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Summative Evaluation of *Special Effects* with a Student Audience

Report for
NOVA Large Format Films
WGBH, Boston

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EXECUTIVE SUMMARY OF SUMMATIVE EVALUATION OF *SPECIAL EFFECTS* (ADULT SAMPLE)
MULTIMEDIA RESEARCH, MARCH 12, 1997

With funding from the National Science Foundation, NOVA/WGBH Boston with the participation of 14 U.S. and 4 international science museums have produced an IMAX/OMNIMAX film titled, *Special Effects*. The 40-minute film shows the techniques and methods that special effects filmmakers use to create movie illusions.

The summative evaluation reported here focused on the following major outcomes:

- To what extent did the program appeal to student viewers?
- To what extent did the program achieve its intended viewing goals?
- Did the implementation of school-based activities prior to viewing affect outcomes?
- What did viewers perceive that they learned from the program, if anything?
- Did students acquire knowledge about the use of science and/or math in producing effects?

Method. Two middle schools in the Greater Boston area participated with their sixth graders. A total of 79 students explored in their classrooms film-related concepts prior to viewing the film (ACTIVITY + FILM treatment), and another 102 students viewed the film only (FILM treatment). All 181 students completed a pre-viewing questionnaire five days before visiting the theater and completed a post-viewing questionnaire one day after viewing the film.

The Treatment groups did not differ significantly with respect to the classifications of gender, ethnicity, reported interest in learning about special effects, and reported knowledge of special effects. The sample as a whole included equal males and females and 11% minority students. More than half of the sixth graders were "very interested" in learning about special effects, and more than half reported knowing "very little" about the topic.

Findings

- ***To what extent did the program appeal to student viewers?***

  Of the 181 student viewers, 80.7% thought the program was either "very" or "moderately" interesting. Those who found the film more interesting reported higher interest in learning about the film's topics prior to viewing. Viewers liked the entertainment and educational qualities of the film. They enjoyed most the King Kong scene, learning how to create special effects, and experiencing the "you are there" feeling. The audience most often mentioned wanting more footage of special effects from movies other than those featured in the film. They also expressed a desire for more action and a longer viewing experience.

  Students were surprised to learn about the novel activities of filmmakers who produce special effects and the techniques they use to create the effects. They were surprised by ways that filmmakers use models, film explosions, and create the illusion of motion and relative size. They were surprised also by how realistic special effects can be, by the extent to which special effects are used in films, and by the skill and time required to produce special effects.

  After seeing the film, respondents were asked to rate how interesting or boring *Special Effects* was. Over half of the sample rated the film as "very interesting" (57.5%); nearly one-fourth (23.2%) felt the film was "moderately interesting," 14.4% rated the film as "okay" and 5.0%

thought the program was "moderately" or "very" boring. The following categories describe what the students liked about the film:

- 37.9% The opening segment with King Kong
- 29.4% Information about how special effects are created
- 19.0% The exciting "you are there" feeling captured by the film
- 4.7% The interest in special effects generated by the film
- 3.7% Seeing special effects contained in previously viewed films
- 3.2% Seeing information about *Star Wars*
- 1.1% Miscellaneous aspects of the viewing experience
- 1.1% *No response*

When asked in an open-ended question what they did not like about the film, 23.7% reported that they liked everything about the film and 20.4% gave no response. However, other respondents' answers focused on the following concerns:

- 22.6% Physical discomfort with the viewing experience (e.g., dizziness, aching eyes from lack of proper focus, loud volume, uncomfortable seating)
- 7.7% Too much talking
- 7.7% Boring
- 4.4% Disliked *Star Wars*
- 3.9% Not enough information
- 1.7% Film did not look real
- 1.7% Dispels wanted illusions
- 1.1% History of special effects
- 1.1% Not enough action
- 3.9% Miscellaneous
- 23.7% *Nothing disliked about Special Effects*
- 20.4% *No response*

Students were asked to complete the sentence, "I was surprised . . . ". A small portion of the sample (7.7%) wrote no answer to the question. The remaining responses were sorted into the following mutually exclusive categories:

- 35.5% Surprised by the information provided on how special effects are produced
- 18.8% Surprised by the opening segment highlighting King Kong
- 10.0% Surprised by the "you are there" feeling captured by the film
- 5.5% Surprised by the scenes from *Independence Day*
- 5.0% Surprised by positive film qualities - fun, action, generally interesting
- 3.4% Surprised by the skill and time required to produce special effects
- 2.8% Surprised that film was different from what they expected
- 2.8% Surprised that film did not explain more
- 1.2% Surprised by the extent to which special effects are used in films
- 1.1% Surprised by how scary the movie was
- 1.1% Surprised by theater limitations
- 4.9% Miscellaneous
- 7.7% *No response*

Students also completed the sentence stem: "I was most disappointed . . . . " More than one-third (38.2%) of the sample were either not disappointed or wrote no answer to the question. Two-thirds of the audience were disappointed as follows:

- 14.9% Disappointed that the film was too short
- 13.3% Disappointed that there were not more segments from other films
- 6.1% Disappointed that the film was not more interesting
- 5.0% Disappointed that there was not more action footage
- 4.4% Disappointed that film did not explain more
- 2.2% Disappointed that things in movies are not always what they seem
- 2.2% Disappointed that wanted illusions were dispelled
- 2.2% Disappointed that hard work of modelers is destroyed
- 1.7% Disappointed that there were not more examples of special effects
- 1.7% Disappointed that so much was shown about *Star Wars*
- 1.7% Disappointed that King Kong died
- 1.1% Disappointed that filmmakers have only one chance to blow up building
- 5.5% Miscellaneous
- 11.1% *Not Disappointed by Special Effects*
- 27.1% *No Response*

- ***To what extent did the program achieve its intended viewing goals?***

Viewing the film significantly increased science knowledge, as measured by a 10-point content test on the intended viewing goals. Viewers of *Special Effects* came away knowing more about how filmmakers produce effects of movement, scale, three-dimensionality, explosions and realistic computer images. Viewing the film did not significantly increase students' reported interest in viewing a museum exhibit on special effects, learning the basics of producing special effects or speaking to people who create special effects. After viewing the film, however, there was a significant decrease in students' interest in creating their own special effects. This decline in interest may have resulted from those who learned from the film about the complexity of producing special effects.

The post-viewing mean achievement score for the whole sample was 4.13 out of 10, which was significantly higher than the pre-viewing mean score of 3.08. Short answer questions on the test covered why an audience perceives continuous movement in a film; why explosions look more realistic when filmed in slow motion; how filmmakers can make an object appear larger than it actually is, appear farther away than it actually is or appear to be moving; and finally how computers play a role in special effects and what filmmakers must consider to make computer-generated images look realistic.

Before and after viewing the film, students rated on a 5-point scale how interested they were in doing each of four activities related to special effects. Students were moderately interested in all four activities, both before and after viewing the film, but only one activity showed a significant change in interest level after viewing. After viewing the film, there was a significant decrease in students' interest in creating their own special effects.

- ***Did the implementation of school-based activities prior to viewing affect outcomes?***

Exploration of film-related concepts in class via four student-centered projects prior to seeing the film did not impact science knowledge or interests significantly beyond what the students learned from the film alone.

Doing the film-related activities in class prior to seeing the film did not impact film appeal, learning of film content, or reported interest in doing film-related activities such as viewing a museum exhibit on special effects. In fact, when asked whether they connected the film to anything they had previously known or experienced, none of the students mentioned the class experience with the activities.

- ***What did viewers perceive that they learned from the program, if anything?***

  Almost 92% of the sample provided one idea or fact that they learned from the film. Viewers felt that they had learned how explosions are created in films and how models, motion cameras and computers are used.

  The following indicates the categories of ideas and facts learned by the students:

  - 19.2% Learned about explosions (use of models, filming in slow motion)
  - 10.8% Learned how models are used in films
  - 7.8% Learned how the appearance of motion can be created by moving the camera
  - 7.5% Learned ways to make an object appear larger
  - 6.7% Learned about role of computers in special effects
  - 6.4% Learned miscellaneous information about special effects
  - 4.7% Learned about the illusion of special effects
  - 4.0% Learned that animals are not real
  - 3.9% Learned about the complexity in creating special effects
  - 3.6% Learned generally how effects are created
  - 3.3% Learned how movies are made
  - 2.8% Learned about blue screen
  - 2.2% Learned how frequently effects are used in films
  - 2.0% Learned how movie crews work
  - 1.4% Learned about history of special effects
  - 1.4% Learned information about *Star Wars*
  - 1.1% Learned that anything is possible in films
  - 1.7% *Learned nothing*
  - 9.4% *No response*

  One-fifth of the student audience suggested that they had connected or associated the film with something they had previously experienced or known, and three-fourths of the audience felt that they learned something new about special effects from the film. Viewers said they learned about filming explosions as well as about how and why models, computers and blue screens are used. They understood the complexity of the filmmakers' tasks and appreciated the way the eye can be tricked.

  The listing below describes what new ideas students thought they learned about special effects that they did not know prior to seeing the film:

  - 13.8% How explosions are filmed
  - 9.4% How models are used in films
  - 8.8% How motion camera works
  - 7.2% Illusions of size
  - 5.5% How effects are created
  - 4.4% Making effects is complex
  - 2.8% How computers are used in creating effects
  - 2.2% Everything was new
  - 2.2% How *Star Wars* was made
  - 2.2% How *Jumanji* was made
  - 2.2% How to make things look real
  - 2.2% Special effects can trick the eye

- 1.7% How a blue screen works
- 1.1% Special effects are fun to watch
- 1.7% Miscellaneous
- 6.6% *Learned but gave no example*
- 24.9% *Learned nothing new*
- 1.1% *No response*

- ***Did students acquire knowledge about the use of science and/or math in producing special effects?***

  Viewing the film added little to students' ability to explain how science and math might be needed to produce special effects. In fact, 55% of the sample both before and after viewing the film were either unwilling or unable to provide an example of how science and/or math is used in producing special effects.

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INTRODUCTION

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SUMMATIVE EVALUATION DESIGN

A quasi-experimental pre-test/post-test nonequivalent comparison group design was used with middle school students to evaluate the film and ancillary schoolroom activities. Intact school classes were assigned to one of two treatments: viewing the film only (FILM) and viewing the film after doing related activities (ACTIVITY + FILM).

Five days prior to viewing the film, all students in the sample completed a pre-viewing questionnaire. The following day, two classes from each participating school completed four predetermined activities contained in the *Special Effects Activity Guide*. Four days following students' engagement in film-related activities, all students in the sample visited the Boston Museum of Science and viewed the OMNIMAX film *Special Effects*. The following day, all students completed a post-viewing questionnaire.

METHOD

Sample

Middle schools in the Greater Boston area who were registered to visit the OMNI theater during a one week period in October, 1996, were contacted about participating in the study. One middle school, providing five sixth-grade classes, is located in an urban area within four miles of Boston. The district reports that 85% of its graduates go to college and the income level of residents is at the 76th percentile. The second middle school, also providing five sixth-grade classes, is located in a suburban area 20 miles north of Boston. The district reports that 67% of its graduates go to college and the income level is at the 83rd percentile.

Paired pre and post-viewing questionnaires were obtained from 181 sixth graders. Two of the five urban classes and two of the five suburban classes performed the *Special Effects* activities in school. There were 102 students in the FILM treatment and 79 students in the ACTIVITY + FILM treatment.

Information from demographic and background previewing questions was used to determine whether the two treatment samples were equivalent groups. Chi-square analyses revealed that the

treatment groups (FILM, ACTIVITY + FILM) did not differ significantly with respect to the classifications of gender, ethnicity, reported interest in learning about special effects, and reported knowledge of special effects. The distribution of the sample on these classification variables is presented in Table 1. The sample comprised an equal gender distribution with 10.7% minority representation. More than half of the sixth graders (58.6%) were "very interested" in learning about special effects, and more than half (56.1%) reported that they "knew little" about the topic.

Table 1. Demographic & Background Variables of Student Sample

Variable	*N*	*Categories*	*Percent*
Gender	180	Female	42.2%
		Male	52.8%
Ethnicity	177	White	89.3%
		Minority	10.7%
Interest in Learning about Special Effects	181	Very interested	58.6%
		Moderately interested	29.3%
		A little interested	9.4%
		Not at all interested	2.7%
Knowledge about Special Effects	180	I know a lot	6.1%
		I know a moderate amount	23.9%
		I know a little	56.1%
		I know nothing	13.9%

Procedure

After an instructional session by the researchers, teachers administered the pre-viewing questionnaire five days prior to viewing *Special Effects*. All students in the sample completed the questionnaire as part of their regular classroom activity. Teachers did not mention that the questionnaire was associated with the planned field trip to the museum. Questions on the pre-viewing questionnaire focused on demographic and background classification variables as well as pre-viewing knowledge about and interest in the film's topics.

The day following administration of the pre-viewing questionnaire, the film-related activities were covered by one teacher in the urban school working with two separate classes and by two teachers in the suburban school, each working with one class. The researchers had earlier demonstrated the activities to the teachers and provided necessary materials for the activities. Students in the ACTIVITY + FILM treatment group carried out four student-centered experiments. Because the film emphasized the intersection of human perception and special effects, the four activities were drawn from the two main sections of the *Special Effects Activity Guide* that focus on perception: "More than Meets the Eye" and "A Matter of Perception." The following is a description of each of the four projects as they were adapted for the classroom environment in this study:

> The first project titled, "Fish Gotta Swim" (adapted from pgs. 7, 8 in *Guide*) involved an experiment with two overhead transparencies, one containing random dots and the other showing dots that formed the shape of a fish. By manipulating the pre-prepared transparencies on top of one another, students were to discover that without relative motion – one thing moving past another – we would be in an unchanging world, unable to orient ourselves to anything around us.
>
> The second project titled, "Shoebox Studio" (adapted from pgs. 7, 8 in *Guide*) involved moving action figures of varying size in a box and viewing them through a small hole at one end to discover that the apparent size of an object is also a matter of perspective.
>
> The third project titled, "So Close and Yet So Far" (adapted from pgs. 10, 12 in *Guide*) had students use a cardboard tube to view two different sized Koosh™ balls arranged at different distances, exploring the idea that perception of distance and size depends on perspective.

The fourth project titled, “Out of the Blue” (adapted from pgs. 11, 12 in *Guide*) involved an experiment with a half-white, half-blue piece of paper, a pink piece of paper and one clear transparency. The clear transparency showed blue snowflakes and a black outlined drawing of a bi-plane. Students manipulated the transparency and colored pieces of paper to simulate using a blue screen as a way of seeing/filming an actor separately from the background of a scene.

All ACTIVITY + FILM treatment classes followed the same procedure. Four activity sites were set up in each participating classroom; each site contained instructions and materials for performing one of the four experiments. The four activities as defined in the *Guide* suggest that students prepare all the materials themselves. To save time, the researchers prepared all materials for the students beforehand, so that students could focus on the manipulation of the materials rather than the making of them. Students were divided into four groups, each proceeding to a different activity site to perform one of the activities. At each activity site was a sheet of instructions adapted from the *Special Effects Activity Guide* and on the reverse side of the instruction sheet was a "Behind the Scenes" explanation, also adapted from the *Guide*. These two-sided activity sheets are included in the Appendix. After engaging in project activities for approximately 15 minutes, each group then rotated to a new site and performed the associated experiment. This rotation process repeated until each group had performed all four activities.

Four days following the activities, all participating students from both schools visited the Boston Museum of Science Mugar OMNI Theater and viewed *Special Effects*. The day after viewing, the teachers administered the post-viewing questionnaire. Questions on the post-viewing questionnaire included the pre-viewing film content questions and questions to assess viewers’ reactions to the film (as described below).

Questionnaires

Demographic and Background Variables. The pre-viewing questionnaire established respondents’ status with respect to demographic classification variables (gender and ethnicity) and background classification variables (pre-viewing interest in and previewing knowledge of the film’s topics).

Program Appeal. Post-viewing respondents chose one of five scaled statements to indicate how interesting or boring they found *Special Effects*. Viewers also explained what they liked and did not like about the film and why. Finally, an attempt was made to capture unintended effects by utilizing two sentence completion items: “I was surprised...” and “I was disappointed...”

Science Interests. Students rated their level of interest in four film-related activities both before and after viewing the film: learning the basics of movie special effects; viewing a museum exhibit on special effects; speaking to people who create special effects; and creating their own special effects.

Science Knowledge. Both pre- and post-viewing questionnaires included a knowledge test to assess understanding of the viewing goals. Seven short answer questions comprised a 10-point test about the following topics covered in the 40-minute film. Questions and answers drawn from the film’s content appear below.

1. If a film is made up of a series of still images, why does an audience perceive continuous movement.
   An audience perceives continuous movement in a film for the following three reasons: (1) the brain fills in the gap between still images, (2) after-image effect, and (3) apparent motion.

2. A filmmaker uses multiple ways to make an object appear to be larger than it actually is. One way is zooming in. Please describe two other ways a filmmaker can make an object appear to be larger than it actually is.
   Ways that a filmmaker makes an object appear to be larger than it actually is, besides zooming in, are: (1) shooting from an angle looking up, (2) placing a smaller-scale object in the background, (3) adding objects of

familiar size so models look big, (4) using miniature props, and (5) filming a small-scale explosion in slow motion to make it look more realistic.

3. Describe two ways a filmmaker can make a stationary object appear to be moving.
   Ways that a filmmaker can make a stationary object appear to be moving are: (1) changing the size of the object, (2) using a computer to replace the color blue with a film of a moving scene or object in the background, and (3) moving a camera around a stationary model of an object or scene.

4. Describe one way a filmmaker can make an object appear to be farther away than it actually is.
   Ways that a filmmaker can make an object appear to be farther away than it actually is are: (1) using two or more models built to different scales in order to create the perception of depth, and (2) combining two different models of different scales – smaller in the background, larger in the foreground.

5. Describe why explosions using small-scale models look more realistic when filmed in slow motion.
   Explosions using small-scale models look more realistic when filmed in slow motion because it makes the debris from the explosion appear on the screen for a longer time, thus making the explosion look bigger.
6. Give one example of a role that a computer might play in producing special effects in a movie.
   Some of the roles that a computer might play in producing special effects are: (1) combining background plates and other images using a blue screen, (2) controlling a camera that takes pictures of models, (3) inserting graphics/animations.

7. Describe two design issues a filmmaker has to consider to make a computer-generated image of an object look realistic.
   Some of the design issues a filmmaker has to consider to make a computer-generated image of an object look realistic are: (1) placement of the object in a scene and its relationship to other objects in the scene, (2) shadowing and lighting of the object, (3) the object's motion/movement (e.g., right attitude, rhythm, and timing), (4) small graphic details, (5) the object's color and its relationship to background colors, and (6) the object's texture.

After viewing the film, students responded to additional open-ended content questions: (a) describe two ideas or facts learned from the film; (b) what, if anything, was learned about special effects that was not known before the film, (c) what, if any, connections or associations were made between the film and anything previously known or experienced and (d) how is knowledge of science and/or math used in producing special effects.

RESULTS

Appeal of *Special Effects*

After seeing the film, respondents were asked to rate how interesting or boring *Special Effects* was (See Table 2). Over half of the sample rated the program as "very interesting" (57.5%); only 5% thought the program was boring.

Table 2. Rating of Appeal of *Special Effects* by Students

Variable	*N*	*Categories*	*Percent*
Appeal	181	Very interesting	57.5%
		Moderately Interesting	23.2%
		Okay	14.4%
		Moderately Boring	4.4%
		Very boring	0.6%

Expected frequencies for chi-square analyses were increased beyond 1 by combining the appeal categories of "moderately boring" and "very boring." Appeal ratings were independent of school, treatment, gender, ethnicity, and prior estimated knowledge about special effects. Prior interest in learning about the film's topics was significantly related to appeal ratings (c^2 (9) = 23.38, p = .025). As students' reported pre-viewing interest in learning about the film topics increased, so did their mean appeal ratings of the film itself. Table 3 presents the mean appeal ratings for each level of interest in the film's topics.

Table 3. Mean Ratings of Appeal of *Special Effects* by Pre-viewing Interest in Film Topics where 1 = Very Interesting and 5 = Very Boring

Categories of Interest	*N*	*Mean Appeal Ratings of Film*
I am interested	179	1.5
Moderately interested		1.8
A little interested		2.0
Not interested		2.2

What viewers liked. After viewing the film, students were asked what they liked about *Special Effects* and why. All but two students provided an answer to this question. Responses were sorted into mutually exclusive categories presented in Table 4 below. Over one-third of the students (37.9%) liked *Special Effects* because of the King Kong scene. Approximately 29.4% of the students liked that they learned how special effects are created. Another 19.0% liked the exciting "you were there" feeling, and 4.7% felt that the film was interesting. Some (3.7%) of the students liked seeing previously viewed films, whereas 3.2% specifically mentioned information about Star Wars. A small percentage (1.1%) identified miscellaneous film elements they liked.

Table 4. What Viewers Liked about *Special Effects*

Categories	*% of 181 Viewers*	*Examples of Responses*
King Kong scene because of the "you were there" feeling.	20.0%	• "I liked when King Kong fell from the building because it seemed like you were falling, too." • "A lot of action and when King Kong fell off the roof it was like we were about to hit the floor."
When King Kong fell off the Empire State Building	12.6%	• "I liked the part when King Kong fell off the building because it was the most exciting part" • "I liked the part when King Kong was falling off the Empire State Building because you could see the fear in his eyes when he was falling."
The King Kong scene overall	5.3%	• "The King Kong scene because the clip was exciting."
King Kong scene, Total	**37.9 %**	
General Info. about creating special effects	14.7%	• "What I liked about the film was that they explained to you how they make special effects." • "I really like how they filmed the movies, and the fires they did, because I have always wanted to know how they did it."
Info. about Explosions	6.8%	• "I liked how they showed the buildings blowing up. I liked this because it was neat to see how they did it."
Info. about models	5.3%	• "I liked how the big city turned out to be a tiny model." • "I like how they made models of the movie and then made it bigger because it totally fooled my mind."
Info. about lion and other animals	2.6%	• "I liked when they showed about *Jumanji* - how they use animals."
Learned how create effects	**29.4 %**	
Exciting "you were there" feeling	**19.0 %**	• "Whenever the movie showed a scene I felt like I was there." • "It seemed like you were right there experiencing those things and I really liked that."
Interesting	**4.7%**	• "I liked it because it was interesting." • "It was very interesting and realistic."
Seeing previously viewed films	**3.7%**	• "I liked how I could see my favorite movies being made." • "I liked the parts on *Independence Day* and *Jumanji*, because I liked those movies."
Star Wars	**3.2%**	• "I liked the part they did about *Star Wars* because I like that movie and wondered how they made it. Now I know."
Miscellaneous	**1.1%**	• "The introduction and how it was put together." • "I liked the sound in the film."
No response	**1.1%**	

What viewers did not like. After the film, students were asked also what they did not like about *Special Effects* and why. About one-fifth of the sample (20.4%) did not answer this question. The remaining responses of those who specified what they disliked were sorted into mutually exclusive categories presented in Table 5. Over one-fifth (23.7%) of the sample reported liking everything about the film. In contrast, 22.7% found features of the theater discomforting. A total of 7.7% complained that there was too much talking, and 7.7% reported that the film was boring. About 4.4% didn't like the scenes from *Star Wars*. Some (3.9%) felt there was not enough information about how special effects are made. A few (1.7%) felt some scenes looked unrealistic, and 1.7% didn't like that the film dispels wanted illusions. Smaller groups reported disinterest with the history of special effects (1.1%) or felt there was not enough action (1.1%). Finally, 3.9% identified miscellaneous items that they didn't like.

Table 5. What Viewers Did Not Like About *Special Effects*

Categories	*% of 181 Viewers*	*Examples of Responses*
Liked all	**23.7%**	• "I liked everything about *Special Effects*."
Disliked feeling dizzy	11.6%	• "That sometimes you got a little sick and missed good parts." • "I got dizzy from all the fast movement."
Too loud	4.4%	• "I did not like how it was so loud, it gave you a headache."
Theater intro	3.3%	• "I didn't like the beginning when you tested the lights and screens."
Complaints about seating	2.2%	• "I didn't like where I was sitting because it was uncomfortable to keep looking at the screen."
Disliked how it hurt eyes	1.1%	• "I didn't like when they did the close-up on the model with snow because it hurt my eyes. When hunter was running in *Jumanji*, it was hard to focus."
Complaints about theater	**22.6%**	
Too much talking	**7.7%**	• "I did not like it when they just talked about the special effects, because I liked it when they showed how to do it."
Boring	**7.7%**	• "I didn't like the way the film was getting better and you were getting into it and then it just went into boring things."
Disliked Star Wars	**4.4%**	• "I did not like anything about *Star Wars*. I didn't like it because I never have liked space stuff."
Not enough information	**3.9%**	• "I liked the movie, but I don't think it was informative enough." • "That it didn't tell enough."
Film did not look real	**1.7%**	• "I didn't like it because it looked fake."
Dispels wanted illusions	**1.7%**	• "What I didn't like was when you find out in some of the movies they don't move. It kind of kills the purpose to believe what you see."
History of special effects	**1.1%**	• "The old movies because I wanted to see how they make the new movies."
Not enough action	**1.1%**	• "I think there should have been more action."
Miscellaneous	**3.9%**	• "All the movies they showed clips from I already saw."
No response	**20.4%**	

What surprised viewers. In order to capture unplanned effects, students were asked to complete the sentence, "I was surprised..." Again, responses were sorted with keywords and the percentages of each mutually exclusive category are presented in Table 6, on the next page. A small portion of the sample (7.7%) wrote no answer to the question. More than one-third (35.5%) of the sample was surprised by features of making effects such as seeing how special effects are made (10%); discovering how realistic special effects can be (8.8%); how often models are used (5.5%); how explosions are created (3.9%); how objects are built and then destroyed (2.8%); how objects can be made to appear larger than they actually are (2.8%), and how moving the camera creates the appearance of motion (1.7%).

Almost one-fifth (18.8%) of the sample were surprised by the opening segment featuring King Kong, and 10.0% of the students were surprised by the "You are there" feeling. Others were surprised by seeing scenes from *Independence Day* (5.5%). Small groups of students were surprised by what they perceived to be positive aspects of the film such as how much fun learning can be (2.8%); the amount of action (1.1%); and how interesting the film was (1.1%).

About 3.4% of the students were surprised by the time and difficulty of making special effects. Some students (2.8%) were surprised that the film was different than they had expected or that the film didn't explain more about how special effects are created. A few students (1.2%) were surprised

by the extent to which special effects are used in films, that some segments were scary, and by the limitations of the theater itself, such as seats that don't tilt back for a better viewing angle.

Table 6. Respondents' Completion of "I was surprised..."

Categories of Surprise	*% of 181 viewers*	*Examples of Responses "I was surprised..."*
How effects are made	10.0%	• "at how they filmed the special effects."
How realistic effects can be	8.8%	• "how they make everything seem so real." • "that they made the model of the White House look so real."
Use of models	5.5%	• "because I didn't know that they made models and made them look real."
How explosions are created	3.9%	• "about the explosions and how they were made."
How objects built, then destroyed	2.8%	• "that it took months to build a little building that was shown for 5.9 seconds and then it was blown up."
How objects made to appear larger	2.8%	• "when the objects were so small but looked huge."
Camera movement	1.7%	• "that they move the camera, not the object." • "that cameras can trick people's eyes."
Features of effects, Total	**35.5%**	
King Kong falling	8.8%	• "When King Kong fell off the building."
Kong was a toy	6.1%	• "King Kong was a small doll."
King Kong was caught by a net	3.9%	• "when a net was there when the gorilla fell."
King Kong, Total	**18.8%**	
The "You are there" feeling	**10.0%**	• "when it was like us falling off the building." • "when we went into a comet."
Scenes from Independence Day	**5.5%**	• "to find out how they made the movie *Independence Day* after I saw it."
Fun learning	2.8%	• "how fun learning about special effects was."
Amount of action	1.1%	• "with all the action."
How interesting the film was	1.1%	• "that the museum actually managed to make this fairly dull subject fascinating."
Positive Film features, Total	**5.0%**	
Time involved making effects	2.2%	• "When I learned they spent days on one model."
Difficulty of creating effects	1.2%	• "How much work it is to do special effects."
Task of making effects, Total	**3.4%**	
Film different than expected	**2.8%**	• "that it was about something different than I thought"
Film didn't explain more	**2.8%**	• "they didn't explain more about making effects."
Extent to which effects are used	**1.2%**	• "that there were so many movies that use special effects."
It was scary	**1.1%**	• "how scary it was."
Theater limitations	**1.1%**	• "that the seats did not move in the Omni Theater."
Miscellaneous	**4.9%**	• "when they got the man from the 3rd Rock TV show to narrate the movie."
No response	**7.7%**	

What most disappointed viewers. Students also completed the sentence stem: "I was most

disappointed..." Responses were sorted with keywords and percentages of each mutually exclusive category are shown in Table 7. A little over one-tenth of the sample (11.1%) reported no disappointment, and 27.1% wrote no answer to this item. Students felt the film was too short (14.9%) and were disappointed that there weren't enough/better segments from other movies (13.3%).

Some viewers were disappointed that it wasn't interesting enough (6.1%) or were bothered that there wasn't enough action (5.0%). Some (4.4%) were disappointed that the film didn't explain more about how special effects are created. Other disappointing aspects of the film experience included the feeling that movies are not what they seem (2.2%); the film dispels wanted illusions (2.2%); after so much hard work, the models are destroyed (2.2%); there weren't more special effects (1.7%); that King Kong died at the beginning of the film (1.7%); there was too much attention given to *Star Wars* (1.7%); and that filmmakers are limited to only one chance to blow up a building correctly (1.1%).

Table 7. Respondents' Completion of "I was disappointed..."

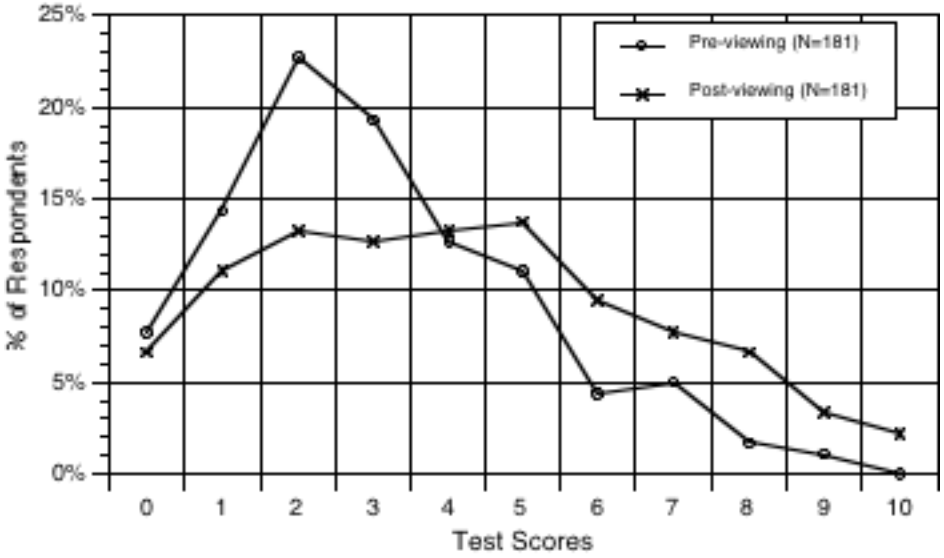
Categories of Disappointment	*% of 181 Viewers*	*Examples of Responses "I was disappointed..."*
The film was too short	14.9%	• "because the show was too short." • "that the movie wasn't longer."
Not enough/ better movie segments	13.3%	• "that they didn't do better movies." • "because they didn't show how they made Twister." • "when they didn't show anything from Gremlins or Aliens."
Not interesting enough	6.1%	• "that it wasn't as interesting as I thought it would be."
Not enough action	5.0%	• "that they didn't have more action scenes."
Film didn't explain more	4.4%	• "that they showed too much movie, instead of how they do it." • "how it was not very informative."
Movies are not what they seem	2.2%	• "because people made it out to be what it is not."
Dispels wanted illusions	2.2%	• "seeing how they did Jumanji ruined it a little." • "to find out things aren't like I wanted them to be."
Hard work gets destroyed	2.2%	• "because the model builders put all their work into the models and then they blew it up."
Too few effects	1.7%	• "because there was not much special effects."
Too much about Star Wars	1.7%	• "because most of it was *Star Wars*."
King Kong died	1.7%	• "when they killed the gorilla."
One chance to blow up building	1.1%	• "that they have only one chance to get things right you blow it up."
Miscellaneous	5.5%	• "when the history came on."
Not disappointed	11.1%	• "I wasn't disappointed."
No response	27.1%	

Impact on Knowledge

Achievement of intended viewing goals. Understanding of *Special Effects* content was assessed via a 10-point test with short answer items. Figure 1 shows the distribution of the students' test scores for both the pre-viewing and post-viewing samples.

The post-viewing mean achievement score for the whole sample was 4.13, significantly higher than the pre-viewing mean score of 3.08, as tested by a paired *t*-test, $t(1,180) = 6.782$, $p<.0001$). A multiple regression analysis with post-test scores as the criterion variable and pre-test scores entered as the first predictor resulted in an R^2 of 37.5 and a significant coefficient ($t = 10.4$, $p<.0001$). Treatment (FILM, ACTIVITY + FILM) added as a second predictor decreased the value of the adjusted R^2. Thus, a little over one-third (37.5%) of the variability in the post-test was accounted for by its linear relationship with the pre-test, and the treatments did not contribute to the predictive power of the regression. Having experienced the activities in class did not impact students' film knowledge.

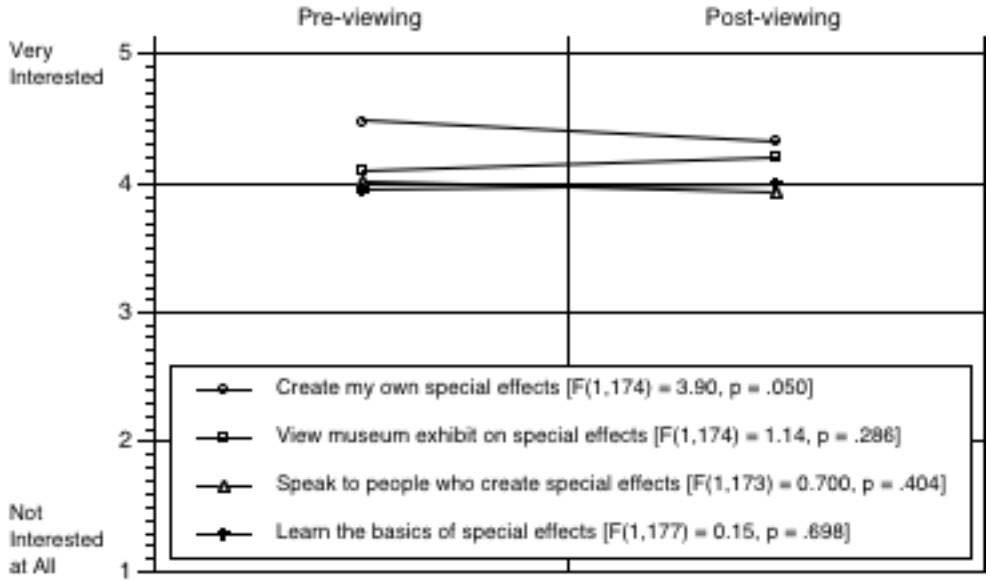
Figure 1. Distribution of Test Scores for Pre- and Post-viewing Samples



Interest in Special Effects-related activities. Before and after viewing the film, students rated on a 5-point scale how interested they were in doing each of four activities related to special effects. On average, students were moderately interested in all four activities, both before and after viewing the film (See Figure 2). ANOVAs with repeated measures were applied to the pre-post mean interest ratings for each activity with Treatment as a factor. Treatment was not significant in the four analyses, but the pre/post difference for one activity was significant. After viewing the film, there was a significant decrease in students' interest in creating their own special effects ($F(1,174)=3.90$. $p=.50$). The decline in interest may have resulted from the difficulty students attributed to producing special effects, after seeing the film.

Seeing the film with or without doing pre-viewing classroom activities had no significant impact on students' interest in the other three activities: viewing a museum exhibit on special effects, speaking to people who create special effects, or learning the basics of special effects (See Figure 2 below).

Figure 2. Pre- and Post-viewing Means for Interest Ratings in Four Special Effects-Related Activities



General ideas or facts learned. Prior to completing the test section mentioned above, the questionnaire asked viewers to describe two ideas or facts that they learned from the film. Of the 181 students in the sample, 161 provided two ideas or facts, 6 provided one idea or fact, and 14 students did not answer at all. The ideas/facts were sorted with keywords, and percentages of each mutually exclusive category and sub-category are shown in Table 8 on the next page. The percentages were calculated based on the possibility of receiving 362 responses to this question (two facts per student).

Table 8. Ideas and facts viewers learned from the film

Categories of What was Learned	*% of 362 responses*	*Examples of Responses*
Use of models in explosions	11.7%	• "They use models to make a building explode."
Explosions filmed in slow-motion	3.1%	• "When explosions are small you show it in slow motion to make it look big."
Gen. info. about explosions	4.4%	• "I learned how to blow up stuff." • "How they create explosions on the screen."
Explosions, Total	**19.2%**	
Use of models in films	**10.8%**	• "That you use models to make things that are impossible to make."
Move camera to make object appear to move	**7.8%**	• "To make an object move you move the camera backwards." • "The camera moves, not the model."
Enlarging the size of a small object/image	**7.5%**	• "How to make things look larger than they are." • "That you can make a small things big and a big things small."
Role of computers in special effects	**6.7%**	• "They use a lot of computer graphing." • "When they make someone fall from a high place they use computers and action figures."
The illusion of special effects	**4.7%**	• "Things might not always be what they look like." • "Everything in effective movies are fake."

Animals are not real	**4.0%**	• "I liked it because it showed you how they made animals work."
Difficulty making special effects	**3.9%**	• "I learned that special effects are hard to do." • "It takes time to have special effects in a movie done right."
How effects created	**3.6%**	• "How special effects are made."
How to make movies	**3.3%**	• "How movies were made."
Blue screen	**2.8%**	• "Sometimes they use blue screens to make a background."
How frequently effects are used	**2.2%**	• "That special effects are used in just about every movie."
How movie crews work	**2.0%**	• "That there were people doing the decorating for the actions."
History of effects	**1.4%**	• "That special effects started in the early 1900s."
How Star Wars was made	**1.4%**	• "I learned how they made the movie *Star Wars*."
Anything is possible	**1.1%**	• "In special effects anything can happen."
Miscellaneous	**6.4%**	• "How your brain fills in spots where there isn't movement on film."
Learned nothing	**1.7%**	
No response	**9.4%**	

One-fifth (19.2%) of the sample learned about explosions (way models are used in filming explosions; why explosions are filmed in slow motion, other general information about explosions). About 10.8% of viewers gained an understanding about the use of models in films (other than in explosions). Students also learned about motion cameras (7.8%) and ways to make an object appear to be larger than it is (7.5%). An understanding of roles computers play in producing effects was gained by 6.7%. Other ideas and/or facts viewers reported learning included what we see in movies isn't always real (4.7%), that animals are sometimes mechanical or computer graphics (4.0%), the difficulty of making effects (3.9%), how effects are made (3.6%), how movies are made [excluding special effects] (3.3%), how a blue screen is used (2.8%), how frequently special effects are used (2.2%), how a movie crew works (2.0%), how *Star Wars* was made (1.4%), and finally that anything is possible with special effects (1.1%). There were 3 students who reported they had learned nothing from the film.

Learning about special effects specifically. We were interested to learn from our viewers if they learned anything new about special effects, after viewing the film. Of the 181 students, 134 (74%) felt they had learned something about special effects that they did not know before viewing the film, and 122 went on to describe what they had learned. Those responses were sorted with keywords, and percentages of each mutually exclusive category are shown in Table 9 below.

Table 9. What viewers learned about special effects that they didn't know before the film.

Categories of Learning	*% of 181 Viewers*	*Examples of Responses*
How explosions are filmed	**13.8%**	• "I learned how they made a small explosion look big." • "I learned that they had professionals do the explosions."
Use of models	**9.4%**	• "That they use small models to make movies."
Moving camera to make object appear to move	**8.8%**	• "I learned that the camera moves sometimes, and not the object." • "Because I always thought somehow the aircraft were moving and not the camera."
Illusions of size	**7.2%**	• "That you can make small things look big and big things look small."
How effects are created	**5.5%**	• "I learned how special effects for movies were made." • "How they make the films."
Making effects is very involved	**4.4%**	• "How much work it is to make a special effects movie."
Use of computers	**2.8%**	• "I learned that they use a lot of computer graphing."
Everything was new	**2.2%**	• "I learned everything in the film.
About the making of Star Wars	**2.2%**	• "Things from *Star Wars*." • "I learned that children played Jawas."
Jumanji effects	**2.2%**	• "I learned that they smashed the cars in *Jumanji* without the animals."
How to make things look real	**2.2%**	• "I learned how they make all the realistic movies."
Special effects can trick the eye	**2.2%**	• "Special effects trick the eye and mind." • "Things aren't always what they seem."
About the use of a blue screen	**1.7%**	• "How to make the blue screen."
Special effects are fun to watch	**1.1%**	• "Special effects are pretty fun to watch."
Miscellaneous	**1.7%**	• "How they check things before they begin."
Learned, but gave no example	**6.6%**	
Did not learn anything new	**24.9%**	
No response	**1.1%**	

Viewers felt they learned about how explosions are filmed, how models, cameras, computers, and blue screens are used. They developed an appreciation for the complexity of creating special effects, and an understanding about the way the eye can be tricked to make things look real. Some students enjoyed learning about the special effects used in feature films they had seen, such as *Star Wars* and *Jumanji* .

Personal associations with the film. Respondents were asked if they connected or associated the film with anything they previously knew or experienced. Although 44% of the sample had performed activities related to the film content during the week prior to seeing the film, **none** of these students connected the activities with the film, as indicated by their responses to this question. Of the sample of 181 viewers, 37 (20.4%) responded positively, but only 30 of these respondents described the association/connection. The 30 sorted responses are presented in Table 10.

Small groups of the sample associated the film with their prior knowledge about the use of models (3.3%), computers (2.8%), blue screens (2.8%), and motion cameras (1.1%). A few (2.8%) reported that they had seen the featured films, although it seems very likely that most of the sample had at least seen *Star Wars* on videotape previously. Others (3.9%) indicated that they associated the film with information about special effects obtained from miscellaneous sources, such as television programs, magic shows, magazines, and Las Vegas exhibitions.

Table 10. Viewers' associations or connections with the film

Categories of Associations	*% of 181 Viewers*	*Examples of Responses*
Knew about using models	**3.3%**	• "I knew they made miniature cities and models."
Knew about use of computers	**2.8%**	• "I knew how they used a computer to add images."
Knew about blue screens	**2.8%**	• "I knew they used blue screens to create some backgrounds."
Had seen the featured films	**2.8%**	• "I saw all the movies they were talking about."
Knew about motion cameras	**1.1%**	• "I knew that they moved the camera to make the stationary object look moving."
Miscellaneous	**3.9%**	• "Going to a magic show." • "I went to Las Vegas and saw an exhibition on special effects." • "A magazine I read."
Association made, but not described	**3.9%**	
No response	**83.4%**	

Use of science and/or math in producing special effects. Students were also asked to provide an example of how math and/or science is used in producing special effects. Prior to viewing the film, 23.8% of the 181 students provided no response and 31.5% responded with "I don't know." After viewing the film, 46.4% provided no response and 9.4% responded with "I don't know." Thus, the same percentage of students (55%) were unwilling or unable to answer this question before and after viewing the film. Responses from the students who did provided examples were sorted into mutually exclusive categories, which are presented in Table 11 below.

Respondents gave a variety of examples before and after viewing the film including the use of science and/or math in measurement and scale, to create explosions, to use computers, and to obtain perfect timing. Chi-square analyses of the pre- and post-viewing responses for each of these four co-occurring categories showed no significant differences. After seeing the film, two categories were dropped: numbers are involved and making an object/image using science; and two additional

categories were added by two to three students: computing camera angles and creating blue screen effects. Viewing the film had little significant impact on students' ability to explain how science/math is needed to produce special effects.

Table 11. Pre- and Post-viewing examples of how science/math is used to produce special effects

Categories of Examples	*% of Pre viewers*	*% of Post viewers*	*Examples of Previewing Responses*	*Examples of Postviewing Responses*
Math for measure-ment and scale	13.8%	17.7%	• "Math is used if you have to measure things." • "They have to know how big the model is going to be."	• "How big or small something has to be or needs to be." • "So you know what scale and what works with what."
To create explosion s	5.5%	10.5%	• "Science is used to make an explosion." • "You need to know how many watts are needed for explosions."	• "Knowing how to make things explode." • "Because then you know what chemicals to use."
To use computers	3.3%	6.1%	• "You need to know how to use computers and other electronics."	• "Science is used in the computers that are used."
Perfect timing needed	3.3%	3.3%	• "The filmmakers have blown up a building or any other object at the right time."	• "Math – because everything has to be timed perfectly."
Camera angles	0	1.7%		• "When positioning the cameras"
Bluescreen effects	0	1.1%		• "How to make the blue-screen effect."
Misc.	5.0%	3.9%	• "Science is used to find out the environment of an animal used in a movie."	• "If people want to do an animal movie, they have to know what its environment is."
Numbers are involved	7.2%	0	• "Anything can be converted into numbers."	
Make object using science	6.6%	0	• "How to make the image using science."	
Don't know	31.5%	9.4%		
No Response	23.8%	46.4%		

DISCUSSION

- *To what extent did the program appeal to student viewers?*

Of the 181 student viewers, 80.7% thought *Special Effects* was either "very" or "moderately" interesting. Those more interested in learning about the film's topics prior to viewing found the film more interesting. In comparing these results to students' responses to *Stormchasers* ,[1] 57.5% rated *Special Effects* as "very interesting" and 38.8% rated *Stormchasers* as "very interesting." The rating of "moderately interesting" was given to *Special Effects* by 23.2% and to *Stormchasers* by 32.1%. Student viewers rated*Special Effects* more positively than *Stormchasers*, although both films were appealing to a large majority of their audiences.

Viewers liked both the entertainment and educational qualities of the film. They enjoyed most the King Kong scene, learning how to create special effects, and the exciting "you were there" feeling. Their main complaints were related to the theater's features: dizziness, loud volume, seating, and focusing problems.

The student audience was surprised to learn about the ways that filmmakers use models, film explosions, and create the illusion of motion and relative size. They were surprised also by how realistic special effects can be, by the extent to which effects are used in films, and by the skill and time required to produce effects. Also, the King Kong segment, in particular, took students by surprise.

Students were disappointed mainly by the film's short length, the restricted number of movie examples given, and its lack of action and explanation.

- *To what extent did the program achieve its intended viewing goals?*

Viewing the film significantly increased science knowledge, as measured by a 10-point content test on the intended viewing goals. The test covered why an audience perceives continuous movement in a film; why explosions look more realistic when filmed in slow motion; how filmmakers can make an object appear larger than it actually is, appear farther away than it actually is or appear to be moving; and finally, how computers play a role in special effects and what filmmakers must consider to make computer-generated images look realistic. Viewers of *Special Effects* came away knowing more about how filmmakers produce effects of movement, scale, three-dimensionality, explosions and realistic computer images. The previewing mean test score was 3.08 out of 10 points compared with the significantly higher post-viewing mean score of 4.13. Viewing the film did not significantly increase interest in viewing a museum exhibit on special effects, learning the basics of producing special effects or speaking to people who create effects. There was, however, an observed significant decrease in students' interest in creating their own special effects. This decrease in interest may have resulted from those who learned from the film about the complexity of producing special effects.

[1] Flagg, B.N. & Johnson, A.C. (1996). Summative evaluation of *Stormchasers* with a student audience. Bellport, NY: Multimedia Research.

- *Did the implementation of school-based activities prior to viewing affect outcomes?*

Doing film-related activities prior to seeing the film did not impact film appeal, learning of film content, or interest in other film-related activities such as viewing a museum exhibit on special effects. Thus, exploration of film-related concepts via four student-centered projects prior to seeing the film did not impact science knowledge or interests significantly beyond what the students learned from the film alone. In fact, when asked whether they connected the film to anything they had previously known or experienced, none of the students mentioned the class experience with the activities. *Stormchasers*' student viewers were similarly unaffected by doing activities in class prior to seeing that film.

- *What did viewers perceive that they learned from the program, if anything?*

The film had the most impact on what the audience perceived they learned about how explosions are created in films. The film also affected students' awareness of the use of models, motion cameras, perspective manipulations, and computers. One-fifth of the student audience felt that they had connected or associated the film with something they had previously experienced or known, and three-fourths of the audience felt that they learned something new about special effects from the film. Viewers said they learned about how explosions are filmed in slow motion with the use of models. They also learned general information about the creation of special effects and specifics about how and why models, computers, and blue screens are used. They developed an appreciation for the time and special skills required for creating special effects and for the quality of results produced by filmmakers' efforts. Finally, some students reported that they learned that the eye can be tricked and that what we see in films isn't always what it appears to be.

- *Did students acquire knowledge about the use of science and/or math?*

Viewing the film added little to students' ability to explain how science and math might be needed to produce special effects, although two types of information were reported by a few students only after viewing the film: (1) examples of how math/science is required for computing camera angles and (2) for creating blue-screen effects.

In conclusion, *Special Effects* was interesting to 81% of the student audience and made a significant impact on their knowledge of and learning about special effects in film but not on their understanding of how science and/or math is used in these endeavors. Moreover, film-related activities experienced prior to viewing did not affect the film's impact.[2]

[2] We would like to acknowledge the support and aid of the staff of the Mugar OMNI Theater at the Boston Museum of Science as well as that of WGBH's Kelly Tyler, Susanne Simpson, and Lisa Roberts.