering. Hidden Figures is a dramatic-biographical movie addressing the position of the USA in the space race and its contribution to technology. The movie, "Hidden Figures" sent different messages to the audiences, it can be used as a teaching tool that can aid students' understanding of STEM, STEM careers, and discrimination in STEM. Also, the movie could be used as a course content as well. Therefore, movies have similar content to "Hidden Figures" that are suitable for teaching engineering-related knowledge.

"Hidden Figures" is about three successful African American women (Kathrine Johnson, Dorothy Vaughan, and Mary Jackson) who play a key role in the launch of the Mercury – 7 spacecraft (America's first spacecraft) and in the space race between the Soviet Union (USSR) and the United States (US). The USSR is planning to launch the Korabl-Sputnik-4 satellite to orbit to become the first country to send humans into space. NASA is concerned that that might be a security threat as the USSR may collect intelligence about the United States. This news accelerates the work on the design of a spacecraft. Al Harrison, who is the first director of NASA's Manned Spacecraft Center, realizes that the IBM computer is not developed enough for space calculations. To overcome this problem, he demands that the employees of that department specialize in analytical geometry, and then, hires Kathrine, Dorothy, and Mary, who are three African American female mathematicians of West Area Computing. Dorothy is the head of West Area Computing, Mary is an assistant engineer, and Katrine is a geometric analyst. After a while, Dorothy tells her manager, Vivian Mitchell, that she is underpaid and has not been promoted to the position she had been promised for. However, Vivian ignores her complaint. Meanwhile, Mary works at the engineering department and witnesses that the Mercury – 7 spacecraft fails the wind tests. Karl Zielinski, the head of the engineering department, asks her what she thinks might be the problem and is impressed by her intelligence. He challenges racial and gender stereotypes and encourages Mary to become an engineer.

Meanwhile, Glenn's team starts preparing for a pilot test to launch "Friendship 7" spacecraft into space. Dorothy is worried that the IBM 7090 computer purchased by NASA will put them out of work. However, Dorothy, who specializes in FORTRAN programming language, secures herself a position to work with the IBM computer. Meanwhile, Mary receives a court rule that grants her permission to attend night classes to obtain her engineering degree. She is the first African American female to attend an all-white college to become an engineer. John Glenn asks Kathrine, Paul, and Al to make orbital calculations for the launch of Friendship 7, however, IBM fails that task. Therefore, Kathrine starts to make the calculations. The day John Glenn is to fly the Friendship 7 mission, Al realizes that IBM calculations are erroneous, and therefore, asks Kathrine to do them instead. Friendship 7 is successfully launched and orbited the Earth.

Development of Interview Form for the Movie "Hidden Figures"

Semi-structured interviews were conducted to determine participants' views of Hidden Figures. All preservice teachers were informed of the research purpose, procedure, and protocol prior to participation. Informed consent was obtained from those who agreed to participate. The purpose of a semi-structured interview form is to help researchers to control the course of interviews. The Interview Form for Hidden Figures (IFFHF) consisted of five open-ended questions. After development of initial version of the form, IFFHF was consulted to two experts with completed their doctoral studies on STEM education. The researcher finalized the IFFHF based on expert feedback. Afterwards, a pilot study was conducted with three preservice teachers, who were asked if they had difficulty understanding any of the IFFHF items. After the pilot study, the IFFHF was finalized (Appendix 1).


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Data Analysis

Hidden Figures Analysis Process

Analysis of the Movie "Hidden Figures"

First, movies about gender perception in science and STEM fields and their impact on society were determined. Two researchers watched the movie separately and evaluated its content-appropriateness for STEM. Hidden Figures was the movie of choice because it contains scenes related to gender equality in STEM and many other aspects of it.

A code booklet was developed before film analysis and then the researcher and an expert watched the movie. The researcher and an expert identified the characters and took notes of the events that the characters experienced while watching movie. Only the events that happened to the characters were noted. The researchers transferred the notes to a computer separately. The notes were examined comparatively, and codes were developed. Table 1 shows the codes.

Table 1
Gender Perception, Technology, and Design Process in Hidden Figures

Theme	Codes	Theme	Codes
Gender Perception in STEM	Interest in mathematics	Gender Perception in STEM	Interest in programming
	Problem-solving ability		Studying at the faculty of engineering
	Fault detection and elimination		Right to education
	Being a mathematician		Teaching Programming
	Engineering education program		Being an astronaut
Technology	Technological advancements	Design process	Testing and evaluating
	Benefits of technology		Identifying problems
	Ergonomics of technological devices		Developing possible solutions
	Arise of ethical problems after technological innovations		Redesigning
	The emergence of new jobs		Completing the model

The parts on which the researchers and expert agreed and disagreed were identified during coding. They discussed the codes on which they disagreed to reach a consensus. Afterwards, interrater reliability was calculated using the formula [Reliability = (number of agreements) / (number of agreements + number of disagreements)*100] suggested by Miles and Huberman (1994). The interrater reliability was ((20/20 + 5) * 100) = 80%, indicating acceptable reliability in this study.

The codes were analyzed using semiotics analysis and presented in Tables under the categories of the sign, signified, signifier, and connotation. The researchers first created the Tables separately. Afterwards, they and the expert discussed the Tables to reach a consensus. All stages of the content and semiotics analysis were explained in detail to achieve reliability and objectivity.

Analysis of Interview

Data were analyzed using content analysis. The researchers transcribed the 285-minute audio recording and coded it. The interviews lasted 10 to 20 minutes. Table 2 shows the duration of the interviews. The researcher and expert determined the agreed and disagreed parts of table during coding to reach a consensus. Afterwards, interrater reliability was calculated using the formula [Reliability = (number of agreements) / (number of agreements + number of disagreements)*100] suggested by Miles and Huberman (1994). The interrater reliability was ((36/36 + 6) * 100) = 85.71% indicating an acceptable reliability in this study.

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Table 2
Interview Duration

Participant Code	Duration (min)	Participant Code	Duration (min)	Participant Code	Duration (min)	Participant Code	Duration (min)
T1	10	T6	10	T11	17	T16	16
T2	11	T7	18	T12	14	T17	20
T3	20	T8	12	T13	16	T18	10
T4	13	T9	19	T14	15	T19	15
T5	17	T10	18	T15	14		

* The values in the table are approximate.

Research Results

Analysis of "Hidden Figures" in Terms of Gender Perception in Science

The first result of the semiotics analysis was "gender perception in science." Table 3 shows the results.

Table 3
Semiotic Analysis of the Results of Gender Perception in Science

Sign	**Signified**	**Signifier**	Connotation
Interest in mathematics	A Girl enjoys counting prime numbers and polygons	One can be interested in mathematics.	Girls can be interested in mathematics.
Problem-solving	A 10-year-old girl solves a high school math problem.	One can solve problems.	Girls can have superior math skills.
Fault detection and elimination	Dorothy detects and repairs the failure of the car.	One can detect and repair car failures.	Women can also detect and repair car failures.
Being a mathematician	There is no male mathematician to work in the space mission group, and therefore, Katherine is included in the space mission group as a mathematician.	One can be a mathematician.	Both men and women can be mathematicians.
Enrolling in Engineering education program	Mary's application to the engineering education program is rejected because she is a woman.	One can enroll in the engineering program.	Women can also enroll in the engineering education program.
Being an astronaut	All the astronauts to be sent into space by The USA are men.	One can be an astronaut.	Only men can be astronauts.
Interest in programming	Dorothy wants to work on a computer with the IBM 7090 operating system, but her request is ignored.	One can be interested in programming.	Women may also be interested in programming training.
Studying at the faculty of engineering	Mary wants to study at the faculty of engineering but is rejected because she is a woman.	One can study at the faculty of engineering.	Women can also study engineering.
Applying to court	Mary applies to the court to study at the faculty of engineering.	One can apply to the court for the right to education.	Everyone has the right to education regardless of gender.
Teaching Programming	Dorothy teaches programming.	One can teach programming.	Women can also teach programming.

All cases referred to as signs could be performed by both men and women. However, the movie argued that only men could have math and engineering skills and be interested in working in those fields. For example, Mary was not allowed to study engineering because she was a woman.

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Analysis of "Hidden Figures" in Terms of the Importance of STEM Fields

The second result of the semiotics analysis was analyzed under the titles of the "design process" (Table 4) and "advances in technology" (Table 5).

Table 4
Semiotic Analysis of the Results of Design Process

Sign	**Signified**	**Signifier**	Connotation
Testing and evaluating	The Mercury 7 spacecraft designed by NASA to launch into space is tested.	Spacecraft can be tested and evaluated.	After prototypes are designed, they are tested and evaluated based on test results.
Identifying problems	The heat shields of the Mercury 7 spacecraft fail during testing.	Problems can be identified.	Some problems may arise during the testing of prototypes.
Developing possible solutions	NASA engineers cannot find a solution to the failure of the heat shields; however, Mary suggests a solution.	Solutions can be developed.	There are multiple solutions to everyday problems.
Redesigning	The Mercury 7 spacecraft is retested after a solution is proposed for the heat shields.	Spacecraft can be redesigned.	All prototypes can be improved.
Completing the model	NASA finishes testing the Mercury-7 and then launches it.	Models can be completed.	Longitudinal studies and tests yield successful results.
Doing calculations correctly	The Mercury 7 spacecraft is brought back from space; however, it falls into the ocean and disappears because of inaccurate mathematical and engineering calculations.	Calculations can be done correctly.	Doing math and engineering calculations correctly are critical.

Table 5
Semiotic Analysis of the Results Regarding Technology

Sign	**Signified**	**Signifier**	Connotation
Keeping up with developments	Americans watch Russia launch a rocket.	Advances in technology can be kept up.	Advances in technology concern the whole community on a global scale.
Using the computer	An IBM computer with a 7090 operating system is purchased to calculate the trajectory of the rocket quickly and correctly.	The computer can be used.	Technological tools can be used to make faster and more reliable calculations.
Big computer	The IBM computer with the 7090 operating system is the size of a room.	A computer can be the size of a room.	Earlier inventions may not be ergonomic and useful.
Being unemployed	Dorothy and her colleagues are worried that the IBM 7090 computer will put them out of work.	One can be unemployed.	Developments in technology may cause some jobs to disappear
The emergence of new jobs	Dorothy, worrying about unemployment, starts to work on programming and teaches it to her colleagues as well.	New jobs may emerge.	Software-based jobs may emerge in the future.
Sending people into space	Russia made technological progress and sent Yuri Gagarin into space.	Humans can be sent into space.	Technology always advances.
Protecting the independence of the country	After Russia's first successful human space flight, Americans think that Russia will attack their country.	The independence of the country can be protected.	Advances in technology can be used for different purposes.

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All stages referred to as signs were about the steps of the engineering design process. The movie focused especially on testing and evaluating, followed by identifying problems, developing solutions and redesigning. In prototype testing, the problems in the prototypes were determined. For example, the failure of the heat shields of the Mercury – 7 spacecraft during the test and Mary's suggestion of replacing screws with a different material was about the step of "testing and evaluating."

All signs were about technology. The movie highlighted the pros and cons of technology and that the earliest inventions were not ergonomic. For example, Dorothy and her colleagues were worried that the IBM 7090 computer purchased by NASA would put them out of work.

Analysis of "Hidden Figures" in Terms of the Importance of STEM Fields by Pre-Service Teachers

Participants' Views of Gender Perception in Science in "Hidden Figures"

The second research question addressed participants' views and observations of gender perception in science. Table 6 presents their views of gender perceptions in "Hidden Figures".

Table 6
Participants' Views of Gender Perception in Science in "Hidden Figures"

Theme	Codes	Quotes
Gender Perception in Science	Female mathematician (*N*=8)	*Women can be mathematicians, too. For example, to everyone's astonishment, the female characters in the movie calculated the trajectory of the craft (T1).*
	Female engineer (*N* = 6)	*The movie portrays that only men are encouraged to be involved in engineering. However, Mary and her colleagues' interest in engineering shows that engineering is not just a man's world (T2).*
	Gender equality in education (*N* = 5)	*The movie tells the story of women who overcome numerous obstacles to achieve great things and shows that education and science know no gender boundaries (T4).*
	Female scientist (*N* = 5)	*As portrayed by the movie, women can be successful in different fields and engage in science as well as men (T13).*
	Social pressure (*N* = 3)	*The movie portrays gender discrimination, where women's educational and occupational opportunities are very limited, and they do not have much say in social life (T3).*
	Women's interest in math-related fields (*N* = 2)	*Anyone can be a mathematician or an engineer, and women can also be interested in those fields (T18).*

Participants believed that women could be interested in math-related fields and become successful mathematicians, scientists, and engineers. Moreover, they were in favor of gender equality in education and were against social pressure.

The second research question of the second subproblem addressed in what way participants changed their perceptions of gender stereotypes in science after they watched the movie (Table 7).

The movie did not change most participants' gender perceptions in science. However, some participants stated that their gender perceptions in science changed after watching it. One participant was undecided because she did not know about the concept of gender perception in science (Table 7).

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Table 7
Changes in Participants' Views of Gender Perception in Science

Theme	Codes	Quotations
Change in Views	No (*N*=10)	I didn't change my mind either before or after I saw the movie because I believe that women are as successful in the scientific world as men anyway (T5). I already believed that there should be no gender discrimination in science before I saw the movie, and seeing the movie made me realize that I was right on that (T11).
	Yes (*N*=8)	It's always male scientists that get the spotlight when it comes to popularity or success, and women are always pushed back, so I think that everybody should see the movie "Hidden Figures." (T7). I changed my mind when I saw the movie because I think that both men and women should be allowed to speak up their minds, and whichever makes more sense should be the way to go (T8).
	Undecided (*N*=1)	I had no idea about the gender discrimination going on in science before I saw the movie, so I really don't know what to say (T2).

The second research problem addressed what participants thought about the conviction that there was only room for gifted women in STEM fields. All participants stated that it was wrong to believe that only gifted women could be successful in STEM fields. The following are direct quotations from participants:

> T1: I don't think it's right to assume that it's only gifted women that can thrive in STEM fields. I think that people who are trained in STEM fields can be successful at different levels depending on personal differences rather than their gender. I also think that gifted students can become more successful than others.
> T9: You don't need to be gifted to succeed in STEM or any other field. Anyone who believes in themselves can succeed in whatever they may want to do.
> T14: Katherina is gifted and successful in mathematics. But Mary and Dorothy are successful in engineering and management, even though they are not gifted.
> T15: It would be sexist if we took only Katherine or argued that it is only women that succeed things. All people are successful in paths that suit their interests and abilities.

Participants' views and observations of gender discrimination in science highlighted by the movie were conveyed to preservice teachers. All participants stated that they found it wrong. The following are direct quotations from participants:

> T4: I find gender discriminatory statements and sexist remarks wrong because they divide us and alienate and marginalize people.
> T7: We can't just look at STEM as a male or female thing. Intelligence, talents, and views of both men and women matter.
> T12: Any discrimination is ridiculous, not only in STEM fields but in any field. Women can be great engineers, and men can be great chefs, I mean, discrimination just doesn't make any sense.

Participants' Views of the Importance of STEM Fields in "Hidden Figures"

Participants' views and observations of technological advances portrayed by the movie were also conveyed to preservice teachers. Table 8 presents their views.

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Table 8
Participants' Views of Advances in Technology in "Hidden Figures"

Theme	Codes	Quotes
Technology	Economic development (*N*=11)	*Development level of a country depends largely on technology because technological innovations contribute to the economy (T12).*
	Protecting independence (*N*=7)	*If a country is technologically backward, it is weaker than other countries. They can easily destroy it. For example, in the movie, Americans fear that Russia will bomb them from space (T17).*
	Keeping up with the times (*N*=5)	*In Hidden Figures, they used technology for space exploration. A country with high technology becomes wealthy and ahead of its time and rules it (T13).*
	Improving quality of life (*N*=4)	*A country with no technology has poor living conditions. Technology improves living conditions (T3).*
	International competition (*N*=4)	*Technology is essential to countries because they compete with each other not through tomatoes or cucumbers that they produce but through technology that they develop. The production of rockets in the movie proves this point (T16).*
	Making life easier (*N*=4)	*Technology makes our lives easier (T15).*
	Emergence of new jobs (*N*=3)	*The characters in the movie fear that the computer will cost them their jobs, but new technology will actually create new jobs (T9).*
	Concern of the whole society (*N*=2)	*As can be seen in Hidden Figures, global developments concern all humanity. Russia launching the first human spaceflight and Americans watching it (T1).*
	Being unemployed (*N*=2)	*As can be seen in Hidden Figures, new technology may eliminate many jobs, which is a disadvantage of technological advances (T4).*

Participants focused on the social effects of advances in technology. They stated that technological progress played a crucial role in economic development, protecting independence, keeping up with the times and improving quality of life. For example, the fact that Dorothy and her colleagues learned programming suggests that a new job had emerged.

The third question addressed participants' views of the way the steps of the engineering design process are used in "Hidden Figures". Table 9 shows the interview results.

Table 9
Participants' Views of Steps of Engineering Design Process in "Hidden Figures"

Theme	Codes	Example Quotes
Engineering design process Developing possible solutions (*N*=8) Defining the problem (*N*=8) Completing the model (*N*=4) Redesigning (*N*=1)	Prototype testing and evaluating (*N*=12)	*First of all, deficiencies of the rocket had to be detected and overcome. For example, the rocket material was found to have no frictional resistance and so was replaced by a better metal (T18).*
	In their investigations on the rocket, they first identified the problem and tried to find solutions to it (T11).	
	NASA's rocket was not launching, which was a problem. It mobilized people and got them to start working on it (T14).	
	They followed a specific process to build the rocket, the rocket satisfied the necessary conditions, and so, they finalized it and successfully launched it (T13).	
	With the heat shields being dislodged, Mary suggested that screws be replaced with another material, and so the rocket was rebuilt (T18).	

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Theme	Codes	Example Quotes
Advantages of Engineering	New product design (*N*=7)	*We live in an era of technology. Advances in technology bring people together. For example, the engineers and mathematicians in the movie worked together to build a rocket (T1).*
	Application of theoretical knowledge (*N*=7)	*Scientists develop scientific knowledge, which engineers use to develop new products. In the movie, they used all the necessary information and built a perfect spaceship (T8).*
	Emergence of new ideas (*N*=6)	*New technological devices result in new technological knowledge. While building a spacecraft, scientists and engineers discovered new things that they did not intend to discover at the beginning (T6).*
	Problem-solving (*N*=3)	*Engineering helps us solve problems. Engineers first identify problems. For example, in the movie, the U.S.A. saw the USSR as a threat, and so the engineers had to figure out how to build a spacecraft (T4).*
	Increase in productivity (*N*=3)	*We can use machines to have higher productivity instead of us doing calculations manually (T9).*
	Life improvement (*N*=4)	*Advances in technology improve the way we live and work; they make us more productive (T5).*
Engineering Careers	Careers in engineering (Metallurgical and materials engineering) (*N*=2)	*Engineering is necessary to know what design and materials to use. That's why material engineering is important. Designing rockets with different materials is an excellent example of this in the movie (T2).*

Most participants addressed the steps of the engineering design process of "prototype testing and evaluating," "developing possible solutions," "defining the problem," "completing the model" and "redesigning."

Participants' views and observations on the use of mathematics in "Hidden Figures" were asked to preservice teachers. Table 10 presents their views.

Table 10
Participants' Views of Use of Mathematics in "Hidden Figures"

Theme	Codes	Quotes
Mathematics	Mathematical calculation (*N*=12)	*The rocket did not launch because of incorrect mathematical calculations (T10).*
	Problem solving (*N*=10)	*Math was used to launch the rocket and to solve design problems (T7).*
	Being in every aspect of life (*N*=3)	*Mathematics is in every aspect of our lives. For example, in Hidden Figures, mathematics was used to send the rocket into space and to bring it back and so mathematics is everywhere in life (T2).*
	Use for product development (*N*=3)	*Technological products are not developed by trial and error. Products are developed as a result of mathematical knowledge and calculations (T6).*

Most participants stated that in "Hidden Figures", mathematics was used to make calculations and to solve problems. They also stated that mathematics was everywhere in life and was also used in product development.

The fifth question addressed participants' views of use of engineering in "Hidden Figures". Table 11 presents their views.

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Table 11
Participants' Views of Use of Engineering in "Hidden Figures"

Theme	Codes	Quotes
Engineering	Product design (*N*=7)	We live is the era of technology, and therefore, the objective of engineering is to develop technological products, like building a rocket in the movie (T1).
	From theory to practice (*N*=7)	A theory should be put into practice to develop products. At this point, we turn to engineering. In the movie, a good design was secured after all the necessary information was provided (T8).
	The emergence of new ideas (*N*=6)	It enables new ideas to emerge (T6).
	Problem solving (*N*=3)	If it were not for engineering, many design process problems would have arisen (T4).
	Productivity (*N*=3)	There is no production, design or innovation without engineering (T9).
	Being in every aspect of life (*N*=2)	Engineering is in every aspect of our lives (T14).
	Improvement of living conditions (*N*=2)	If it were not for engineers, there would be no new advances in technology and no improvement in living conditions (T5).
	Metallurgical and materials engineering (*N*=2)	Engineering is necessary for the proper design and use of materials. That is why material engineering is important. Designing rockets with different materials is an excellent example of this in the movie (T2).

Participants stated that, in "Hidden Figures," engineering was used to design new products, to put theory into practice, and to develop new ideas as well as to solve problems. They also stated that engineering was in every aspect of life.

Discussion

Firstly, film analysis results are given in the first sub-problem. The results show that "Hidden Figures" contain three STEM-related themes: (1) Gender perception in science, (2) design process and (3) advances in technology. First, we focus on gender perception in science. Both men and women can perform jobs (doing mathematical calculations, using a computer, etc.) highlighted by the movie. However, the movie also conveys messages that those jobs are being performed only by men due to gender norms of the period. Movies provide information about social, economic and cultural structures (Chansel, 2003). "Hidden Figures" also underlines the gender norms of the period. From a holistic perspective, we can argue that it delivers messages about gender norms. As a matter of fact, movies in the US emphasized gender inequality until 1970. The feminist movement emerging after 1970 took action to prevent from gender inequality in movies and encouraged women to pursue industry-related careers (Bielby & Bielby, 1996). The results show that Hidden Figures contains messages about negative gender perceptions in science, which has been reported by previous studies as well (Knight & Cunningham, 2004; Legewie & DiPrete, 2014).

Another result is about the social impacts of technology. "Hidden Figures" points out that advances in technology concern whole society with positive and negative social impacts. The movie also argues that technology is necessary to take the lead in the space race and to protect the independence of the country. Moreover, the movie also shows that women can make significant contributions to technology as well as men irrespective of gender. Scenes from "Hidden Figures" provides good examples of the social impacts of advances in technology. Therefore, it can be used to expand a course content. Previous studies highlight that movies are affective learning materials to teach different topics (Akbaş et al., 2018; Birkök 2008; Bursalı & Topçuoğlu Ünal, 2015; Chansel, 2003; Demirel, 2012; Derin & Yıldız, 2018; Pekdağ & Le Marechal, 2007; Stoddard, 2009). Movies can be shown in entirely or by scene. Movies turn abstract concepts into tangible and visual representations and increase learning


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retention. Movies also appeal to multiple senses and provide effective learning (Demirel, 2012; Stoddard, 2009). Movies provide effective learning environment and evoke emotions (Derin & Yıldız, 2018).

The last result is about the "design process.""Hidden Figures" describes the Mercury-7 rocket design process in detail. The movie highlights the testing and evaluation of the prototype. The movie shows an example of engineering design processes. It can, therefore, be used to teach the steps of the engineering design process to preservice teachers. The movie also illustrates possible design problems and solutions that engineers might experience. These results show that "Hidden Figures" can be used as an audiovisual course material to teach the steps of the engineering design process. It also shows preservice teachers how design stages are used in daily life. Sarıtaş (2007) argues that preservice teachers cannot make much sense of theoretical knowledge to use it in everyday life unless they learn skills, attitudes, and behaviors in real educational settings. Concrete examples allow preservice teachers to reinforce what they have learned. We can state that Hidden Figures provides preservice teachers with the opportunity to experience skills, attitudes, and behaviors in real educational settings. Kocabaş et al. (2000) state that preservice teachers should see theoretical knowledge in real-life settings. Movies portraying design processes should, therefore, be used in educational settings. Movies portraying design processes should be used in educational settings. "Hidden Figures" showed our participants incidents related to design processes proving that team-work with an involvement of both men and women. The fact that a woman is involved in the design processes in the movie shows that women can also be as successful in engineering as men.

The first research question of the second subproblem discussed participants' views of gender perception in science. They emphasized that women can also be engineers, mathematicians, and scientists. Yıldırım and Türk (2018) also concluded that engineering is a suitable job for both women and men in consistent with the results. Numerous studies, however, show that there is a misconception that mathematics and engineering are more suitable for men (Capobianco et al., 2011; Koçabaş et al., 2000; NRC, 2012; The Girl Scout Research Institute [GSRI], 2012). That misconception may be due to social culture (Dasgupta & Stout, 2014; Konrad et. al., 2000). Our participants also highlighted that social pressure is an important factor in the formation of that misconception.

Social pressure, misconceptions, and negative attitudes confine women to a limited number of occupations and encourage only few of them to pursue careers in fields that would empower them and let them enjoy leadership and prestige (Purvis, 1997). For example, there is a misconception in American culture that men are more suited to mathematics than women (NSF, 2003). In some societies, there is a misconception that women are good at verbal fields but not at mathematics and engineering (GSRI, 2012). The misconception that women are bad at mathematics and engineering is taught at an early age. From that period on, boys and girls are assigned different societal roles, which teach them what kind of gender roles they are expected to perform (Dasgupta & Stout, 2014). Girls are taught about altruism, social skills, and the importance of having a family with children. On the other hand, boys are encouraged to explore the world, learn the mechanics of objects, compete with one another, make money, and solve problems (Konrad, et. al, 2000). These assigned gender roles cause girls to lose interest in engineering and mathematics (Yıldırım & Türk, 2018) which is reinforced by movies as well. In fact, until 1970, movies in the US reproduced unequal gender roles and dissuaded women from pursuing a career in engineering and mathematics. Although the feminist movement turned the tide, women are still not interested enough in those areas (Bielby & Bielby, 1996). For example, the Society of Women Engineers stated that only 20% of engineering faculty students were women in 2003 (Reinking & Martin, 2018). Research also shows that men are more interested in mathematics, science and engineering than women (Gündüz et al., 2015). The majority (81.39%) of the top 1000 students who choose to study STEM fields in Turkey are male (Tarkın-Çelikkıran & Aydın-Günbatar, 2017). State institutions and organizations work to increase female students' interest in STEM fields (GSRI, 2012; UAPET, 2016).

Preservice teachers stated that there should be gender equality in education. As emphasized by the Universal Declaration of Human Rights, everyone has the right to education regardless of language, religion, race, or gender. In practice, however, not everyone has equal educational opportunities. Girls are the most deprived of education (Maya, 2013) and are more likely to drop out of school than their male counterparts (United Nations International Children's Emergency Fund [UNICEF], 2002). Today, gender equality in education is very critical (Unterhalter, 2008). Hidden Figures delivers messages that gender equality in education should be a priority. We can, therefore, state that everyone has the right to education, regardless of gender, and that that right should not be denied in any way. Preservice teachers should be encouraged to watch movies emphasizing gender equality and portraying successful women. Female characters depicted as role models in movies may negatively affect girls' self-perceptions and cause them to develop the belief that they cannot be as successful in some fields as

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men. Hidden Figures illustrates that women also have the right to education and that they can be successful in the fields of mathematics and engineering. Although the movie portrays women who are successful in STEM, it also features Katherine Johnson's marriage, which causes girls to embrace the misconception that marriage is necessary for women to be successful in life. It is, however, not necessary to refer to marriage to portray a woman who is successful in STEM fields.

The first research question of the second subproblem discussed whether participants changed their minds about gender perception in science after they watched the movie. Most of them stated that it did not make a difference in their views because they had no idea that there were such things as gender stereotypes in science until they watched the movie. However, some participants stated that the movie changed their views. They used to think that men were more successful in STEM fields than women but when they saw the success story of the three women in the movie, they changed their minds about gender roles in science. One participant was undecided because she did not know about the concept of gender perception in science. These results show that the movie was effective in changing some participants' views of gender stereotypes in science. Even though movies about gender discrimination in science do not change the opinions of all viewers, they convey instructive messages that might change some viewers' opinions. American movies until the 1970s reproduced gender inequality. However, the feminist movement that started in the 1970s took action to tackle sexism in the movies and encouraged women to choose careers in the film industry (Bielby & Bielby, 1996). Our results are consistent with the literature. However, some movies still convey discriminatory messages. For example, Kalaycı (2015) mentioned that the movie "Pepee" conveyed the messages that reproduce gender stereotypes in science, which was inconsistent with our result.

The third question of the first research question of the second subproblem discussed what participants thought about the conviction that there is only room for gifted women in STEM fields. All participants stated that one did not need to be gifted to succeed in STEM fields. The last result of the second subproblem showed that all participants believed that gender discrimination addressed by the movie was wrong.

Another result is about advances in technology. Participants emphasized the positive and negative societal impacts of advances in technology. They stated that technology plays a crucial role in economic development, protecting independence, keeping up with the times and improving quality of life. This result is similar to those reported by previous studies. Barro and Sala-i-Martin (1995) stated that advances in technology promote economic development and increase capital accumulation. Yıldırım (2016) also concluded that technological progress increases the growth rate of economy, improves quality of life, and makes life easier. Both our results and those of previous studies suggest that technological advances have social and individual impacts.

Participants stated that technology causes unemployment but also creates new jobs. This result is consistent with those of previous studies. Research shows that technology will eliminate some jobs and cause an increase in unemployment but that it will also create new jobs (Çepni & Ormancı, 2018). The World Economic Forum (2018) also states that increased robotization and automation will eliminate many jobs and increase unemployment but will also open up new fields of occupation and employment. Shellenbarger (2019) argues that such jobs as network system analysis and biomedical engineering will have developed by 2018. Talwar and Hancock (2010) also state that such jobs as building human body parts, elderly health management, space piloting, waste data processing and virtual clutter organizing will be popular in the future. These results show that technological progress has an effect on jobs. For example, in Hidden Figures, Dorothy and her colleagues are afraid of losing their jobs because NASA buys a computer with the IBM 7090 operating system to calculate the trajectory of the Mercury 7 rocket, and therefore, they begin to learn how to do programming. In fact, Çepni and Ormancı (2018) also argued that Industry 4.0 will create new jobs while making some others completely obsolete, which is similar to our results.

Another result is about the design process. Participants stated that Hidden Figures addressed the steps of the design process of "prototype testing and evaluating," "developing possible solutions," "defining the problem," "redesigning" and "completing the model," which are regarded as the steps of the engineering design process. The engineering design process is defined as the process of finding solutions to real problems in a meaningful way (NRC, 2012). According to Hynes et al. (2011) the engineering design process consists of eight steps: (1) defining the problem, (2) researching the problem, (3) developing possible solutions, (4) choosing the best solution, (5) creating a prototype, (6) testing and evaluating, (7) communicating and (8) redesigning. Seeing real examples of these steps allows preservice students to learn them in a meaningful way.

This study determined preservice teachers' views and observations on the use of mathematics and engineer-

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ing in the movie "Hidden Figures." Participants stated that mathematics is used to make calculations, to solve problems, and to develop products, and that it is in every aspect of life. Engineering helps to develop new ideas, put theoretical knowledge into practice, and design new products and that it is also in every aspect of life. Our results are similar to those of previous studies. According to Kızılay (2016), engineering allows us to develop new products and inventions and put theory into practice. Feisel and Rosa (2005) pointed out engineering as a process in which theoretical knowledge was put into practice. Asunda (2012) also defined it as an area that integrates scientific knowledge with technology. The results, therefore, show that our participants' perceptions of the use of engineering are similar to those of teachers and preservice teachers reported by previous studies.

Conclusions

The results showed that the movie "Hidden Figures" focused on "Gender Perception in Science," "Design Process," and "Advances in Technology." The movie depicts how some occupational fields were dominated by men, even though women are as capable as men to pursue careers in those fields. This points to the gender norms and beliefs that were dominant in the American society back then. The movie also shows that advances in technology change the social structure both positively and negatively. For example, the movie elaborates that advance in technology provides new job opportunities while causing some other jobs to disappear.

The movie also addresses gender-based stereotypes in science. Participants had no gender-based stereotypes regarding professions. They believed that both men and women could be engineers, mathematicians, and scientists. They also believed in gender equality in education. As for the movie, they noted that advances in technology had pros (providing new job opportunities and improving the standards of living) and cons (causing unemployment). They also remarked that these developments affected the social structure. They stated that the movie depicted all steps of a design process that should be followed to achieve advances in technology.

Implications for Further Research

Future studies should focus on different movies about gender perception in science and STEM professions. In-depth and long-term studies should adopt the data diversification method to discuss movies from different perspectives. Movies have great impacts on society. Therefore, movies should focus more on gender equality in education and science. This study focused on the movie "Hidden Figures" because it addressed STEM education and gender perception in STEM fields. Educators should incorporate movies into their classes. This study explored female preservice teachers' views. Future studies focus on different groups. We think that this study will be of great interest to researchers in the fields of STEM education, gender stereotypes in professional contexts, and gender perception in science.

Appendix -1:

Interview Form for Hidden Figures (IFFHF)

1. Consider the movie "Hidden Figures" and evaluate gender perception in STEM education.
   (a) Do you think that the movie "Hidden Figures" changed your views on gender perception in science? Could you please elaborate on it?
   (b) What do you think about gender discrimination underlined by the movie?
   (c) Do you think that only gifted women can be successful in STEM fields? Could you please elaborate on it?
2. What are your views and observations concerning the importance of technological developments illustrated by the movie "Hidden Figures"?
3. What are your views on the importance of engineering design processes illustrated by the movie "Hidden Figures"?
4. What are your views on the importance of mathematics underlined by the movie "Hidden Figures"?
5. What are your views on the use of engineering by the movie "Hidden Figures"?

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Declaration of Interest

Authors declare no competing interest.

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