Mathematics in the Media Mirror

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Overview

How are mathematicians and the subject of mathematics itself viewed in our society? And is that perception a fair and accurate one? How are mathematicians and mathematics portrayed in film and other branches of popular media? Once again, is that portrayal fair and accurate? As teachers of mathematics, we want students to value the subject they are learning, but this desire often flies in the face of what students are exposed to in the popular culture, and in fact, in society in general. The purpose of this document is to explore the answers to the questions posed above and to suggest ways in which students and teachers can examine the perceptions and portrayals of mathematics and mathematicians in the media and in society in useful ways to deconstruct the often negative and misleading messages that are conveyed.

Rationale

A *Google* search on the words "popular culture," "mirror," and "society" will return close to 600,000 results. This is just a quick search of the Internet, and doesn't even begin to scratch the surface of what has been put into print on this subject. It seems that a lot of people have a lot to say on how film, television, music and fiction serve as a mirror to our society. Within these branches of popular media, we see an image of the real world. There is no question that the image is distorted, but the distortion itself often provides tremendous insight into our society's perception of this so-called "real world." It can reveal what we value and what we disdain; it can expose our fears and our hubris, our strengths and weaknesses. An exploration of these reflections can be a very valuable thing.

Since it is the case that these reflections truly are distorted, examining these reflections and understanding them is often critical to undoing the damage that

can be done by negative perceptions created by the distortions. The image of reality that is seen in the mirror of popular media can significantly impact an individual's or even the public's perception of the reality reflected there. How often do we hear news stories about concerns with scenes of violence on television, in movies and video games, and similarly sexual content in those media as well as popular music? The concern is how these images and content impact the public perception of sex and violence particularly in young people. Understanding and deconstructing the reflection we see in popular culture can help to lead to solutions for these types of problem.

This document is meant to address one small, but significant, aspect of our "real" world that is reflected just like everything else in the popular media, and that is the subject of mathematics. We can find numerous reflections of mathematics in television, film, books and play. Often those reflections are seriously misleading and can be damaging in the public perception they create. Examining the reflections of mathematics we find in our popular culture can help us construct the remedy to negative connotations that are often found in these distorted reflections.

Consider the opening scene from a relatively recent Oscar winning film. The scene opens with a panoramic shot of the city of Boston. The camera sweeps over the Charles River and pans in on the expansive campus of the Massachusetts Institute of Technology. As the camera shot gets closer and closer, one building begins to fill the screen. The scene cuts to the interior of a filled, auditorium-style classroom; the camera focuses on the professor at the front of the room. This is clearly a mathematics class, and the professor is finishing what appears to be a very difficult proof – it fills more than three chalk boards. After completing the proof, the professor turns to the class and announces that he has posted a problem on the whiteboard outside the classroom. Apparently this problem is being posted there as a challenge to the students at MIT and from what the professor says, it is a very difficult problem. The professor describes the problem as "an advanced Fourier system" and says that it is his "hope" that one member of his class will be able to solve it during the semester. He goes on further to state that in previous years the person to solve the annual challenge problem has gone on to great things – Nobel prize winners, Fields medal winners and the like have been the previous "winners." This must be a difficult problem indeed! As the students are dismissed from the class, the camera sweeps out of the room and pans around to the whiteboard hanging on the wall outside. There, we see the problem the professor has posted.

The scene just described is the opening scene from the movie *Good Will Hunting*. This film is about a brilliant but troubled young man, Will, played by Matt Damon, from a working class background who works as a janitor at MIT. Within

the first 15 minutes of the movie, Will has solved the problem on the board; so clearly, Will is a genius.

But wait a minute! Let's take a closer look at that problem posted on the whiteboard. It turns out, the problem is a basic problem from discrete graph theory*. The fundamentals of discrete graph theory can be mastered by anyone who has completed a course in intermediate algebra - in most high schools this would be Algebra 2. The problem posted on the board is given in four parts. As it turns out, three of those parts require no mathematics beyond a basic grounding in discrete graph theory and some intermediate algebra; the fourth part requires the same, plus some understanding of basic calculus. That's it – nothing else is required.

So what's going here? Why does the professor in the film imply that the rather elementary problem posted on the whiteboard is such a difficult problem? There are multiple layers to the answer to this question. Perhaps the simplest answer involves the well known concept of suspended disbelief. When approaching any piece of fiction particularly for entertainment purposes, whether it be a film or text, the reader/viewer must temporarily set aside certain knowledge of the real world and be willing to accept what is presented in the story as "the truth." In the case of *Good Will Hunting* then, the specific problem posted on the whiteboard is essentially irrelevant – the details involved in the solution are not a part of the plot of the film. So the viewer of the film can't be too concerned with the actual problem, but instead, must simply accept that the problem is a very difficult one, and thus, when Will solves it, this is a demonstration of the fact that Will is extremely intelligent. In fact, the board could just as easily have been filled with complete nonsense. As long as the viewer is willing to believe that what is written on the board is a very high-level and challenging problem, the writers and the director have achieved their purpose.

But this answer of suspended disbelief isn't quite satisfactory in this case, because the problem on the board is an actual mathematics problem, but it is a rather simple one. Certainly the writers and director could have added a touch of realism to this scene by just choosing one of the many difficult, high-level unsolved problems which exist in mathematics – so why didn't they? To answer

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* Discrete graph theory is relatively new branch of mathematics. First introduced in the late 1700's by Leonard Euler, discrete graphs weren't widely studied by mathematicians until the early 1900's when numerous applications in business and economics, biology and ecology, psychology and sociology and numerous other scientific and social endeavors. Discrete graph theory involves the representation of problem situations with diagrams (graphs) made up of discrete points (vertices) connected by segments and arcs (edges).

this question we need to understand the public perception of mathematics in our society and how that perception can be tied to the reflection of mathematics that we see in the mirror of popular culture.

I will certainly come back to *Good Will Hunting* and the issue raised above, but first, greater description and rationale of the curricula to be laid out in this document is probably in order.

The lessons presented here are being designed to be used in a course I currently teach called Advanced Topics in Mathematics. As such, they contain material very specific to that course. Thus, what will be presented here would not necessarily be appropriate as a complete unit in most high school math courses. Rather, it is my hope that the lessons presented here will provide ideas and inspiration to teachers who would like to explore the ideas discussed here in their own classrooms.

Advanced Topics opens with a unit on mathematics in literature, and I plan on using the proposed unit described herein as the closing unit – in a sense bringing the course full circle. In the opening unit, we look at how authors use mathematics to drive a story or make a point within a story. But at the same time we must be aware that the literature also reflects an image to the reader of the author's perception about mathematics. This unit on mathematics in film and television – "Mathematics and Popular Culture" – will explore similar questions and ideas. It is my intent to have this unit really serve as a capstone unit to the entire course. During the year, Advanced Topics explores a number of different topics in math that are not usually covered in a traditional high school sequence. Some unit topics include number theory and the Fibonacci numbers, game theory, chaos theory and discrete graph theory. Each of these branches of mathematics has been used in one or more films and/or television episodes. My aim will be to have students reflect on what they have done during the year as they watch several films, film clips, television episodes and clips from television shows. In this way I believe the unit will have the greatest impact.

Students will be prepared to critically think about the question, how does the portrayal of mathematics in popular culture compare to the "real" mathematics we have studied in class. For example, we spend a significant amount of time in the number theory unit on the Fibonacci numbers and the golden ratio. These related topics are employed in the film, *The Da Vinci Code*. So while watching *The Da Vinci Code*, students will have the opportunity to see the mathematics they have learned reflected in a popular film. Students will be able to discuss and write about how and why a screen writer or director might choose to use mathematics in a film, and to further analyze how the mathematics is portrayed and how that compares to the reality of the mathematics they have learned. Ultimately the unit

will provide students the opportunity to do this kind of reflection and analysis of many of the topics we have covered in class.

In general, the mathematical knowledge students will need to critically view and analyze the films, film clips and television episodes we will watch will be attained through various units in the course Advanced Topics in Mathematics. For teachers reading this document who would like to replicate this type of activity in their own classroom, I would simply recommend choosing films that touch on content they teach. Many films about schools and education include scenes from a mathematics room. The scenes may not be central to the film, but the idea here is to find mathematical content being displayed (often the chalkboards in movie classrooms are filled with content) and to analyze how mathematics is being portrayed on film. Students should also review the content for accuracy and appropriateness to the context; in a manner similar to the earlier discussion of the content from *Good Will Hunting*.

The ideas and activities to be developed here are a natural fit to the curriculum of Advanced Topics in Mathematics. And since more and more students are taking Advanced Topics in order to earn their fourth credit in mathematics as is now required by the Pittsburgh Public Schools, the lessons presented here are an exciting way to supplement and enrich the curriculum of this course. The ideas and activities explored in these lessons can be seamlessly woven into this class. Since the emphasis in these activities will be to write, analyze and think critically, the activities are also excellent ways of integrating writing into a mathematics class.

Objectives

The main goal of the lessons described in this document is to give students an opportunity to see the mathematics they have been learning all year in class portrayed in popular culture. I have found that students are astonished to see these ideas used in movies and television. In most cases the films we view and the television shows we watch are things many students have seen before, and the experience of viewing them in a mathematics class gives the students a new perspective on the media, and a chance to notice details they missed in their first viewing.

The students should be expected to view the various films and television shows with a critical eye, and with the goal of answering the following questions:

1. How is the mathematics portrayed in the film related to the mathematics we have covered in class?

2. Is the mathematics portrayed in the film, accurate, relevant to the film, appropriate to the film?
3. How does the mathematics help to develop the story or drive the plot?
4. How might the portrayal of mathematics in the film influence public perception of mathematics?

Through journaling, class discussions and more formal writing assignments, students will thoroughly explore the treatment of mathematics in popular media and gain a deeper appreciation for the mathematics that they have explored in class. In addition, by focusing their attention on the portrayal of mathematics in film and television, the students will develop a critical eye toward considering popular media as a mirror to society in general.

This unit was designed to encourage students to make connections between mathematics and the world around them and to encourage communication and writing that will include mathematical thinking. Both of these goals are well aligned with the Pittsburgh Public Schools and Pennsylvania State mathematics standards (see Appendix) as well as the standards set forth by the National Council of Teachers of Mathematics in their *Principles and Standards for School Mathematics* (2000).

Strategies

Essentially, for each film or television episode we view in class, the pedagogical strategies are the same. After viewing a film or television episode, students first write a journal entry to get down onto paper their initial reactions to the content. I use journaling throughout Advanced Topics to give students a chance to give their personal reactions to the new ideas and content they learn in class. Writing a journal entry gives students a chance to react to and reflect on what they have seen in the video selection and serves as a way for the students to formulate their ideas for the next phase of the activity.

After writing their journal entries, the students are given the opportunity to share their thoughts and reactions to the video with their classmates in an open class discussion of the video. Class discussions are very open processes in which all students are encouraged to share their thoughts and everyone is expected to listen to their peers, be respectful of everyone's thinking, but also to challenge each other's thinking and present new ideas and perspectives. Although I try to remove myself as much as possible from the discussion process, I do serve as facilitator during the discussion by asking pointed questions when the discussion lags and highlighting student comments that deal with the mathematical content of the selection. In my interventions, I try to guide students and steer the

discussion toward the relevant content of the film as it relates to what we have done in class.

Finally, as the culminating activity for each video selection, I have the students do a more formal writing assignment in which they specifically address the four questions I stated above. Generally this takes the form of a brief "review" type paper of 2 to 3 pages in length.

Classroom Activities

Rather than creating a day-by-day listing of "lessons," in this section, I will provide a brief summary of each piece of media I plan on using and briefly analyze some of the significant mathematical content integrated into each selection along with how the mathematics is portrayed. While I will present the pieces in the order I use them in my Advanced Topics classes, there is no prescribed order to these activities, and the reader should feel free to pick and choose from these selections. In addition, this set of films and television episodes is by no means exhaustive and I strongly encourage the reader to incorporate his or her own favorite films in activities of this type.

Good Will Hunting

After teaching an introductory unit on discrete graph theory I always show my classes the first ten minutes of *Good Will Hunting*. This clip is a prime example of the distorted portrayal of mathematics in popular media and thus serves as a excellent tool for introducing the theme of popular media as a mirror to society. As previously discussed, this clip involves a college professor posting what he describes as a highly challenging mathematics problem on the board and suggesting that only a handful of the best and brightest students in the class will be able to solve the problem during the term. Of course in actuality, the problem isn't difficult at all – after our introduction to graph theory, all the students in my classes can solve three of the four parts of the problem. Just a little background in calculus would allow the students to solve the fourth problem as well.

This naturally raises the question of why the writers of the film would use this particular problem in this context, and what the use of this content in this manner suggests about mathematics. *Good Will Hunting* uses mathematics in the most cliché manner possible. In order to portray a character as a genius, he is good at mathematics. This is a common portrayal of mathematics in popular culture – geniuses are good at math. This suggests that mathematics is an extremely difficult subject area – beyond the comprehension of the average person. The specific problem used in this clip isn't terribly important. All the writers needed was a problem that would seem foreign to most viewers of the film. Because graph theory is a relatively new branch of mathematics that most people never get

the opportunity to study, any problem from this field of mathematics would serve that purpose.

But the fact that the writers used this specific problem gives students a great opportunity to see the distorted image of mathematics being employed in popular media. Watching this clip and analyzing it during class gives my students a chance to deconstruct this media distortion and really begin to see the way that the image of mathematics, among other things, may be seriously warped in popular media. Viewing this clip has always been a real eye-opener for my students. In addition, students get the opportunity to see that some new, important and so-called advanced mathematics is well within their grasp.

The Da Vinci Code

This film is perhaps most notable for the mathematics it omits from the work it is based on. The novel by Dan Brown extensively discusses the Fibonnaci sequence and analyzes the use of the golden ratio in art of Leonardo Da Vinci. This film gives students an opportunity to see how, often, significant mathematics is simply given lip service in popular media. I generally show clips of this film to my classes after an extensive unit on the Fibonacci sequence and golden ratio. Early in the film the Fibonacci numbers play a role in breaking a simple anagrammed code while the art of Da Vinci is put on prominent display. Much later, a lengthy conversation involving an analysis of Da Vinci's "Last Supper" takes place – this conversation includes some mathematical elements to it. Once the students have had a chance to really explore these elegant, seemingly omnipresent numbers in class, they are stunned to see these marvelous yet relatively simple ideas passed over so shallowly in the film.

Once again, this provides an excellent opportunity for students to contemplate why the mathematics presented is, essentially, distorted in this portrayal and to compare the "Hollywood" treatment with the reality. It is remarkable to witness how indignant the students become over this "short-shrifting" of the subject matter.

The Butterfly Effect and *A Sound of Thunder*

After completing a unit on chaos theory, I show students scenes from both of these movies which each present interpretations of the famous "butterfly effect[*]" result from this branch of mathematics. The first popularization of this mathematical result was put into print in the form of the short story "A Sound of

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[*] The "butterfly effect" principle is actually based on a mathematical phenomenon known as extreme sensitivity to changes in initial conditions. The effect suggests that a butterfly flapping its wings in the rain forests of Brazil may be responsible for a typhoon months later in Thailand.

Thunder" by Ray Bradbury (1953). Bradbury applies the mathematical principle to the fantasy of time travel – what if a traveler to the past changed a very small, seemingly insignificant thing in the past? How might that affect the "present" from which he came? Both of these films explore this question, so this presents an excellent "compare and contrast" opportunity to have students consider how the same mathematical concept is presented in two different films. The films approach the mathematics in very different ways, and with different degrees of depth. But there are numerous similarities as well. In addition, both films distort the mathematical ideas so students have the chance to also compare and contrast these portrayals with the actual mathematics they have studied in class.

The so-called butterfly effect arises from chaos theory out of some sophisticated and involved mathematics. It would be difficult in film to accurately portray this complexity without losing a significant portion of the audience. Thus, these films also give students the opportunity to consider the necessity of simplifying mathematical themes and content in film and to discuss whether or not such simplifications are legitimate or not.

The Simpsons, "Treehouse of Horror V"
The animated show, *The Simpsons*, has been running for 19 seasons, and the writers continue to make mathematical references in many of the episodes. This particular episode plays on the same themes as those developed in the two films previously mentioned, and I like to show this episode to my classes after we have analyzed and discussed those films. The writers of the *The Simpsons* have always used their show as a vehicle for social commentary, and this particular episode is no exception. So showing this video is particularly interesting as the episode is almost a meta-mirror reflecting the reflection of mathematics in popular culture. The episode is clearly a tongue-in-cheek satire of the use of complicated mathematical ideas in overly simplified and silly ways. Thus, viewing this show gives students the chance to see that, in fact, the entertainment industry, or at least some parts of it, is often self-aware of the ways in which it misrepresents elements of our society.

Jurassic Park
This film is an adaptation of the novel by the same name by Michael Crichton (1990). As with *The Da Vinci Code*, this film removes most of the significant mathematics covered in the book, but it still includes several scenes in which chaos theory is explicitly discussed. In particular, in one scene, a mathematician uses a physical simulation to demonstrate chaos theory at work. Once again, it is a vast over simplification of the mathematical principle, and students can see this immediately. After showing this clip in class, I want students to begin to consider how significant mathematics is often trivialized in its portrayal in popular media and to begin questioning why this is the case. The aim here again, is to recognize

the distorted image of mathematics being reflected in the mirror of popular culture so as to be able to understand and deconstruct it.

The Simpsons, "Homer 3D"
After completing a unit on fractal geometry, in which students are introduced to a completely new way of defining dimension, I like to show this episode of *The Simpsons* in class as the notion of dimension is central to show. It also gives students the opportunities to make connections with the novel *Flatland* which we read in the literature unit of the class and which also focuses on concepts central to the notion of dimension. This particular episode uses the mathematical idea of dimension in very sophisticated ways, and thus viewing this show allows students to see mathematics in a mainstream, popular show being used without over simplifying the content or watering it down. This is a very different portrayal of mathematics than that included in many of the media samples we've viewed up to this point.

A Beautiful Mind
Early in our unit on game theory, I show students the first 40 minutes of this film biopic of the life of John Nash. The first 40 minutes cover Nash's time as a graduate student at Princeton University where he developed what he called his theory of governing dynamics. This theory resolved numerous flaws and paradoxes that existed in the field of game theory up to this point. Nash's inspiration for his theory was remarkably simple, and the insight developed in the film lets students see how elegant, but simple ideas can have major implications in a field of study. While, once again, many of the mathematical ideas presented in the film are simplified, in the case of *A Beautiful Mind*, the simplification helps to make the mathematics clear, rather than trivialize it.

It is also significant to note that John Nash is a schizophrenic and his mental illness plays a central role in the film. This provides an opportunity for students to think about another common use of mathematics in popular media – that is, as a vehicle for connecting genius with madness. While Nash truly is mentally ill, students are aware that this connection is often made in films and television, very often with mathematics as the vehicle for the genius. Discussing this film provides students the opportunity to deconstruct this portrayal and to consider whether these two things are, in fact, connected. Discussing these ideas in the context of this film helps to build a foundation for the final film I use during the class, *Pi*.

The Princess Bride
This film fairy tale by William Goldman weaves game theory throughout the story in both explicit and subtle ways. I show the entire film to my classes after we have completed the unit on game theory and ask students to note as many

different examples from game theory as they can in the story line. This film is a wonderful example of the way in which mathematics can be employed in a piece of popular media without being diluted or trivialized. Students are delighted to see the ideas and concepts they have been studying in class come alive in film.

Pi

This is a very dark film about a mathematical genius's descent into madness. While this film portrays this false connection between genius and insanity, it also covers a lot of significant mathematics from the Fibonacci numbers and the golden ratio to fractals and chaos and game theory. It covers much of this mathematics without over simplification or trivialization. For this reason, this film is an excellent summarizing tool for the year. I like to use scenes from this film – the content is too mature to show the entire film in class – to help tie the themes we have developed on film and popular culture as a mirror to society together, as well as really tying the entire course together. Equipped with the mental tools we have developed in class, students can see the portrayal of madness for what it is – a cliché; while at the same time appreciating the mathematics developed in the film and seeing how connected the study of mathematics really is. Number theory, game theory, chaos theory, fractal geometry, graph theory – these are not disconnected fields of study, but rather all interwoven pieces of a single fabric – mathematics.

War Games

I actually use the final scene from *War Games* as part of the final exam for Advanced Topics. In the scene, tic-tac-toe is analyzed and discovered to be a trivial game, as no player can hope to win, and then this idea is used as a metaphor for nuclear war. Having students write about this scene gives me the opportunity to not only assess their understanding of the ideas we developed in our unit on game theory, but also to assess their internalization of the themes we covered in our exploration of the portrayal of mathematics in popular media.

Annotated Bibliography/Resources

Allen, Don, *Math at the Movies,* 10 June 2007 <http://www.math.tamu.edu/~dallen/hollywood/index.htm>.
This site is a comprehensive source of mathematics caught on film. The site divides the film into categories based on their content. It also includes links to other related sites.

Bradbury, Ray, *Golden Apples of the Sun and Other Stories,* "A Sound of Thunder," 1953, Doubleday, New York, NY.

Crichton, Michael, *Jurassic Park*, 1990, Knopf Publishing, New York, NY.

Dalton, Mary, B., *The Hollywood Curriculum*, 1999, Peter Lang, New York, NY.
This book is a thoughtful, complete consideration of the portrayal of education in film. This work is an excellent starting point for anyone considering using film in their classroom as a means of examining how popular culture serves as a reflection to our society.

National Council of Teachers of Mathematics, *Principles and Standards for School Mathematics*, 2000, NCTM, Reston, VA.

Reinhold, A. G., *Math in the Movies*, 28 June 2007 <http://world.std.com/~reinhold/mathmovies.html>.
This site is an excellent source of content cataloguing a myriad of mathematical references on film.

Suggested Film and Television Sources

A Beautiful Mind, 2001, Writers: Akiva Goldsman (screenplay), Sylvia Nassar (book); Director: Ron Howard, DVD.
This movie is a biopic about the mathematician John Nash who revolutionized the branch of mathematics known as game theory by developing a theory of cooperative strategy. Several early scenes in the movie deal specifically with the insights Nash had into game theory and how he turned conventional thinking in the subject upside-down.

The Butterfly Effect, 2004, Writers: J. Mackye Gruber and Eric Bress; Directors: Eric Bress and J. Mackye Gruber, DVD.

This movie is based on the popularization of the mathematical result known as the butterfly effect. The butterfly effect is a result from chaos theory that says that many mathematical systems display an extreme sensitivity to initial conditions. The butterfly effect was first popularized by Ray Bradbury in the short story "A Sound of Thunder" in which the main character travels back in time to hunt dinosaurs and inadvertently steps off a set pathway, thereby crushing a small butterfly. When the time traveler returns to the present, he discovers that everything has changed. This movie plays on a variation of that theme.

The Da Vinci Code, 2006, Writers: Akiva Goldsman (screenplay), Dan Brown (novel); Director: Ron Howard, DVD.
The Fibonacci numbers and the Golden Ratio take center stage in this story. Number theory along with the role of mathematics in art, architecture and beauty itself are implied themes in this film.

Good Will Hunting, 1997, Writers: Ben Affleck and Matt Damon; Director: Gus Van Sant, DVD.
In the opening scene of this film, viewers are briefly exposed to a problem from the branch of mathematics known as discrete graph theory. There is little explicit mathematics in the movie beyond this one scene.

Jurassic Park, 1993, Writer: Michael Crichton; Director: Steven Spielberg, DVD.
Several scenes in this movie explicitly address concepts from Chaos Theory.

Pi, 1998, Writers: Dareen Aronofsky and Sean Gullette; Director: Darren Aronofsky, DVD.
Mathematics takes central stage in this movie with explicit discussions of mathematical content from numerous branches of mathematics.

Mean Girls, 2004, Writers: Rosalind Wiseman (book), Tina Fey (screenplay); Director: Mark Waters, DVD.
This film tells the story of high school girl who goes from a home-schooled environment to that of a public high school. One of the sub-plots of the film involves this girl trying to get the attention of a boy she likes. One of the ways she does this is by intentionally doing poorly in mathematics class so that the boy will tutor here. Several scenes in the problem show characters actively involved in solving calculus problems.

Numb3rs, Season 1, 2004/05, CBS, DVD.

Numb3rs, Season 2, 2005/06, CBS, DVD.
This show, about a brilliant mathematician who works with his brother, an FBI agent, to solve crimes, highlights different mathematical concepts and problem solving strategies in each episode. Generally the descriptions and discussions of mathematics in each episode are significant over simplifications of the actual mathematics.

The Princess Bride, 1987, Writer: William Goldman; Director: Rob Reiner, DVD.
The story line in this film employs elements of game theory throughout. William Goldman intentionally worked the ideas developed in the theory of two-player games into his book and movie script. In particular, the scene where Wesley verbally spars with the Sicilian is a classic example of a zero-sum, two-player game.

Proof, 2005, Writer: David Auburn; Director: John Madden, DVD.
The theme of this movie is the commonly perceived connection between genius and madness. This theme is developed by telling the story of a brilliant mathematician who may have solved one of the greatest unsolved mathematical problems of all time. Or perhaps she is just insane – like her father, also a great mathematician.

The Simpsons, "Homer 3D," 3F04, Season 7, 1995, FOX, DVD.

The Simpsons, "Treehouse of Horror V," 2F05, Season 6, 1994, FOX, DVD.
Even after 19 seasons, *The Simpsons* continues to be a sharp reflection of American society. Numerous episodes include mathematical references and several episodes are devoted to mathematical themes.

A Sound of Thunder, 2005, Writer: Ray Bradbury (short story), Thomas Dean Donnelly (screenplay), Director: Peter Hyams, DVD.
This film is a loose adaptation of the Ray Bradbury story by the same name. In addition to playing on the butterfly effect first popularized in the short story, several scenes from this film include explicit discussions of the mathematics of chaos theory.

Stand and Deliver, 1988, Writers: Ramon Menendez and Tom Musca; Director: Ramon Menendez, DVD.

This film biopic tells the story of Jaime Escalante, a mathematics teacher in a barrio high school in Las Angeles. The film involves several scenes that include explicit mathematics, including images from actual AP Calculus exams from the early 1980's.

War Games, 1983, Writers: Lawrence Lasker and Walter F. Parkes; Director: John Badham, DVD.

Another film explicitly referencing concepts from game theory, this film focuses on nuclear war as the most extreme example of a zero-sum, two player game. The final scene involves an analysis of tic-tac-toe as a futile game because if both players play perfectly, the game will always result in a tie.

Appendix – Content Standards

Academic Standards for Mathematics

Pennsylvania Department of Education

2.4 ***Mathematical Reasoning and Connections***

2.4.11 – At the 11th grade students will be able to:

Connect the mathematics they have learned to other content areas including but not limited to the physical, biological and social sciences.

2.5 *Mathematical Problem Solving and Communication*

2.5.11 – At the 11th grade students will be able to:

A. Select and use appropriate mathematical concepts and techniques from different areas of mathematics and apply them to solving non-routine and multi-step problems.

B. Conclude a solution process with a summary of results and evaluate the degree to which the results obtained represent an acceptable response to the initial problem and why the reasoning is valid.