Dispositions of Scientists in Mainstream Films: The Extraordinary Person Called a Scientist

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Science education reform documents (AAAS, 1989, 1993; NRC, 1996, 2013) stress the notion that K-12 students should have an understanding of science in order to make informed decisions. The scientific endeavor is the overarching theme in K-12 education, but we can get so caught up in “the facts” surrounding science that we forget to inform our students about the people who actually conduct science, i.e. the scientist. There is a widely held stereotypical perception that a scientist is someone who (1) is male with facial hair, (2) wears a lab coat, glasses, and pocket protector, (3) works in a laboratory with bubbling beakers of unknown fluids, and (4) has thoughts of great discoveries or “eureka moments” (Finson, 2002). But is this stereotypical caricature truly reflective of the people who conduct science? Story telling through film and television is a powerful tool for portraying science and the scientist. Extending our research of mainstream films’ portrayal of nature of science (NOS) and scientific inquiry (SI) (Koehler, Binns, & Bloom, 2013), we have developed the construct of the dispositions of scientists (DOS). In this chapter, we introduce this construct to examine the affective behaviors of the scientist in order expand upon the stereotypical perception so often held by students. We
will provide examples from mainstream films in which various DOS aspects are portrayed and will compare and contrast these film characters to demonstrate the variety of dispositions of scientists that are conveyed in mainstream box office films. We will conclude the chapter by providing strategies on how to teach DOS in the classroom using mainstream films and discuss the implications that DOS has for science education and science education research.

**Introduction**

The National Science Board (2010) report, *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation’s Human Capital*, recommended preparing K-12 students with 21st Century skills stating, “early exposure to STEM is particularly important, since interest in STEM often begins to blossom in elementary school, and early exposure to science can strongly influence future career plans” (p. 17). Unfortunately, students often have inaccurate conceptions of the scientific endeavor and perceptions about what kind of person conducts science, (e.g. the stereotypical scientist) and this perception may sway their future plans for a career in science. Much research (Bohrmann & Akerson, 2001; Chambers, 1983; Mason, Kahle, & Gardner, 1991) has explored K-12 students’ perceptions about the scientist, including the type of work they conduct, their mannerisms, and their physical attire. Research uses the draw-a-scientist test (DAST) to reveal how scientists are portrayed by a stereotypical prototype, e.g. as white males with crazy hair, wearing a lab coat with pocket protector, carrying an Erlenmeyer flask, and working in a laboratory. Finson (2002) noted that after 50 years of DAST research, students (of all ages) still draw a scientist to be a white, male chemist with crazy hair. He suggests that teachers are influential in how they portray scientists in their classrooms. We contend that it is not only teachers who have an influence on students’ perceptions about scientists, but also how the media portrays the scientist.
Storytelling is and has been a primary means of communication. In preliterate societies, orally transmitted mythology, folklore, and fairy tales were the literature that conveyed information from one generation to the next (Bettelheim, 1989). Such romanticized stories engage the listener (learner) because they are filled with exciting and exotic representations of the world that can enliven the imagination and encourage learning (Bettelheim, 1975; Bloom, 2011; Egan, 1997). Egan (1997) emphasizes the role of storytelling as a powerful technique “for shaping the hearers’ emotional commitment to content” through “vivid images.” He argues that storytelling is a strategy to be used for “initiation of the young into the knowledge, skills, values and commitments of the adult members of society” (p. 10). Indeed, specific to science instruction, recent research has recognized the impact of romanticizing science content to enhance learning gains (Hadzigeorgiou & Schulz, 2013; Hadzigeorgiou, Klassen, & Klassen, 2012). In today’s modern age, such romanticized stories more often communicated through video media and, with the advent of hand-held mobile devices, people are even more often, and with more ease, able to entertain themselves with television shows, movies, and YouTube™. Science students today often form conceptions of what a scientist is and what a scientist does based on what they see in movies and television; unfortunately, oftentimes this conception is misguided or (Finson, 2002). However, purposeful selection and use of films that depict scientists more authentically can convey more sophisticated and realistic impressions of the qualities that scientists possess (Bloom, Koehler, & Binns, 2013; Koehler, Binns, & Bloom, 2014). It is with the use of mainstream, Hollywood films that we begin our exploration of dispositions of scientists (DOS).

**Literature Review**
Researchers have argued that films portray scientists in many ways, including: mad, bad, and dangerous (Frayling, 2005); sorcerers, tyrants, spies, or traitors (Weart, 1988); and psychotics, false would-be gods, and absentminded, well-meaning goofs (Ribalow, 1998). Haynes (1994) identified six recurrent stereotypes in western literature and films, which include: the alchemist/mad scientist, the absent-minded professor, the unfeeling scientist, the heroic adventurer, the helpless scientist, and the idealist. Kirby (2008) found that these stereotypes were dominant during different decades throughout the 20th century, with heroic scientists as the dominant stereotype found in films over the past 20 years. Others also identified heroic scientists as the more recent theme (Elena, 1993; Frayling, 2005; Perkowitz, 2007). Nisbet and Dudo (2011) identified four archetypes: the sinister or mad scientist, the powerless scientist, the eccentric/anti-social scientist, and the heroic scientist. However, although there seems to be some common stereotypes, there is not one dominant image of scientists in television or films (Bell, Lewenstein, Shouse, & Feder, 2009; Nisbet & Dudo, 2011).

Although there seems to be no common stereotype found in films, it is important to understand the general physical characteristics that filmmakers often portray. Two common physical characteristics of scientists that researchers found were scientists being depicted as white (Dudo et al., 2011; Long, Boiarsky, & Thayer, 2001; Long et al., 2010; Weingart, Muhl, & Pansegrau, 2003) and male (Dudo et al., 2011; Elena, 1993, 1997; Flicker, 2003; Hornig, 1990; Long et al., 2010; Steinke & Long, 1996; Weingart et al., 2003). Only one investigation found that male and female scientist depictions occurred with equal frequency (Long et al., 2001). Additionally, when female scientists were included in the television programs or films, they were generally portrayed as occupying a lower career status than males (Steinke & Long, 1996;
Weingart et al., 2003). One exception is that Steinke (2005) found films presenting female scientists in positions of high professional status equivalent to males.

Steinke (2005) reported that many portrayals of female scientists and engineers highlighted their physical appearance. Flicker (2003) noted that women scientists are typically portrayed in a negative fashion (e.g. old maid, naïve, evil, lonely heroine, etc.). However, Perkowitz (2007) argued that stronger film roles for female scientists emerged in the late 20th century, including Eleanor “Ellie” Arroway in Contact, Jo Harding in Twister, and Ellie Sattler in Jurassic Park.

It is interesting to note that several researchers identified the character Ellie Arroway from Contact as an authentic representation of a female astronomer. Perkowitz (2007) referred to Ellie Arroway as “among the better portrayals of a scientist in film” (p. 206). Steinke (1999) investigated how Ellie was portrayed and compared this to experiences of real female scientists in the United States. She found that like real female scientists, Ellie’s professional status was questioned and she had to deal with several personal issues, such as the impact of family life on her career. Steinke (1999) concluded that Ellie Arroway is the “prototype of what a woman scientist role model should be” (p. 133). Flicker (2003) and Frayling (2005) both identify Ellie Arroway as a scientist-heroine. However, while this character tends to have strong qualifications and typically a higher level of confidence than men, Ellie still has to aggressively advocate for herself when interacting with people in the position of power (Flicker, 2003).

Finally, it is important to understand the role of science consultants when addressing how films represent scientists. Frank (2003) and Kirby (2003, 2011) found that actors tend to go to great lengths to portray scientists authentically, paying close attention to dress, speech, and behavior at the worksite. For example, Jodie Foster, who played Ellie Arroway in Contact,
sought advice from the science consultants as well as NASA scientists in an attempt to present
Ellie as authentic as possible. The actors in the film *Twister* learned from real scientists at the
National Severe Storms Laboratory (NSSL). Nevertheless, while Frayling (2005) agrees that
scientists are presented in a more positive light than in earlier films, he argues that scientists are
presented as “mavericks, usually with a new-age approach, who stand outside the institutions of
science and sidestep their peers” (p. 50).

Research into the psychological characteristics of scientists’ can be found dating back to
1874 when Francis Galton collected self-reported data on 180 English men of science. In his
findings, he reported these men to be: energetic, physically healthy, were independent,
persevering, and had good memories (as cited in Feist & Gorman, 1998). Later research at the
turn of the century (Cattell, 1910; Cox 1926; Terman, 1925) found similar traits for scientists
including desire to excel, originality, ability to reason, determination, neat, accurate, and tending
not to change.

Nay and Crocker (1970) identified “a host of affective attributes underlying first a
person’s choice to become a scientist and subsequently his work in science. These attributes are
primarily dictated by the nature of scientific inquiry and are operationally definable for
scientists” (p. 60). They designed an inventory for the affective characteristics of scientists which
included (1) the motivation for a person to become a scientist (e.g. excitement and enthusiasm),
(2) primary behaviors that underlie competence (e.g. persistence, pragmatism, and cooperation),
and (3) the intellectual attitudes of scientists (e.g. idea sharing and questioning attitude).

Feist and Gorman (1998) conducted a meta-analysis exploring the psychology of science.
In their review, one aspect they investigated was the extensive literature on the psychological
characteristics of scientists from 1952-1995. They concluded that scientists portray four specific
psychological traits as compared with non-scientists. These traits include that scientists are: (1) more conscientious; (2) more dominant, achievement oriented, and driven; (3) more independent, introverted, and less sociable; and (4) more emotionally stable and impulse controlled.

The results of this extensive research into the psychology and affective behaviors of the scientists have resulted in a long and expansive list of attributes which could belie the stereotypical view of scientists commonly held by students. Coupled with the extensive research into how films portray scientists, we have concluded that students should broaden their conceptions of who a scientist is to include the affective characteristics which we call dispositions of scientists (DOS). As such, the notion of DOS was developed. In our research, we use mainstream films to exemplify this construct to show how these films portray the scientist, and how groups of scientists work in a variety of settings, not strictly in a laboratory. Next, we focus on how we created the construct of DOS and how we use films to illustrate various dispositions of scientists in action.

**Constructing the Dispositions of Scientists (DOS) from Mainstream Films**

The initial focus of this line of research was on how films addressed nature of science (NOS) and scientific inquiry (SI). After we began our exploration, we realized that looking at the dispositions of scientists (DOS) was just as important as NOS and SI. This new construct was unexpected, but it gave depth and breadth to our initial inquiry. Additionally, we recognized that the affective disposition of scientists is an important variable to be identified because people construct their perception about scientists based on how they see them through the media (Frank, 2003; Kirby, 2008, 2011).

The findings from the DAST literature (Finson, 2002) and work by Nay and Crocker (1970) and Feist and Gorman (1998) served as a starting point for this part of the investigation.
While the DAST research emphasizes only the physical characteristics of the scientist, we were further interested in the dispositions of the scientists that we observed in films. We grounded our work with dispositions as these qualities emerged from the multiple viewings of each film. The characteristics we identified were: passion, excitement, pragmatic, collaborative, intuitive, inquisitive, creative, risk-taking, and persistent. Table 1 describes each code we observed in the films for DOS.

[Insert Table 1 here]

In the films we initially viewed, Contact and Twister, the lead scientists were portrayed as highly motivated women, driven by their quest to answer questions that were personal to them. In the film, Contact, Ellie Arroway listened for auditory signals from space that would provide evidence of extra-terrestrial life, and in the film, Twister, Jo Harding developed a warning system to provide advance notice to persons in the path of approaching tornadoes. The dispositions of these scientists provide visual aids for students to view not only how research is done, but also how the emotions of these researchers affect how they conduct science. We recognize that DOS is inclusive of gender, race, and ethnicity. The films we chose promote gender neutrality in science and additional films that we will explore will target other aspects such as race and ethnicity.

Data collection and analysis were based on the procedures developed for earlier research (Koehler, Bloom, & Binns, 2013). This involved all three researchers independently viewing the films, Contact and Twister, several times over the course of one month in order to develop the categories described in Table 1. The categories were further refined through the numerous viewings of each film, thus grounding them in the data. Constant comparative methodology was used to systematically examine and redefine the categories described below (Patton, 2002).
Triangulation of the data was achieved through comparing the independent analyses of the researchers, reducing bias by providing validity and inter-coder agreement (Creswell, 2013; Patton, 2002). Figure 1 provides an example of the data we compiled using the categories established earlier. Note that we include the starting time (in hours:minutes:seconds from the beginning of the film) as well as the DVD chapter.

[Insert Figure 1 here]

**Dispositions of Scientists in Mainstream Films**

In this section, we demonstrate how we analyzed two video clips (one from *Twister* and one from *Contact*) that identify how multiple aspects of DOS are portrayed. The dialogue for *Twister* commences from chapter four on the DVD (00:13:00-00:16:00) (Kennedy, Bryce, Crichton, & de Bont, 1996) and for *Contact* at chapter 11 on the DVD (00:39:20-00:43:00) (Zemeckis & Starkey, 1997).

**Scene from Twister**

This example from *Twister* was taken from the scene when Bill goes to the field to find Jo to sign divorce papers. Bill and Jo were the lead scientists of a storm chasing team. He left field research for the “glory of being a weatherman.” He met someone, fell in love, and filed for divorce from Jo. Prior to this scene, Jo had just met Melissa, Bill’s new fiancée. It is clearly an awkward situation due to this new introduction and because many of the team members (other scientists) were confused as to whether Bill was returning to fieldwork. The example of the dialog below is the scene where Bill is shown the new storm-measuring instrument (nicknamed Dorothy) for the first time. The DOS identifiers are in parentheses and underlined.

**Jo:** *I thought you’d be coming out here alone.*

**Bill:** *I wasn’t expecting on coming out here at all you said you meet me-

**Jo:** *It’s about Dorothy.*
Bill:  *Dorothy? What about her?*

Jo:  *She’s here.*

Bill:  *Show me.*

[Going to the back of her truck, Jo rips off the burlap cover over Dorothy; a tornado instrument pack. Bill stands in awe.]

Bill:  *I can’t believe you did it.* *(EXC: Excitement)*

Jo:  *We built four of ‘em.*

Bill:  *She work?*

[Jo smiles and lowers the tailgate. Bill climbs up and examines the instrument.]

Jo:  *Thought you’d want to be here for her first time out. It wouldn’t be right if you weren’t here.*

[The whole team is coming over.]

Joey:  *(Laughing)*  *This is gonna be good!*

Dusty:  *(Bringing Melissa over to the truck, referring to Dorothy)*  *How sweet is that? Bill’s concept man. Boom! The extreme. Man, it came from his brain.* *(CRE: Creative)*

Bill:  *I had a hand in it.*

Melissa:  *Wow, it is great.* *(Pause)*  *What is it?*

Bill:  *It’s an instrument pack for studying tornadoes. First one in history.*

Jo:  *(Explaining)*  *It’s very exciting. Scientists have been studying tornadoes forever, but still, nobody knows how a tornado works. We have no idea what’s going on inside because no one’s ever been able to take scientific measurements from inside the funnel. That’s what she’s gonna do.* *(PRA: Pragmatic)*

Melissa:  *How?*

Jo:  *(Demonstrating)*  *We put her up inside a tornado. She opens up,*  *(Demonstrating by opening the lid on Dorothy and releases hundreds of these sensors)*  *Hands one to Melissa. that measure all parts of the tornado simultaneously.*  *(Melissa looks at sensor, smiles in confusion; hands back to Jo; Jo looks surprised.)*

Bill:  *You see, Melissa, it’s like this.* *(Bill holding a sensor to image on side of Dorothy explaining what Jo just said.)*  *These sensors go up the funnel, and radio back information about the internal structure, wind velocities, flow asymmetry. We could learn more in 30 seconds than we have in the past 30 years. Get a profile of a tornado for the first time.*

Melissa:  *And what will that do?*

Bill:  *If we knew how a tornado really worked, we could design an advance warning system.*
Melissa: Aren’t there already tornado warnings?

Bill: Well, the civil defense...

Jo: They’re not good enough, they’re nowhere near good enough. (Bills nods in agreement) Right now, it’s 3 minutes. If we can get this new information, we can increase warning time to 15 minutes. (PAS: Passion)

Bill: Give people a chance to get to safety. At least that’s what these guys are trying to do! (The team yells and cheers. (EXC: Excitation) Bill jumps down. Others help Jo down.) I can’t believe you actually did it.

Jo: Well, we (referring to the team) did it. (COL: Collaborative)

Melissa: How do you get it in the tornado?

Bill: Well, you got to get in front of the tornado and put it in the damage path. And then get out again before it picks you up too. (R-T: Risk-Taking)

[Melissa has a concerned look]

Dusty: (In Melissa’s ear) It’s the suck zone!

Melissa: (Startled by Dusty) Ohh.

[Haynes has been on the phone with the weather bureau.]

Haynes: Excellent! (Hangs up phone, excited, talking fast) Jo, we got major action! The NSSL says the caps are breaking, the tower’s going up to 30 miles up the dryline! (EXC: Excitement)

[Jo looks up at the sky, music soaring in the background. She pauses. Then suddenly focuses, slamming the tailgate.]

Jo: All right, let’s go!!

Many of the scenes chosen in this study contain multiple aspects of DOS which makes them rich descriptors of these constructs. Table 2 is an example of the codes used in this scene and the rationale as to why we used them. This example is not inclusive of all codes we found in this scene as there were multiple codes exhibited.

[Insert Table 2 here]

Scene from Contact
In the scene from *Contact*, Ellie Arroway has been looking for evidence of extraterrestrial life forms. At the outset of this scene, she is rushing back to the control room from the satellite dishes in the desert after hearing what she believes could be initial contact with alien life forms.

**Ellie:** How you doing? Talk to me guys.

**Fisher:** Partially polarized set of moving pulses, amplitude modulated.

**Willie:** All on, systems check out, signal across the board, what’s the frequency?

**Ellie:** 4.4623 giga-hertz. Hydrogen times pi, told you.

**Fisher:** Strong sucker too.

**Willie:** I got it! I got it, I got it! I’m patched in.

**Ellie:** Okay, let me hear it. (Ellie hears it on the computer). See that? Make me a liar Fish (COL: Collaborative)

**Fisher:** It could be AWACS out of Kirkland jamming us but, I’m doubting it.

**Ellie:** Let’s see if FUDS reading it too. Willie, patch it back and give me the off-axis. Are we recording?

**Fisher:** Never stopped

**Ellie:** Thank you, Elmer. (Ellie kisses the computer) (EXC: Excitement)

**Fisher:** AWACS status is negative.

**Ellie:** What about White Sands?

**Fisher:** On this frequency? No.

**Ellie:** I’m going to punch up the darks. Who is it spying tonight guys? Come on.

**Fisher:** NORAD’s not tracking any snoops in this vector. Shuttle Endeavor’s in sleep mode.

**Willie:** Ok, Point source confirmed. Whatever it is, it ain’t local.

**Ellie:** Position?

**Willie:** I checked in the thermometry, its somewhere in Lyra, I think.

**Ellie:** Vega?

**Fisher:** Can’t be, it’s only 26 light years away.

**Ellie:** What’s the peak intensity?

**Fisher:** Coming up.

**Ellie:** Vega. Vega? I scanned it a bunch of times at Arecibo, and it had negative results, always.

**Fisher:** Got it, it’s reaping over 100 Janskys.

**Willie:** Jesus, it’s picking up on my....

SOUND STOPS
Ellie: No. (long pause then sound starts back) Come on. All right. It’s re-starting. Wait a minute; those are numbers. That was a three, the one before was two. Umm, base 10 numbers, Just start counting now, let’s see how far we can get.

Willie: Five

Fisher & Ellie: Seven, seven

Ellie: Those are primes, two, three, five, seven. Those are all prime numbers. Man there’s no way...that’s a natural phenomenon. (CRE: Creative)

Fisher: Holy shit

Ellie: Let’s calm down and pull up the star file on Vega. (PRA: Pragmatic)

Fisher: No, that doesn’t make any sense; the system is too young. So it can’t have a planetary system, let alone life or a technological civilization.

Willie (talking over Fisher): Zero (EXC: Excitement)

Ellie: No, maybe they didn’t grow up there, maybe they’re just visiting. I don’t know (PRA: Pragmatic)

Fisher: Ok, so space craft? No, that system is full of debris; they would get clobbered.

Willie: (sarcastically) Not if they use the laser blasters and photon-torpedoes.

Fisher: Come on Willie, that’s not funny.

Willie: Well, how else are we going to explain it?

Ellie: No, Willie’s right, if we go public with this and we’re wrong, that’s it, it’s over, we’re cooked. God, I wish Kent was here.

Willie: Whatever the signal is we better do something soon. Vega is going to set.

Ian (a scientist from Australia): That position is confirmed. We got 4.4623 gigahertz.

Confirmed we got 112 Janskys. (COL: Collaborative)

Ellie: All right, do you have a source location yet?

Ian: We put it right smack in the middle, Vega.

Ellie: Ok, thanks, Ian. Just keep tracking and we’ll get back to ya.

Ian: Yup, right oh.

[Pause as Ellie contemplates her next move.]

Fisher: Ok, 101, the pulse sequence through every prime number between the number 2 and 101.

Willie: Who are we going to call now?

Ellie: Everybody.
Table 3 is an example of the codes found in this scene and along with the interpretation of why we used them. This example is not inclusive of all codes we found in this scene as there were multiple codes exhibited.

[Insert Table 3 here]

**Comparing DOS in *Twister* and *Contact***

We identified multiple instances of several DOS aspects in both films. However, we found that for some aspects, one film addressed it better than the other. For example, we found many instances of risk-taking (R-T) in *Twister*. One example was included in the discussion in the scene shared in the previous section when describing how to get Dorothy into the tornado. We also noted that multiple times throughout the film when Bill and Jo have to “put Dorothy in the path of the tornado and then get out.” Another example of DOS in this film clip is collaboration (COL). In the film, *Twister*, Jo’s research team worked to develop the instrument package, Dorothy, and together, they searched for tornadoes where they could use it. Each member of the research team had specific jobs, e.g. driving the vehicle while other members scouted potential tornado sightings, using the maps to find roads, etc. In the example noted for *Twister*, Jo acknowledges that it was a team effort, not a single endeavor.

Collaboration is also well-represented in the film, *Contact*. In this film, Ellie, Fisher, and Willie are a team in search for extraterrestrial life. Each has an identified role, e.g. Ellie is the lead scientist, Fisher is the computer wiz, and Willie works on instrumentation. Although Ellie usually calls the shots in the research, she relies on the expertise of her colleagues to aide in the progress of the science. In particular, she sought the advice of another colleague, Ian (from Australia), to verify that what she was hearing was exactly what he was hearing and each confirmed the position of the source as Vega. Ellie’s pragmatic approach to the verification of
the signal from outer space demonstrates that, although excited about the discovery, she was cautious not to make claims without evidence to back them up. At the conclusion of the example dialog above, Ellie proclaims that she had enough evidence to announce the discovery to the world. When asked “who are we going to call?,” Ellie responds “everybody.”

**Strategies for Including DOS in Science Classrooms**

**Elementary Preservice Science Teachers (PSTs)**

Over the course of our research into how films portray NOS, SI, and DOS (Koehler, Bloom, Binns, 2013), we have had several opportunities to implement a variety of strategies in the classroom setting. The first opportunity to realize the effectiveness of teaching DOS through viewing films was in the context of a course entitled, *Science for Elementary Teachers*. The course was offered during a summer term at a small private university in Texas. The emphasis of the course was to teach the preservice teachers (PSTs) how to develop teacher knowledge for teaching science in the K-6 classrooms and emphasis was given to developing informed views of NOS. There were nine PSTs in the class (8 female, 1 male). The instructor of the course (third author) used the films *Twister, Jurassic Park, Gorillas in the Mist*, and *Contact*. Each film was shown in its entirety and the PSTs were asked to identify instances in the film when NOS was depicted and document such occurrences on a template that was provided by the instructor. At the end of the summer term, students were asked to write a short paper describing how NOS aspects were demonstrated in the films to determine if they had developed a more sophisticated conception of NOS. Pre/post VNOS D+ surveys (Lederman, 2007) revealed that the all of the PSTs had developed more informed views of NOS. Interestingly however, qualitative analysis of their short papers revealed that their understandings of the NOS aspects were contextualized within the actions and dispositions of the characters in the films (Bloom, Koehler, & Binns, 2013).
In other words, in the PSTs’ attempts to describe how the aspects of NOS were exhibited in the films, they actually were describing the dispositions of the scientists. Table 4 gives examples of PST’s descriptions of NOS aspects seen in the films and how they align with the aspects of DOS.

[Insert Table 4 here]

As seen in these examples, the PSTs were trying to describe moments in the film where NOS aspects were well represented. However, each example was equally, if not better, describing the dispositions of the scientists themselves. It appeared as if the PSTs’ access to understanding NOS aspects was through the behaviors and characteristics of the scientists. It became clear that films could be used to develop understanding of DOS in addition to NOS.

Preservice Music Teachers (PSMT)

After realizing that the students were recognizing dispositions of scientists, we opted to explore other ways that films could assist preservice teachers in developing more informed conceptions of scientists. Our second exploration involved preservice music teachers (PSMTs) who were enrolled in a science content course offered at a small, urban college in the Midwest. These PSMTs were required to take only one science course during their tenure in college. The instructor of the course (second author) designed a science content course that would address some common science knowledge that every student should know when he or she graduates from university. These big ideas centered on the disciplines of astronomy, meteorology, and nutrition among other science topics. The PSMTs’ conceptions of the characteristics of scientists using the Draw-a-Scientist Test (DAST) were assessed at the beginning and end of the course (Chambers, 1983). The pre-DAST drawings demonstrated the stereotypical perceptions of scientists.
After pre-assessing the PSMTs’ perceptions of the characteristics of scientists, the instructor used three mainstream films (*Contact*, *Twister*, and *Super Size Me*) to convey more accurate representations of scientists in addition to the content specified in the course. These movies were chosen as they aligned with the science content being discussed; astronomy (*Contact*), meteorology (*Twister*) and nutrition (*Super Size Me*). Post-assessment revealed more authentic portrayals of scientists in the PSMTs’ drawings as seen in Figure 2.

[Insert Figure 2 here]

In this post-assessment drawing, the student debunks the notion that all scientists need to have lab coats or crazy hair, but can be an average person. Most importantly, the student used reference to the films that they viewed indicating the power that films have in a persons’ perception of who a scientist is and does; “they can look like people from the countryside chasing tornadoes (*Twister*), or even a woman that is in a dress today, but going into outer space tomorrow (*Contact*).”

Figure 3 shows the DAST characteristics portrayed in pre- and post-assessment drawings provided by the PSMTs. It was becoming clear that mainstream films were providing more diverse representations of scientists and that the PSMTs, in turn, were widening their referential on what characteristics and dispositions scientists could possess.

[Insert Figure 3 here]

The characteristics of the classic DAST drawings include: (a) lab coat, (b) eye glasses, (c) facial hair, (d) symbols of research-microscope, etc., (e) symbols of knowledge-books, etc., (f) signs of technology-computers, etc., (g) caption, (h) male, (i) signs/labels, (j) pocket protector, and (k) unkempt look. It is important to note that the “caption” and “sign” category did not change in either the pre or post drawings. Typically, these categories indicate that the drawing
has a call-out such as “eureka,” “I got it,” “!!!!” or a sign that indicates a breakthrough moment in science using phrases such as “E=mc2” or an constant such as “c=186,000 mi/sec.” This aligns with the DOS category of excitement. It is no surprise that change was absent in these categories.

As noted in Figure 3, there was a significant change in the pre-post DAST data. The mean for the pre-course DAST was 5.64 (SD=2.13) out of 11 indicating that the students’ perceived the classic scientist caricature as noted in the literature. Coupled with their post-DAST scores (M=2.29, SD=1.94), $t$-test [$t(13)=4.64$] revealed that the intervention, (e.g. film presentation and explicit/reflective discussion of how science is conducted) provided evidence that the students demonstrated a significant change (p<.001, Cohen’s d=1.2405) in their post-DAST scores and conception of what characterizes a scientist.

**Graduate Science Education Students (GSES)**

The third opportunity to observe DOS instruction through the use of mainstream films occurred in a graduate course offered in a teacher education program at a large university in the Southeastern U.S. The course was emphasizing NOS and the instructor of the course (first author) used the VNOS-D+ (Lederman, 2007) and a NOS quiz (Carrier, 2001) at the beginning and end of the course as well as six months after completing the course. To help the graduate science education students (GSES) develop more informed views of NOS, SI, and DOS, the instructor showed the films *Twister, Jurassic Park, Gorillas in the Mist,* and *Contact* in their entirety. During the viewing, students recorded notes on a template that included aspects of NOS, SI, and DOS. After each viewing, the students collaborated with each other in small groups to compile their thoughts for a group discussion of how each construct was portrayed by the films. Like the pilot study, students showed significant gains in their NOS understandings (as...
measured by the VNOS-D+ and the NOS quiz) and communicated that the films greatly enhanced their conceptions of SI. One student clearly emphasized the important role that films played in this knowledge development by stating that the films, “…illustrated different ways SI is done, none of which presented the stereotype of a lab with a controlled experiment” (GSES 1). A similar phenomenon was noted in regard to the students’ perceptions of the DOS. Using the DOS template, the students were able to identify that scientists in Contact collaborated extensively as well as their excitement when they discovered the signal.

Furthermore, the students conveyed that multiple films spread out over the span of the course were helpful as their understanding was developing. One student captured this as she reported that her “…answers from Twister [watched first] are less complex and I didn’t have as great an understanding when compared to Contact [watched last]” (GSES 2). In fact, the examples that she provided on the template for Contact were more accurate and plentiful than those provided for Twister.

**Implications for Science Education**

Story telling has long been an effective tool for passing knowledge from generation to generation and modern day storytelling often takes the form of television and film (Bettelheim, 1975; Egan, 1997). Romanticized storytelling of science can be an effective method of engaging and instructing science students (Bloom, 2011; Bloom, Koehler, & Binns, 2013; Hadzigeorgiou, Klassen, & Klassen, 2012; Hadzigeorgiou & Shulz, 2013; Koehler, Binns, & Bloom, 2014). This chapter describes how box office films can effectively educate learners about the nature of science and scientific inquiry as well as the dispositions of scientists.

In this chapter, we began the discussion about the affective characteristics of a scientist, which we call “dispositions of a scientist” (DOS). The DOS construct differs from the DAST
characteristics as the latter focuses primarily on the physical characteristics of the scientist, not what drives the individual to conduct science. Within the construct of DOS, we have described aspects to include: passion, excitement, pragmatic, collaborative, intuitive, inquisitive, creative, risk-taking, and persistent (see Table 1). We used the mainstream films, *Contact* and *Twister*, as a point to launch our idea about DOS. The main characters in each film, Ellie Arroway (in *Contact*) and Jo Harding (in *Twister*) were strong female leaders of their own research teams. These characters not only debunked the notion that scientists were “old, white men with crazy hair who worked in a laboratory setting with all types of science equipment and bubbling flasks” (Finson, 2002), but were instead, attractive, intelligent, strong women who worked in the field, e.g. with radio telescopes (as in *Contact*) and out chasing tornados in the fields of Oklahoma (as in *Twister*). But most important, these women’s affect toward science as presented in the films helped us ground the construct of DOS.

Describing what DOS is and providing examples of it using mainstream films is only phase one in our research. Applying it in a classroom setting and testing our theory about it and NOS/SI was phase two. In our previous research, we not only investigated how mainstream films depicted DOS, but we also explored how films portrayed NOS and SI (Koehler, Bloom, & Binns, 2013). In our first investigation, we tested our theory about films and NOS with elementary, preservice teachers (PST) using full-length, mainstream films (*Twister, Jurassic Park, Gorillas in the Mist*, and *Contact*) and asked PSTs to depict incidents of where NOS were observed. Our findings revealed students’ conceptions of NOS improved as measured using the VNOS-D+ after watching the films in conjunction with explicit/reflective discussions about it. An example of a quote where a student described “Persistence” in DOS and “Creativity” in NOS demonstrates an informed view of each construct (see Table 4). “When a scientist runs into a
problem, they must be able to figure out a new way to experiment and reach the destination of
the goal they are trying to reach. They must constantly be thinking of new ideas and ways to
experiment or fix experiments that fail” (PST 3). This student did not specifically note which
film she was referring to because all films could be explained by this quote.

In our second investigation, preservice music teachers (PSMT) viewed full-length,
mainstream films (Contact, Twister, and Super Size Me) as part of an undergraduate course that
centered on the content areas of astronomy, meteorology, and nutrition. In this investigation, we
used the films to debunk the notion of the stereotypical characteristics of scientists as measured
by the DAST. Using a pre-post design for drawings using DAST, we found statistically
significant change in their drawings from pre to post. In a quotation from a student’s drawing
(Figure 2), she noted “Scientists don’t need lab coats or test tubes. They don’t even need crazy
hair. Scientists can be anyone you see on the street. They look like the average person. Since
there are so many branches of science, they can look like people from the countryside chasing
tornadoes (reference from Twister) or even a woman that is in a dress today, but going into space
tomorrow! (a reference from Contact).” We conclude that the use of mainstream films had an
impact on PSMT’s perceptions of who is a scientist as measured by the DAST.

In our third investigation, graduate science education students (GSES) explored NOS, SI,
and DOS through the viewing of four mainstream films, Twister, Jurassic Park, Gorillas in the
Mist, and Contact over the course of a semester. During each of the viewings, the GSES used an
instructor-created template to determine incidents of when they saw each construct in the films.
After explicit/reflective discussions about NOS, SI, and DOS led by the instructor after watching
the films, students’ views about NOS significantly changed as measured by the VNOS-D+. This
demonstrates that the use of films for teaching about NOS, SI, and DOS have an impact on students’ views of these constructs.

While the strategies for teaching DOS in the classroom varied, our results consistently demonstrated that students’ conceptions of DOS changed. The use of mainstream films in the classroom has a profound effect on students’ conceptions of a scientist and the scientific endeavor. Earlier in our research, we used full-length films as instructional material, however, as this research evolved, we acknowledged the need to use film clips that demonstrate the essential aspects of DOS, NOS, and SI. Science teachers have limited time each day to instruct so the use of the film clip was a necessary modification to use in the classroom.

It is our hope that films can be used not just to provide opportunities for students to observe more authentic portrayals of science and scientists, but that they can also serve to dispel misconceptions about scientists, breakdown stereotypes of scientists, and can effectively make science more accessible to the next generation of graduates. We hope that this methodology can be used to demonstrate to young learners that scientists can be: men and women who are passionate, inquisitive, exciting and persistent; who take risks, rely upon their intuition, and collaborate with others; and creatively pursue new understanding of the world that benefits to society. We hope that if our young learners can recognize some of these characteristics themselves, that they might open their minds to the possibility of pursuing careers in science as well.
References


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<table>
<thead>
<tr>
<th>DOS Aspect</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passion (PAS)</td>
<td>Scientists exhibit obsession in pursuing the answer to research questions; they <em>live</em> for this work.</td>
</tr>
<tr>
<td>Excitement (EXC)</td>
<td>New discoveries excite the people who work in this field. They happen seldom and when they do, excitement prevails.</td>
</tr>
<tr>
<td>Pragmatic (PRA)</td>
<td>Scientists are pragmatic and practical in their work. The research which scientists conduct has practical implications for society.</td>
</tr>
<tr>
<td>Collaborative (COL)</td>
<td>Science is collaborative process, thus teams of researchers work in concert on the problems they are presented. Each team member brings an expertise to the table in the research group.</td>
</tr>
<tr>
<td>Intuitive (INT)</td>
<td>Intuition plays a role in scientific research. The <em>gut</em> feeling often leads the scientists unto the pathway they follow.</td>
</tr>
<tr>
<td>Inquisitive (INQ)</td>
<td>Scientists possess an inquisitive nature, asking questions that lead the scientific endeavor.</td>
</tr>
<tr>
<td>Creative (CRE)</td>
<td>Scientists need to have creativity and imagination in order to: (1) begin the research process; (2) develop the investigation; (3) create instrumentation that helps them answer their research question; (4) analyze and interpret data; and (5) re-evaluate and redefine research questions when needed.</td>
</tr>
<tr>
<td>Risk-taking (R-T)</td>
<td>Scientists can at times take enormous personal risk when conducting their research. Sometimes it can lead to death.</td>
</tr>
<tr>
<td>Persistent (PER)</td>
<td>Scientists do not take no for an answer. They continue their pursuits when all doors appear to be closed. This aligns with the passion they have for their work.</td>
</tr>
</tbody>
</table>
### Table 2

**DOS Codes Used to Interpret this Scene from Twister**

<table>
<thead>
<tr>
<th>DOS Code</th>
<th>Interpretation</th>
</tr>
</thead>
</table>
| Excitement (EXC)   | • Bill is excited when he sees his idea “Dorothy” is real  
                     • Team is excited when Bill says they are trying to help people  
                     • One of the scientists, Haynes, demonstrates her excitement when telling Jo that they “got major action” after talking with the NSSL |
| Creative (CRE)     | • Dusty describes Dorothy as “it came straight from his (Bill’s) brain” when talking to Melissa                                              |
| Pragmatic (PRA)    | • Jo explains to Melissa the reason for designing Dorothy; explanation was precise, controlled, and to the point                                |
| Passion (PAS)      | • Jo demonstrates her passion for this research throughout the entire film, but it is clear here when explaining why Dorothy is so important to Melissa and that the current warning systems aren’t enough |
| Collaborative (COL)| • When Bill states “I can’t believe you did it,” Jo specifically looks around at everyone and says “Well, we did it,” clearly indicating it was a team effort |
| Risk-Taking (R-T)  | • Bill’s response to Melissa about how to get Dorothy in the tornado                                                                                |
Table 3

*DOS Codes Used to Interpret this Scene from Contact*

<table>
<thead>
<tr>
<th>DOS Code</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative (COL)</td>
<td>• Ellie collaborates with her research assistants to determine the origin of the contact and confirms her hypothesis with a scientist, Ian, from Australia&lt;br&gt;• Ian confirms, “we put it smack in the middle, Vega.”</td>
</tr>
<tr>
<td>Excitement (EXC)</td>
<td>• Ellie displays her excitement throughout the scene over the new discovery by fast-talking, fast movements, and kissing the computer.&lt;br&gt;• Fisher and Willie show their excitement about the discovery by talking over each other.</td>
</tr>
<tr>
<td>Creative (CRE)</td>
<td>• Ellie uses her prior mathematical experience to note that the signal was being transmitted using prime numbers: two, three, five, seven…</td>
</tr>
<tr>
<td>Pragmatic (PRA)</td>
<td>• Ellie questions her own observations and plays the “devil’s advocate” in case that her claims are unrealistic.</td>
</tr>
</tbody>
</table>
Table 4

Examples of DOS in Films by Elementary Preservice Science Teachers

<table>
<thead>
<tr>
<th>DOS Aspect</th>
<th>(Film/NOS Aspect being described) Example given by PST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passion (PAS)</td>
<td>(Contact/Subjectivity) “When her [Ellie Arroway’s] father died and the priest came and told her, ‘It’s God’s will’, you could see that Ellie did not believe that this was true. It then clicked that this is why she was studying this type of science [search for extraterrestrials] and wanted answers so badly.” (PST 3)</td>
</tr>
<tr>
<td>Excitement (EXC)</td>
<td>(Gorillas in the Mist/Tentative) “After many encounters with the gorillas, Diane states, “Every time I think I know everything there is to know about gorillas, something new happens.” (PST 2)</td>
</tr>
<tr>
<td>Pragmatic (PRA)</td>
<td>(Twister/Social and Cultural) “…Twister [was] about technology and how it can be used to better society and give people an early warning sign for tornadoes.” (PST 5)</td>
</tr>
<tr>
<td>Collaborative (COL)</td>
<td>(Twister/Social and Cultural) Students often referred that Jo was conducting her research with “her team” (PST 2)</td>
</tr>
<tr>
<td>Intuitive (INT)</td>
<td>(Twister/Empirical) “When watching this movie, I was thinking that empirical evidence was hard evidence when the example I got from Twister was Bill throwing sand to study wind.” (PST 4)</td>
</tr>
<tr>
<td>Inquisitive (INQ)</td>
<td>(Gorillas in the Mist/Theories and Laws) “When Dr. Louis Leakey is making a presentation to describe his motivation for gorilla research, he says, ‘I want to know who I am and what made me that way.’”…”…he believes getting more information about them [gorillas] will help him learn more about himself.” (PST 2)</td>
</tr>
<tr>
<td>Creative (CRE)</td>
<td>(Jurassic Park/Creativity) “…the scientists use fossilized mosquitoes to clone the dinosaurs. Scientists believe the blood within these insects would carry the blood of a dinosaur. After drawing the blood and getting DNA from it, the scientists are able to recreate these extinct animals.” (PST 5)</td>
</tr>
<tr>
<td>Risk-Taking (R-T)</td>
<td>(Twister/Social and Cultural) “We see an ‘ugly side of science’ when Dr. Miller and Bill are competing to be the first to record empirical data from the inside of a tornado using Dorothy or DOT 2. Ultimately, the competitive personality of Dr. Miller results in his death.” (PST 2)</td>
</tr>
<tr>
<td>Persistent (PER)</td>
<td>(No movie identified/Creativity) “When a scientist runs into a problem, they must be able to figure out a new way to experiment and reach the destination of the goal they are trying to reach. They must constantly be thinking of new ideas and ways to experiment or fix experiments that fail.” (PST 3)</td>
</tr>
<tr>
<td>DOS Aspect</td>
<td>Time (DVD chapter #)</td>
</tr>
<tr>
<td>--------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Passion (PAS)</td>
<td>0:13:06 (4)</td>
</tr>
<tr>
<td></td>
<td>0:28:00 (8)</td>
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<tr>
<td></td>
<td>0:32:32 (10)</td>
</tr>
<tr>
<td>Excitable (EXC)</td>
<td>0:08:30 (3)</td>
</tr>
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<td></td>
<td>0:13:06 (4)</td>
</tr>
<tr>
<td></td>
<td>0:22:10 (7)</td>
</tr>
<tr>
<td>Pragmatic (PRA)</td>
<td>1:34:40 (29)</td>
</tr>
<tr>
<td>Collaborative (COL)</td>
<td>0:06:30 (3)</td>
</tr>
<tr>
<td></td>
<td>0:14:45 (4)</td>
</tr>
<tr>
<td></td>
<td>0:22:10 (7)</td>
</tr>
<tr>
<td>Intuitive (INT)</td>
<td>0:20:45 (6)</td>
</tr>
<tr>
<td></td>
<td>0:23:00 (7)</td>
</tr>
<tr>
<td></td>
<td>0:38:30 (12)</td>
</tr>
<tr>
<td>Inquisitive (INQ)</td>
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</tr>
<tr>
<td>Creative (CRE)</td>
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<td></td>
<td>1:21:20 (23)</td>
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<tr>
<td></td>
<td>1:36:00 (29)</td>
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<tr>
<td>Risk-taking (R-T)</td>
<td>0:28:00 (8)</td>
</tr>
<tr>
<td></td>
<td>0:35:50 (11)</td>
</tr>
<tr>
<td></td>
<td>0:54:11 (16)</td>
</tr>
<tr>
<td>Persistent (PER)</td>
<td>0:35:50 (11)</td>
</tr>
</tbody>
</table>

*Figure 1. An example of the DOS fingerprint for the film, *Twister.*
Scientists don’t need labcoats or test tubes. They don’t even need crazy hair. Scientists can be anyone you see on the street. They look like the average person. Since there are so many branches of science, they can look like people from the countryside chasing tornadoes, or even a woman that is in a dress today, but going into outer space tomorrow!

*Figure 2. Example post-assessment drawing of a scientist (PSMT 2).*
Figure 3. DAST Characteristics in Pre-Post Drawings for PSMT (N=14).