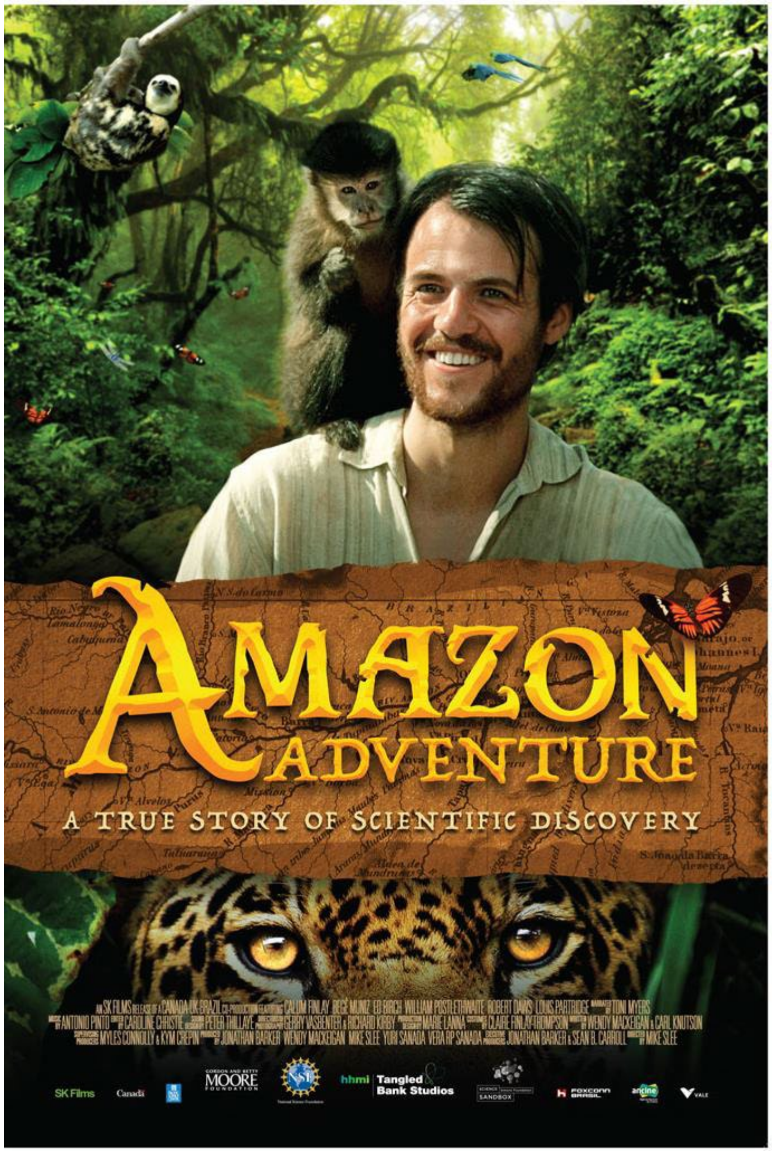

Examining the role of format on science identity, presence and knowledge after viewing the giant screen film *Amazon Adventure*

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Executive Summary

This research examined the role of format in learning from the GS film, *Amazon Adventure.* Funded by the National Science Foundation (NSF), *Amazon Adventure* is an Innovations in Development project directed by Pacific Science Center in partnership with SK Films; Rutgers, The State University of New Jersey; Embodied Games; and the Howard Hughes Medical Institute's Tangled Bank Studios. The project deliverables produced during the grant period included a giant screen film, live stage presentation for use at informal science education (ISE) institutions, and educational resources.

As part of the NSF funding for *Amazon Adventure*, the project supported both external research and evaluation studies of the film. This report focuses on the research component of the grant, specifically the traditional paper assessment of participants pre and post responses to the film: engagement (presence/immersion) science knowledge and nature of science, science identity, and knowledge of natural selection as a mechanism of evolution. Given the lack of empirical research on the impact of learning specifically focused on the different giant screen film formats, this study used *Amazon Adventure* to provide baseline information on the learning potential of the giant screen formats compared to both a small screen version of the film, and a classroom lesson using the same content as the film. In summary, this research found:

Are there differences in knowledge pre- and post-viewing between the giant screen formats?
There were some inconsistent differences in knowledge before and after viewing *Amazon Adventure.*

Does learning from the giant screen differ as compared to a traditional class lesson?
There did not appear to be any significant differences in learning, but there was a difference in sense of presence between the classroom lesson and the giant screen formats, which may augment learning.

Does giant screen support and augment knowledge or acceptance of natural selection as compared to a class lesson?
There does not appear to be any significant difference in knowledge or acceptance of natural selection between the giant screen formats and the classroom lesson.

Are there unique attributes in learning between the giant screen formats?
There did not appear to be any unique results in learning between the formats.

Does format play a role in science interest and science identity?
Participants came into the study with high levels of science interest and identity that, except for one question, was consistent throughout the study timeline.

Introduction

In the almost 50 years since the first giant screen (GS) film, *Tiger Child*, there has been no purposeful research to examine any of the claims and assumptions about their potential impact in learning (Fraser et. al., 2012; Heimlich, Sickler, Yocco & Storksdieck, 2010; Lantz, 2011; Schnall, Hedge & Weaver, 2012; Ucko & Ellenbogen, 2008). The existing research and evaluation of GS films does not provide objective comparative data to support the claim that these experiences influence, enhance, or contribute to learning in more meaningful ways than other media used in museums. Research suggests that making meaning from experiences with giant screen films, whether cognitive or affective, does contribute to science learning, but that the degree to which that learning is possible and the incremental value of the various giant screen formats remain without definitive empirical research (Fraser et. al., 2012).

Rather than examine the cognitive, affective or immersive nature of giant screen, research has tended to focus on evaluation methods that consider the response of the audience to a specific film and consequently are not generalizable due to variations in methodology, audience and definitions of learning. Unfortunately, many of those evaluations are considered proprietary and unavailable for review. A 2005 review of evaluation results showed that verbal knowledge learning outcomes, interest in the film topic, and professed behavioral change increased the week following film viewing (Flagg, 2005). A review of three giant screen films presented at the NSF-funded conference, *Connecting Society with Science: The Greater Potential of Giant Screen Experiences* (NSF/DRL #0803987) found that the film narrative was key to learning from giant screen films (Apley, 2008). Two separate single film evaluations found that there were questions about the role of 3D in learning from giant screen (Apley, Streitburger & Scala, 2008; Knight Williams, Inc., 2008).

To date, there has been no empirical research on the impact of learning specifically focused on the different giant screen (GS) film formats. Related studies have pointed to potential for the format: an unmatched participant evaluation of the film *Dinosaurs Alive*, it was suggested that there may be unique learning outcomes from 2D and 3D films. Cognitive learning outcomes were perceived to be higher in 2D, while effect and entertainment were rated higher in 3D (Apley, Streitburger & Scala, 2008). A complementary study in a full dome planetarium examined audience immersion and presence to three versions of *Maya Skies*, a full-dome planetarium show. Participants viewed the film either in a full-dome planetarium (full immersive), standard movie screen theater (semi-immersive) or on a 42" television screen (non-immersive). Results suggested a positive correlation between immersion levels and reported interest in learning (Heimlich, Sickler, Yocco & Storksdieck, 2010)

For a medium that is strongly connected with education—indeed, the giant screen industry is to a great degree predicated on its unique characteristics having significant impact on learning—this lack of research in cognition, affect, presence and learning is surprising. It has been shown that that technology has the potential to not only support inquiry, but promote learning (Ansbacher, 1998; Linn, Davis & Bell, 2004; Sandifer, 2003; Ucko &

Ellenbogen, 2008). Combined with the understanding that visuals have become the predominant form by which people receive knowledge (Eilam & Ben-Peretz, 2010), form opinions (Barry, 2007) and increase understanding of abstract data complex concepts (Card, MacKinley & Shneiderman 1999), the lack of knowledge of the impact of giant screen formats is surprising. Especially as giant screen theaters worldwide are positioned and marketed as providing informal learning experiences that complement and support formal education.

This research examined the role of format in learning from the GS film, *Amazon Adventure.* Funded by the National Science Foundation (NSF), *Amazon Adventure* is an Innovations in Development project directed by Pacific Science Center in partnership with SK Films; Rutgers, The State University of New Jersey; Embodied Games; and the Howard Hughes Medical Institute's Tangled Bank Studios. The project deliverables produced during the grant period included a giant screen film, live stage presentation for use at informal science education (ISE) institutions, and educational resources.

The centerpiece of the project, the *Amazon Adventure* film, is a 45-minute giant screen film shown in both 2D and 3D flat screen and 2D dome format versions. The film is based on the true story of Henry Bates' 11-year journey through the Amazon in the 1850s, focusing on his quest as a young man to find evidence of species change. As summarized in the NSF proposal (2014):

> *The film will engage audiences emotionally with an inspirational story of a scientist's passion, determination and ultimate success…Bates had an insatiable curiosity about nature and younger audiences will relate to his adventures. His incremental steps of scientific discovery unfold in a compelling way, with a remarkable outcome that can be easily understood by all ages.*

As part of the NSF funding for *Amazon Adventure*, the project supported both external research and evaluation studies of the film. The summative evaluation study, the subject of another report, assessed the immediate and longer-term impacts of the film on a general audience of adults who viewed the film in a local science center or museum theater setting[1]. This report focuses on the research component of the grant, specifically the traditional paper assessment of participants pre and post responses to the film: engagement (presence/immersion) science knowledge and nature of science, science identity, and knowledge of natural selection as a mechanism of evolution. Given the lack of empirical research on the impact of learning specifically focused on the different giant screen film formats, this study used *Amazon Adventure*, to provide baseline information on the learning potential of the giant screen formats compared to both a small screen version of the film, and a classroom lesson using the same content as the film. The research asked:

[1] The evaluation and research components of the project were designed to have different focuses. While the research investigated differences in students' content learning *"among the various film formats, their unique attributes, and whether format plays a role in science interest and science identity," (*see NSF award page), the evaluation prioritized understanding viewers' immediate and longer-term experiences with the film with respect to science learning, narrative engagement, and spatial presence.

RQ: Are there differences in knowledge pre- and post-viewing between the giant screen formats?
RQ: Does learning from the giant screen differ as compared to a traditional class lesson?
RQ: Does giant screen support and augment knowledge or acceptance of natural selection as compared to a class lesson?
RQ: Are there unique attributes in learning between the giant screen formats?
RQ: Does format play a role in science interest and science identity?

Methodology

Using a repeated measures design prior to intervention, immediately after intervention, and 6 weeks post intervention, the study examined the knowledge of natural selection as a mechanism of change; as well as measures of engagement (presence/immersion), nature of science, science interest and science identity across the five formats (classroom, small screen, 2D flat giant screen, 3D flat giant screen, dome giant screen).

Groups of fifth grade students from public or private schools in St. Paul, Minnesota; Seattle, Washington, Sacramento, California; Boston, Massachusetts; Edison, New Jersey; Hamilton, New Jersey, and Somerset, New Jersey were invited to participate in research on the role of format in learning (Figure 1; Table x; Appendix D). They were recruited either by direct contact with the museum/theater site or by flyer disseminated to a New Jersey teacher listserv.

Participating school groups at Rutgers University were randomly assigned to view *Amazon Adventure* in either 2D small screen (12' diagonal) or participate in a classroom lesson with the same content as *Amazon Adventure.* Museum/theater groups were assigned to format as a function of museum/theater facilities. Students watched the film in 2D flat screen (112' diagonal) at Esquire Theater or Pacific Science Center, 3D flat screen (112' diagonal) at Pacific Science Center or dome at Museum of Science Boston or Science Center of Minnesota (N ~100 per format/lesson). All research was performed under Rutgers University IRB protocol 18-119Mcx: *A Giant Screen Film, Educational Outreach and Research about 2D, 3D and Dome Formats Using a Gaming Assessment Tool*.

Table 1. Participants by format.

	Pre	**Post**	**Long**
Classroom lesson	63	63	60
Small screen	135	135	130
Flat 2D giant screen	143	143	137
Flat 3D giant screen	96	96	87
Dome giant screen	102	102	93
Totals	539	539	507

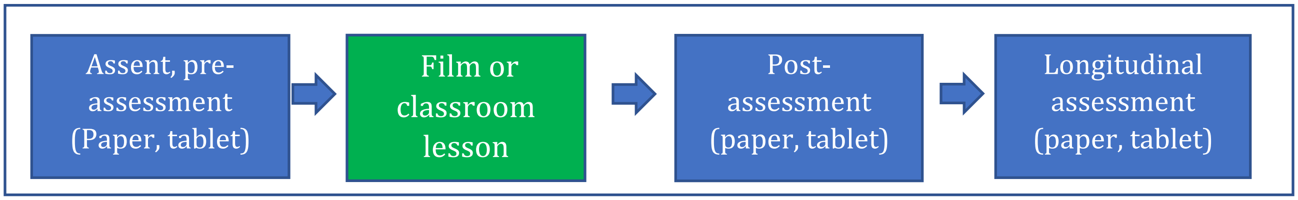

Figure 1. Research schedule.

Pre, post and longitudinal assessments asked questions relating to presence/engagement, science identity and knowledge (Table 2; see Appendices). Assessments used paper and tablet game. This research reports only on the paper assessment.

For the purpose of this research, engagement was defined as a composite of the theories of immersion and presence/place illusion, both of which have been implicated in enhanced learning (Dede, 2009; Korakakis et al, 2009; Plummer, 2009; Sumners, Reiff & Weber, 2008). Immersion is the degree to which a viewer feels like they are part of the mediated experience through the technical characteristics of the medium (Arsenault 2005; Fiore et al. 2009; Nunez 2004). Presence/place illusion is the sense that the viewer is connected to the people, events and objects on the screen (Lombard, 2008) and is dependent on the viewer having the belief that they can be an actor in the mediated environment (Fraser, et al, 2013). Engagement measures were a composite of measures drawn from existing scales of presence (Lessiter et al., 2001; Hartman et al., 2016).

Science identity was defined as the sense of who students are, what they believe they are capable of, and what they want to do and become in regard to science (Brickhouse, 2001). An individual's image of science engages their process knowledge with their practical, procedural and declarative knowledge sets (Jordan & Duncan, 2009). It is based on how students view themselves and believe others view them as they participate in science endeavors (Aschbacher, Li & Roth 2010). Science identity measures were drawn from existing identity scales (Fraser, 1978, 1981; Moore & Hill Foy, 1997; Weinburgh & Steele, 2000).

Table 2. Constructs included in the study instruments.

	Pre assessment	**Post assessment**	**Longitudinal assessment**
Engagement		x	
Nature of science	x		
Science identity	x	x	x
Knowledge	x	x	x

Knowledge was defined as the student's ability to correctly select the mechanism of action for change over time in various target species across the taxonomic spectrum (dinosaurs, fish, birds, mammals). Multiple choice questions were phrased to allow for one of four

possible explanations for change over time, appropriate to a developmental connection understanding of natural selection (Evans, 2000):

- teleological (goal directed or intentional change; want or desire to change)
- evolutionary (natural selection)
- essentialist (living organisms cannot change, they are separate and stable)
- supernatural (creationist: something or someone made them change) explanations.

Prior to the lesson or film, all participants completed IRB-required consent (parents or guardians) and assent procedures; participants who did not complete both consent and assent were dropped from the study prior to analysis. Following completion of assent, participants watched a PowerPoint on how to use the adapted SmileyFace Likert scale (Figure 2; Yahaya & Salam, 2008). To avoid reading issues, all pre, post and longitudinal assessments were read aloud by a researcher while displayed on PowerPoint. After completion of assent, participants watched the film or had a classroom lesson consisting of images from the film, and language from the script. The film run time was 45 minutes, the classroom run time was 35 minutes (adjusted down as no credits were included). Six weeks post intervention, participants completed a longitudinal assessment at their home school. Assessments were administered by research staff. Participants received compensation in the form of travel to the sites to view the film, and lunch. Classroom lesson participants received lunch as compensation.

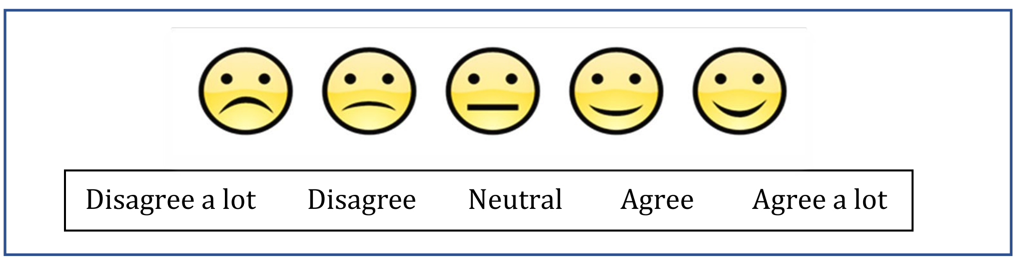

Figure 2. Likert scale used in pre, post and longitudinal assessment.

Consents and assent forms were matched for all participants, and any students that did not have either a signed consent or signed assent were dropped from the study. All results were transcribed from the paper instruments into Excel, cleaned and transposed to SPSS and analyzed for descriptive statistics, and as appropriate to the data, by paired t-tests and ANOVA.

Results

<u>Nature of science</u>

We asked two questions regarding the student's understanding of the process or science/nature of science. If students did not understand how science worked, it could potentially indicate a potential to misinterpret Bates' work in the Amazon—why would he be spending time there observing? Why would looking at patterns in wing coloration be valuable?

Students were asked in the pre-assessment, prior to any intervention, whether "scientific questions are answered by observing things." Descriptive statistics analysis (frequency) showed that regardless of format, the majority of students noted agree/agree a lot (39.5%/28.9%; 68.4%) that this is true (Table 3).

Table 3. Descriptive statistics (frequency) analysis of nature of science (observation) prior to intervention.

Id3precl

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree a lot	5	.9	.9	.9
	disagree	27	5.0	5.0	5.9
	neutral	137	25.4	25.5	31.4
	agree	213	39.5	39.6	71.0
	agree a lot	156	28.9	29.0	100.0
	Total	538	99.8	100.0	
Missing	System	1	.2		
Total		539	100.0		

Students were also asked "Scientists do research to answer questions about the world. What is the most important thing that scientists need to answer those questions?" with response options of:

- They need to be smarter than anyone else.
- They need to get evidence to answer the questions.
- They need to work all the time.

Descriptive statistics analysis (frequency) (Table 4) showed that 98% of students, regardless of format, agreed that scientists needed evidence to answer questions. One-way between groups ANOVA (not displayed here) did not show significance between any groups regardless of question, indicating that prior to any intervention, participants did not vary significantly in their understanding of the nature of science as observational or requiring evidence to answer questions.

Table 4. Descriptive statistics (frequency) analysis of nature of science (evidence) prior to intervention.

scientistsdoresearch

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	need to be smarter	3	.6	.6	.6
	need to get evidence	529	98.1	98.1	98.7
	need to work all the time	6	1.1	1.1	99.8
	99	1	.2	.2	100.0
	Total	539	100.0	100.0	

<u>Presence</u>

In the post-assessment only (after film or classroom lesson) we examined whether the sense of presence differed by format. Presence, engagement and immersiveness are similar terms indicating a belief that one becomes part of, immersed in or engaged with a text, which is associated with the enhancement of learning (Dede et.al, 1999; Dede, 2009; Korakis et al, 2009; Plummer, 2009; Sumners, Reiff & Weber, 2008; Yalowitz, 2010). Students were asked three presence questions:

- I felt I could have reached out and touched the plants and animals in the film.
- I felt like I was actually there in the Amazon.
- When I watched the film I was sure that things were actually happening around me.

A one-way between subjects ANOVA was conducted to examine the role of format on the sense of presence following viewing *Amazon Adventure* in classroom lesson, small screen, 2D GS, 3D GS or dome GS. There were significant differences between groups regardless of question ("I could reach out and touch the plants and animal [F 4, 530=49, $p < .005$]; "I felt like things were actually happening around me" [F 4, 532=16, $p<.005$]; "I felt like things were actually happening around me" [F 4, 532=24, $p<.005$] (Table 5).

Table 5. One-way between groups ANOVA results for presence/engagement.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
touchedplantsanimals	Between Groups	270.413	4	67.603	49.053	.000
	Within Groups	730.428	530	1.378		
	Total	1000.841	534			
actuallythere	Between Groups	96.550	4	24.137	16.207	.000
	Within Groups	793.785	533	1.489		
	Total	890.335	537			
actuallyhappening	Between Groups	135.302	4	33.825	23.845	.000
	Within Groups	754.657	532	1.419		
	Total	889.959	536			

Post hoc comparisons using the Tukey HSD test (Table 6 a,b,c) indicated that significance differed between groups depending on question. No significant differences were seen between the classroom and small screen formats when participants were asked, "I felt like I could have touched the plants and animals on the screen." No significant differences were seen between classroom and small screen, and flat 2D and flat 3D when asked, "I felt like I was actually there" or when asked "I felt like things were actually happening around me." But regardless of question, the dome format was significantly different from all other formats. Taken together, it appears that there is a difference of sense of presence/engagement by format, and that the phrasing of the question (action questions: happening around me, actually happening versus potential question: felt like I could have) may influence response.

Table 6a. Post hoc (Tukey HSD) results for sense of presence/engagement ("touched the plants and animals").

Multiple Comparisons

Dependent Variable: touchedplantsanimals
Tukey HSD

(I) format	(J) format	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
classroom	small screen	.159	.179	.902	-.33	.65
	flat 2d	-.867*	.178	.000	-1.35	-.38
	flat 3d	-1.438*	.191	.000	-1.96	-.91
	dome	-1.619*	.188	.000	-2.13	-1.10
small screen	classroom	-.159	.179	.902	-.65	.33
	flat 2d	-1.026*	.141	.000	-1.41	-.64
	flat 3d	-1.597*	.158	.000	-2.03	-1.17
	dome	-1.778*	.154	.000	-2.20	-1.36
flat 2d	classroom	.867*	.178	.000	.38	1.35
	small screen	1.026*	.141	.000	.64	1.41
	flat 3d	-.571*	.156	.003	-1.00	-.14
	dome	-.752*	.153	.000	-1.17	-.33
flat 3d	classroom	1.438*	.191	.000	.91	1.96
	small screen	1.597*	.158	.000	1.17	2.03
	flat 2d	.571*	.156	.003	.14	1.00
	dome	-.181	.168	.818	-.64	.28
dome	classroom	1.619*	.188	.000	1.10	2.13
	small screen	1.778*	.154	.000	1.36	2.20
	flat 2d	.752*	.153	.000	.33	1.17
	flat 3d	.181	.168	.818	-.28	.64

*. The mean difference is significant at the 0.05 level.

Table 6b. Post hoc (Tukey HSD) results for sense of presence/engagement ("actually there in the Amazon").

Multiple Comparisons

Dependent Variable: actuallythere
Tukey HSD

(I) format	(J) format	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
classroom	small screen	-.243	.186	.687	-.75	.27
	flat 2d	-.785*	.185	.000	-1.29	-.28
	flat 3d	-.786*	.198	.001	-1.33	-.24
	dome	-1.301*	.196	.000	-1.84	-.77
small screen	classroom	.243	.186	.687	-.27	.75
	flat 2d	-.542*	.146	.002	-.94	-.14
	flat 3d	-.543*	.163	.008	-.99	-.10
	dome	-1.058*	.160	.000	-1.50	-.62
flat 2d	classroom	.785*	.185	.000	.28	1.29
	small screen	.542*	.146	.002	.14	.94
	flat 3d	-.001	.162	1.000	-.44	.44
	dome	-.516*	.158	.010	-.95	-.08
flat 3d	classroom	.786*	.198	.001	.24	1.33
	small screen	.543*	.163	.008	.10	.99
	flat 2d	.001	.162	1.000	-.44	.44
	dome	-.515*	.174	.027	-.99	-.04
dome	classroom	1.301*	.196	.000	.77	1.84
	small screen	1.058*	.160	.000	.62	1.50
	flat 2d	.516*	.158	.010	.08	.95
	flat 3d	.515*	.174	.027	.04	.99

*. The mean difference is significant at the 0.05 level.

Table 6c. Post hoc (Tukey HSD) results for sense of presence/engagement ("actually happening around me").

Multiple Comparisons

Dependent Variable: actuallyhappening
Tukey HSD

(I) format	(J) format	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
classroom	small screen	-.329	.182	.368	-.83	.17
	flat 2d	-.880*	.180	.000	-1.37	-.39
	flat 3d	-1.021*	.194	.000	-1.55	-.49
	dome	-1.564*	.191	.000	-2.09	-1.04
small screen	classroom	.329	.182	.368	-.17	.83
	flat 2d	-.551*	.143	.001	-.94	-.16
	flat 3d	-.692*	.159	.000	-1.13	-.26
	dome	-1.235*	.156	.000	-1.66	-.81
flat 2d	classroom	.880*	.180	.000	.39	1.37
	small screen	.551*	.143	.001	.16	.94
	flat 3d	-.141	.158	.900	-.57	.29
	dome	-.684*	.155	.000	-1.11	-.26
flat 3d	classroom	1.021*	.194	.000	.49	1.55
	small screen	.692*	.159	.000	.26	1.13
	flat 2d	.141	.158	.900	-.29	.57
	dome	-.543*	.170	.013	-1.01	-.08
dome	classroom	1.564*	.191	.000	1.04	2.09
	small screen	1.235*	.156	.000	.81	1.66
	flat 2d	.684*	.155	.000	.26	1.11
	flat 3d	.543*	.170	.013	.08	1.01

*. The mean difference is significant at the 0.05 level.

<u>Science identity (pre)</u>

Students were asked a series of questions related to science identity. Science identity is the sense of who students are, what they believe they are capable of, and what they want to do and become in regard to science (Brickhouse, 2001). An individual's image of science engages their process knowledge with their practical, procedural and declarative knowledge sets (Jordan & Duncan, 2009). It is based on how students view themselves and believe others view them as they participate in science endeavors (Aschbacher, Li, Roth 2009). Identity becomes an issue when communicating science with a goal to engage students: if they can't see themselves as a scientist they will likely not be interested, engage with materials or consider science as a career. Participants were asked four questions in the pre-assessment:

- A scientist must have a good imagination to create new ideas.
- Scientists have to study too much.
- Science is one of my favorite subjects.
- Working in a science laboratory would be fun.

Descriptive statistics analysis (frequency) showed that when looking at the students as a group, it appeared that students had a positive sense of science (Table 7a,b,c,d). The majority of students (79%) agreed a lot/agreed that imagination was important to being a

scientist, 53% said that science was their favorite subject, and 69% said that working in a science lab would be fun. Only when asked whether scientists had to study too much were students less sure, with 44% indicating they were unsure.

Table 7a. Descriptive statistics (frequency) analysis for nature of science ("scientists must have a good imagination").

goodimagination

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree a lot	8	1.5	1.5	1.5
	disagree	28	5.2	5.2	6.7
	neutral	71	13.2	13.2	19.9
	agree	237	44.0	44.0	63.8
	agree a lot	193	35.8	35.8	99.6
	99	2	.4	.4	100.0
	Total	539	100.0	100.0	

Table 7b. Descriptive statistics (frequency) analysis for nature of science ("scientists have to study too much").

studytoomuch

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disgree a lot	39	7.2	7.2	7.2
	disagree	125	23.2	23.2	30.4
	neutral	242	44.9	44.9	75.3
	agree	89	16.5	16.5	91.8
	agree a lot	43	8.0	8.0	99.8
	99	1	.2	.2	100.0
	Total	539	100.0	100.0	

Table 7c. Descriptive statistics (frequency) analysis for nature of science ("science is one of my favorite subjects").

sciencefavorite

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree a lot	37	6.9	6.9	6.9
	disagree	63	11.7	11.7	18.6
	neutral	152	28.2	28.2	46.8
	agree	115	21.3	21.3	68.1
	agree a lot	171	31.7	31.7	99.8
	99	1	.2	.2	100.0
	Total	539	100.0	100.0	

Table 7d. Descriptive statistics (frequency) analysis for nature of science ("working in a science laboratory would be fun").

sciencelabfun

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	disagree a lot	13	2.4	2.4	2.4
	disagree	21	3.9	3.9	6.3
	neutral	129	23.9	23.9	30.2
	agree	152	28.2	28.2	58.4
	agree a lot	224	41.6	41.6	100.0
	Total	539	100.0	100.0	

One-way between group ANOVA for these questions showed that there were only significant differences between groups for the "working in a science laboratory would be fun" question (Table 8) [F 4, 534=1.3, p<.005]. Post-hoc analysis using Tukey HSD (Table 9) showed that there were significant differences between the classroom format and the small screen, 2D flat and 3d flat formats.

Table 8. One-way between subjects ANOVA results for science identity.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
goodimagination	Between Groups	177.363	4	44.341	1.300	.269
	Within Groups	18220.778	534	34.121		
	Total	18398.141	538			
studytoomuch	Between Groups	44.315	4	11.079	.610	.656
	Within Groups	9705.106	534	18.174		
	Total	9749.421	538			
sciencefavorite	Between Groups	65.932	4	16.483	.895	.467
	Within Groups	9839.000	534	18.425		
	Total	9904.931	538			
sciencelabfun	Between Groups	28.694	4	7.173	7.297	.000
	Within Groups	524.943	534	.983		
	Total	553.636	538			

Table 9. Post hoc (Tukey HSD) results for science identity.

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) format	(J) format	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
goodimagination	classroom	small screen	-1.575	.891	.394	-4.01	.86
		flat 2d	-.245	.883	.999	-2.66	2.17
		flat 3d	-.362	.947	.995	-2.95	2.23
		dome	-.430	.936	.991	-2.99	2.13
	small screen	classroom	1.575	.891	.394	-.86	4.01
		flat 2d	1.330	.701	.320	-.59	3.25
		flat 3d	1.213	.780	.527	-.92	3.35
		dome	1.145	.766	.567	-.95	3.24
	flat 2d	classroom	.245	.883	.999	-2.17	2.66
		small screen	-1.330	.701	.320	-3.25	.59
		flat 3d	-.118	.771	1.000	-2.23	1.99
		dome	-.185	.757	.999	-2.26	1.89
	flat 3d	classroom	.362	.947	.995	-2.23	2.95
		small screen	-1.213	.780	.527	-3.35	.92
		flat 2d	.118	.771	1.000	-1.99	2.23
		dome	-.067	.831	1.000	-2.34	2.21
	dome	classroom	.430	.936	.991	-2.13	2.99
		small screen	-1.145	.766	.567	-3.24	.95
		flat 2d	.185	.757	.999	-1.89	2.26
		flat 3d	.067	.831	1.000	-2.21	2.34
studytoomuch	classroom	small screen	-.330	.650	.987	-2.11	1.45
		flat 2d	-.713	.645	.803	-2.48	1.05
		flat 3d	.075	.691	1.000	-1.82	1.97
		dome	-.224	.683	.998	-2.09	1.65
	small screen	classroom	.330	.650	.987	-1.45	2.11
		flat 2d	-.383	.512	.945	-1.78	1.02
		flat 3d	.406	.569	.954	-1.15	1.96
		dome	.107	.559	1.000	-1.42	1.64
	flat 2d	classroom	.713	.645	.803	-1.05	2.48
		small screen	.383	.512	.945	-1.02	1.78
		flat 3d	.788	.563	.627	-.75	2.33
		dome	.489	.553	.902	-1.02	2.00
	flat 3d	classroom	-.075	.691	1.000	-1.97	1.82
		small screen	-.406	.569	.954	-1.96	1.15
		flat 2d	-.788	.563	.627	-2.33	.75
		dome	-.299	.606	.988	-1.96	1.36
	dome	classroom	.224	.683	.998	-1.65	2.09
		small screen	-.107	.559	1.000	-1.64	1.42
		flat 2d	-.489	.553	.902	-2.00	1.02
		flat 3d	.299	.606	.988	-1.36	1.96
sciencefavorite	classroom	small screen	.975	.655	.571	-.82	2.77
		flat 2d	.327	.649	.987	-1.45	2.10
		flat 3d	.980	.696	.623	-.92	2.89
		dome	.632	.688	.890	-1.25	2.51
	small screen	classroom	-.975	.655	.571	-2.77	.82
		flat 2d	-.648	.515	.717	-2.06	.76
		flat 3d	.006	.573	1.000	-1.56	1.57
		dome	-.342	.563	.974	-1.88	1.20

	flat 2d	classroom	-.327	.649	.987	-2.10	1.45
		small screen	.648	.515	.717	-.76	2.06
		flat 3d	.653	.566	.778	-.90	2.20
		dome	.305	.556	.982	-1.22	1.83
	flat 3d	classroom	-.980	.696	.623	-2.89	.92
		small screen	-.006	.573	1.000	-1.57	1.56
		flat 2d	-.653	.566	.778	-2.20	.90
		dome	-.348	.610	.979	-2.02	1.32
	dome	classroom	-.632	.688	.890	-2.51	1.25
		small screen	.342	.563	.974	-1.20	1.88
		flat 2d	-.305	.556	.982	-1.83	1.22
		flat 3d	.348	.610	.979	-1.32	2.02
sciencelabfun	classroom	small screen	.601*	.151	.001	.19	1.02
		flat 2d	.767*	.150	.000	.36	1.18
		flat 3d	.634*	.161	.001	.19	1.07
		dome	.415	.159	.070	-.02	.85
	small screen	classroom	-.601*	.151	.001	-1.02	-.19
		flat 2d	.166	.119	.630	-.16	.49
		flat 3d	.033	.132	.999	-.33	.40
		dome	-.186	.130	.606	-.54	.17
	flat 2d	classroom	-.767*	.150	.000	-1.18	-.36
		small screen	-.166	.119	.630	-.49	.16
		flat 3d	-.133	.131	.847	-.49	.22
		dome	-.353*	.128	.049	-.70	.00
	flat 3d	classroom	-.634*	.161	.001	-1.07	-.19
		small screen	-.033	.132	.999	-.40	.33
		flat 2d	.133	.131	.847	-.22	.49
		dome	-.219	.141	.527	-.61	.17
	dome	classroom	-.415	.159	.070	-.85	.02
		small screen	.186	.130	.606	-.17	.54
		flat 2d	.353*	.128	.049	.00	.70
		flat 3d	.219	.141	.527	-.17	.61

*. The mean difference is significant at the 0.05 level.

<u>Science identity (post and longitudinal)</u>

Can science identity be changed by watching *Amazon Adventure*? This is the basis for examining students' perceptions of their science identity immediately after and 6 weeks post film. As seen in the results for the pre-assessment (Tables 7-9), participants had a positive sense of science/science identity coming into the study. Does identity change after watching the film? Do we see and increase/decrease? And is that change maintained over time or does it also change? Students were asked five matched sets of identity questions in the post and longitudinal assessments:

- I like discovering new things
- Science is easy for me.
- Most people can understand science.
- I would like to be a scientist.
- A scientist's job would be boring.

Data was analyzed with paired samples t-test. Only the questions "science is easy for me" and "I want to be a scientist" show a weak but positively correlation (r=0.098, p=0.029;

r=0.178, p<0.01) (Table 10 a,b,c). Participants scored higher in agreement over time for the "science is easy for me" (at the 6 week they more strongly agreed that science was easy for them), while for the "I want to be a scientist" they scored lower in agreement over time (at 6 weeks they were less likely to want to be a scientist).

Table 10a. Paired samples t-test results for science identity (post and longitudinal assessments).

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	discnewpost	4.24	505	.923	.041
	discnewlong	4.17	505	.824	.037
Pair 2	scieeasypost	3.29	504	.940	.042
	scieasylong	3.42	504	.893	.040
Pair 3	mostunderpost	2.92	503	.902	.040
	mostunderlong	2.90	503	.869	.039
Pair 4	bescipost	2.71	504	1.313	.058
	bescilong	2.53	504	1.278	.057
Pair 5	scijobpost	2.15	500	1.062	.047
	scijoblong	2.25	500	1.120	.050

Table 10b. Paired samples t-test results for science identity (post and longitudinal assessments).

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	discnewpost & discnewlong	505	.042	.348
Pair 2	scieeasypost & scieasylong	504	.098	.029
Pair 3	mostunderpost & mostunderlong	503	.049	.276
Pair 4	bescipost & bescilong	504	.178	.000
Pair 5	scijobpost & scijoblong	500	.068	.127

Table 10c. Paired samples t-test results for science identity (post and longitudinal assessments).

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	discnewpost - discnewlong	.071	1.211	.054	-.035	.177	1.323	504	.187
Pair 2	scieeasypost - scieasylong	-.129	1.231	.055	-.237	-.021	-2.351	503	.019
Pair 3	mostunderpost - mostunderlong	.016	1.222	.054	-.091	.123	.292	502	.771
Pair 4	bescipost - bescilong	.187	1.661	.074	.041	.332	2.520	503	.012
Pair 5	scijobpost - scijoblong	-.106	1.490	.067	-.237	.025	-1.591	499	.112

Knowledge

Students were asked a series of questions at pre, post and 6 weeks longitudinal to determine if there were significant post-intervention knowledge changes (learning) regarding an understanding of the mechanism of natural selection. These questions were based on research by Evans (2013) that pointed to developmentally-related cognition of natural selection as a mechanism for change. Each question had four possible responses, which related to concepts of organismal change:

- teleological (goal directed or intentional change; want or desire to change)
- evolutionary (natural selection)
- essentialist (living organisms cannot change, they are separate and stable)
- supernatural (creationist: something or someone made them change) explanations

The questions also considered whether the kind of organism (dinosaur, guppies, finches, horse) had any influence on selection of mechanism of change, as it has been shown in previous research that "Participants of all ages were more likely to accept evolutionary ideas for animals that…were taxonomically distant from the human, in the following order: butterflies > frogs > non-human mammals > humans" (Evans, 2013).

Descriptive statistics (frequency) analyses (Tables 10 a,b,c) prior to any intervention, and regardless of format, showed that more than 60% of students offered a natural selection explanation for change in birds and dinosaurs, as opposed to 50% of students who offered

an essentialist explanation for change in guppies. There were no significant differences between groups in one-way ANOVA analyses.

Table 10a. Descriptive statistics (frequency) analysis related to understanding of the mechanism of natural selection in guppies.

guppiescolor

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	123	22.8	22.8	22.8
	evolution natural selection	129	23.9	23.9	46.8
	unchanging essentialism	268	49.7	49.7	96.5
	supernatural creationist	14	2.6	2.6	99.1
	99	5	.9	.9	100.0
	Total	539	100.0	100.0	

10b. Descriptive statistics (frequency) analysis related to understanding of the mechanism of natural selection in birds (beak size).

beaksbirds

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	61	11.3	11.3	11.3
	evolution natural selection	343	63.6	63.6	75.0
	unchanging essentialist	111	20.6	20.6	95.5
	supernatural creationist	16	3.0	3.0	98.5
	99	8	1.5	1.5	100.0
	Total	539	100.0	100.0	

10c. Descriptive statistics (frequency) analysis related to understanding of the mechanism of natural selection in dinosaurs as ancestors of birds.

dinosaurbird

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	2	.4	.4	.4
	evolution natural selection	360	66.8	66.8	67.2
	unchanging essentialism	136	25.2	25.2	92.4
	supernatural creationist	38	7.1	7.1	99.4
	99	3	.6	.6	100.0
	Total	539	100.0	100.0	

After intervention, questions examined whether students would use an alternative mechanism of action for species that differed by class (taxonomic classification: birds, mammals). The questions used the same structure and answer choices (teleological, evolutionary, essentialist, supernatural) as prior to intervention. The question related to birds was the same scenario (color change) as the pre-assessment question about guppies. The question related to mammals (horses) was a reworded version of the guppies/finch questions.

Descriptive statistics (frequency) analyses showed that immediately after intervention, there were no changes in attributing change to a creationist explanation regardless of class or organism, a decrease in attributing change to goal directed teleology, slight (non-significant) changes in attributing change to essentialist mechanism, and increases in natural selection as the mechanism of action (Figure 2). There was no significance seen in one way matched pairs ANOVA.

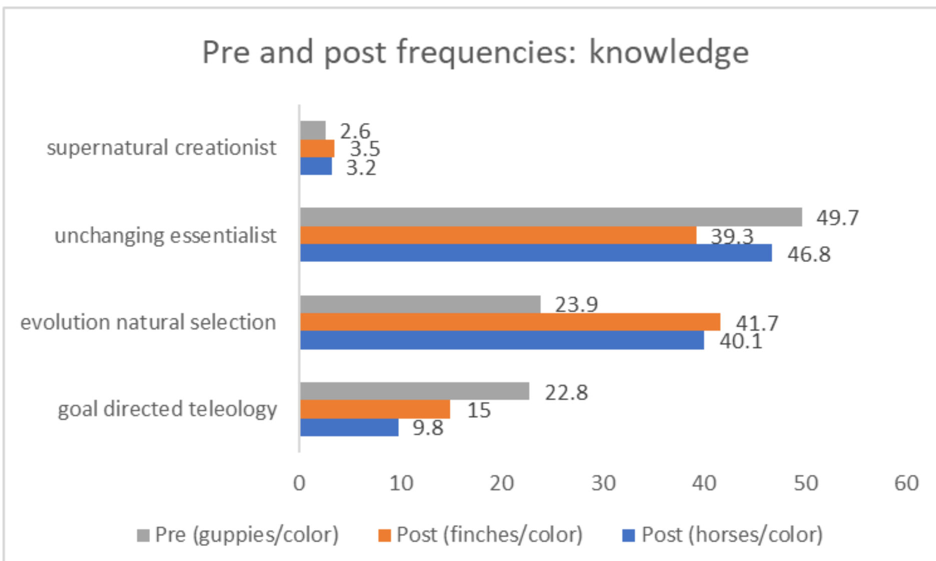

Figure 2. Descriptive statistics (frequency) analyses for knowledge related to mechanism of action for color change between taxonomic classes.

Descriptive statistics (frequency) analysis (Table 11 a,b,c,d) of matched post and longitudinal bird and mammal questions showed similar rates of selection of natural selection and essentialism as mechanisms of action for both birds and mammals.

Table 11a. Post descriptive statistics (frequency) analyses for mechanism of action of color change in birds (finches).

finchescolorpost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	81	15.0	15.1	15.1
	evolution natural selection	225	41.7	41.9	57.0
	unchanging essentialist	212	39.3	39.5	96.5
	supernatural creationist	19	3.5	3.5	100.0
	Total	537	99.6	100.0	
Missing	System	2	.4		
Total		539	100.0		

Table 11b. Longitudinal descriptive statistics (frequency) analyses for mechanism of action of color change in birds (finches).

finchescolorlong

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	55	10.2	10.9	10.9
	evolution natural selection	213	39.5	42.1	53.0
	unchanging essentialist	218	40.4	43.1	96.0
	supernatural creationist	20	3.7	4.0	100.0
	Total	506	93.9	100.0	
Missing	System	33	6.1		
Total		539	100.0		

Table 11c. Post descriptive statistics (frequency) analyses for mechanism of action of color change in mammals (horses).

horsescoatpost

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	53	9.8	9.9	9.9
	evolution natural selection	216	40.1	40.1	50.0
	unchanging essentialist	252	46.8	46.8	96.8
	supernatural creationist	17	3.2	3.2	100.0
	Total	538	99.8	100.0	
Missing	System	1	.2		
Total		539	100.0		

Table 11d. Longitudinal descriptive statistics (frequency) analyses for mechanism of action of color change in mammals (horses).

horsescoatlong

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	goal directed teleology	41	7.6	8.1	8.1
	evolution natural selection	229	42.5	45.4	53.6
	unchanging essentialist	219	40.6	43.5	97.0
	supernatural essentialist	15	2.8	3.0	100.0
	Total	504	93.5	100.0	
Missing	System	35	6.5		
Total		539	100.0		

Matched pair t-tests showed that there was a significant difference between the post bird question (M=2.30; SD=.767) and the longitudinal bird question (M=2.40; SD=.734); t(503)=-2.205, p<0.028, but there was no significance for the paired horse questions. Post hoc (Tukey HSD) after ANOVA showed significance only for the post intervention questions between flat 3D and dome (bird) and classroom and flat 3D (mammal).

Table 12. Post hoc (Tukey) knowledge questions (pre, post and longitudinal).

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) formatpre	(J) formatpre	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
guppiescolorpre	classroom	small screen	-.706	1.423	.988	-4.60	3.19
		flat 2d	-1.252	1.410	.901	-5.11	2.61
		flat 3d	-1.837	1.512	.742	-5.98	2.30
		dome	.148	1.494	1.000	-3.94	4.24
	small screen	classroom	.706	1.423	.988	-3.19	4.60
		flat 2d	-.546	1.119	.988	-3.61	2.52
		flat 3d	-1.131	1.245	.893	-4.54	2.28
		dome	.854	1.223	.957	-2.49	4.20
	flat 2d	classroom	1.252	1.410	.901	-2.61	5.11
		small screen	.546	1.119	.988	-2.52	3.61
		flat 3d	-.586	1.230	.989	-3.95	2.78
		dome	1.400	1.208	.775	-1.91	4.71
	flat 3d	classroom	1.837	1.512	.742	-2.30	5.98

		small screen	1.131	1.245	.893	-2.28	4.54
		flat 2d	.586	1.230	.989	-2.78	3.95
		dome	1.985	1.326	.565	-1.64	5.61
	dome	classroom	-.148	1.494	1.000	-4.24	3.94
		small screen	-.854	1.223	.957	-4.20	2.49
		flat 2d	-1.400	1.208	.775	-4.71	1.91
		flat 3d	-1.985	1.326	.565	-5.61	1.64
dinosaurbirdpre	classroom	small screen	1.497	1.099	.652	-1.51	4.50
		flat 2d	1.569	1.089	.601	-1.41	4.55
		flat 3d	-.449	1.168	.995	-3.65	2.75
		dome	1.395	1.154	.746	-1.76	4.55
	small screen	classroom	-1.497	1.099	.652	-4.50	1.51
		flat 2d	.072	.864	1.000	-2.29	2.44
		flat 3d	-1.947	.961	.255	-4.58	.68
		dome	-.102	.945	1.000	-2.69	2.48
	flat 2d	classroom	-1.569	1.089	.601	-4.55	1.41
		small screen	-.072	.864	1.000	-2.44	2.29
		flat 3d	-2.019	.950	.211	-4.62	.58
		dome	-.174	.933	1.000	-2.73	2.38
	flat 3d	classroom	.449	1.168	.995	-2.75	3.65
		small screen	1.947	.961	.255	-.68	4.58
		flat 2d	2.019	.950	.211	-.58	4.62
		dome	1.844	1.024	.374	-.96	4.65
	dome	classroom	-1.395	1.154	.746	-4.55	1.76
		small screen	.102	.945	1.000	-2.48	2.69
		flat 2d	.174	.933	1.000	-2.38	2.73
		flat 3d	-1.844	1.024	.374	-4.65	.96
beaksbirdspre	classroom	small screen	.008	1.789	1.000	-4.89	4.91
		flat 2d	-2.754	1.773	.528	-7.61	2.10
		flat 3d	-1.977	1.901	.837	-7.18	3.23
		dome	-2.030	1.879	.817	-7.17	3.11
	small screen	classroom	-.008	1.789	1.000	-4.91	4.89
		flat 2d	-2.763	1.407	.286	-6.61	1.09
		flat 3d	-1.986	1.565	.711	-6.27	2.30
		dome	-2.038	1.538	.676	-6.25	2.17
	flat 2d	classroom	2.754	1.773	.528	-2.10	7.61

		small screen	2.763	1.407	.286	-1.09	6.61
		flat 3d	.777	1.547	.987	-3.46	5.01
		dome	.724	1.520	.989	-3.44	4.88
	flat 3d	classroom	1.977	1.901	.837	-3.23	7.18
		small screen	1.986	1.565	.711	-2.30	6.27
		flat 2d	-.777	1.547	.987	-5.01	3.46
		dome	-.053	1.667	1.000	-4.62	4.51
	dome	classroom	2.030	1.879	.817	-3.11	7.17
		small screen	2.038	1.538	.676	-2.17	6.25
		flat 2d	-.724	1.520	.989	-4.88	3.44
		flat 3d	.053	1.667	1.000	-4.51	4.62
finchescolorpost	classroom	small screen	.192	.116	.469	-.13	.51
		flat 2d	.076	.115	.964	-.24	.39
		flat 3d	.281	.124	.157	-.06	.62
		dome	-.022	.122	1.000	-.36	.31
	small screen	classroom	-.192	.116	.469	-.51	.13
		flat 2d	-.115	.092	.719	-.37	.14
		flat 3d	.090	.102	.905	-.19	.37
		dome	-.214	.100	.205	-.49	.06
	flat 2d	classroom	-.076	.115	.964	-.39	.24
		small screen	.115	.092	.719	-.14	.37
		flat 3d	.205	.101	.255	-.07	.48
		dome	-.099	.099	.856	-.37	.17
	flat 3d	classroom	-.281	.124	.157	-.62	.06
		small screen	-.090	.102	.905	-.37	.19
		flat 2d	-.205	.101	.255	-.48	.07
		dome	-.304*	.109	.043	-.60	-.01
	dome	classroom	.022	.122	1.000	-.31	.36
		small screen	.214	.100	.205	-.06	.49
		flat 2d	.099	.099	.856	-.17	.37
		flat 3d	.304*	.109	.043	.01	.60
horsescoatpost	classroom	small screen	.230	.108	.208	-.07	.52
		flat 2d	.275	.107	.076	-.02	.57
		flat 3d	.393*	.115	.006	.08	.71
		dome	.176	.113	.524	-.13	.49
	small screen	classroom	-.230	.108	.208	-.52	.07

		flat 2d	.045	.085	.984	-.19	.28
		flat 3d	.163	.095	.418	-.10	.42
		dome	-.053	.093	.979	-.31	.20
	flat 2d	classroom	-.275	.107	.076	-.57	.02
		small screen	-.045	.085	.984	-.28	.19
		flat 3d	.118	.093	.715	-.14	.37
		dome	-.099	.091	.818	-.35	.15
	flat 3d	classroom	-.393*	.115	.006	-.71	-.08
		small screen	-.163	.095	.418	-.42	.10
		flat 2d	-.118	.093	.715	-.37	.14
		dome	-.217	.101	.200	-.49	.06
	dome	classroom	-.176	.113	.524	-.49	.13
		small screen	.053	.093	.979	-.20	.31
		flat 2d	.099	.091	.818	-.15	.35
		flat 3d	.217	.101	.200	-.06	.49
finchescolorlong	classroom	small screen	.108	.112	.871	-.20	.41
		flat 2d	.172	.111	.529	-.13	.48
		flat 3d	.070	.119	.976	-.26	.40
		dome	.117	.128	.892	-.23	.47
	small screen	classroom	-.108	.112	.871	-.41	.20
		flat 2d	.064	.088	.949	-.18	.31
		flat 3d	-.038	.098	.995	-.31	.23
		dome	.009	.109	1.000	-.29	.31
	flat 2d	classroom	-.172	.111	.529	-.48	.13
		small screen	-.064	.088	.949	-.31	.18
		flat 3d	-.102	.097	.831	-.37	.16
		dome	-.056	.108	.986	-.35	.24
	flat 3d	classroom	-.070	.119	.976	-.40	.26
		small screen	.038	.098	.995	-.23	.31
		flat 2d	.102	.097	.831	-.16	.37
		dome	.046	.116	.995	-.27	.36
	dome	classroom	-.117	.128	.892	-.47	.23
		small screen	-.009	.109	1.000	-.31	.29
		flat 2d	.056	.108	.986	-.24	.35
		flat 3d	-.046	.116	.995	-.36	.27
horsescoatlong	classroom	small screen	-.070	.104	.961	-.35	.21

		flat 2d	.149	.103	.598	-.13	.43
		flat 3d	.069	.110	.970	-.23	.37
		dome	-.034	.118	.999	-.36	.29
	small screen	classroom	.070	.104	.961	-.21	.35
		flat 2d	.219	.082	.059	.00	.44
		flat 3d	.140	.091	.537	-.11	.39
		dome	.037	.101	.996	-.24	.31
	flat 2d	classroom	-.149	.103	.598	-.43	.13
		small screen	-.219	.082	.059	-.44	.00
		flat 3d	-.079	.090	.903	-.32	.17
		dome	-.182	.100	.357	-.46	.09
	flat 3d	classroom	-.069	.110	.970	-.37	.23
		small screen	-.140	.091	.537	-.39	.11
		flat 2d	.079	.090	.903	-.17	.32
		dome	-.103	.107	.872	-.40	.19
	dome	classroom	.034	.118	.999	-.29	.36
		small screen	-.037	.101	.996	-.31	.24
		flat 2d	.182	.100	.357	-.09	.46
		flat 3d	.103	.107	.872	-.19	.40

*. The mean difference is significant at the 0.05 level.

Discussion

The research presented here was the first empirical study to examine the presence/engagement in giant screen by format and the role of giant screen format on nature of science, science identity and knowledge related to mechanisms of evolutionary change. The fifth-grade student participants were tested prior to watching a film or having a classroom lesson on the film content, immediately after intervention and 6 weeks post intervention.

This age group was selected for a number of reasons, 1.) this age group is considered a key group to see a giant screen film through a class trip, 2.) filmmakers recognize their films are for all age informal learners, but writing for a fifth grade level is comprehensible to a wide age range, and 3.) that it is not till around the end of the elementary years that children are able to reason in evolutionary terms (Evans, 2013).

<u>Learning influences and outcomes</u>
The concepts examined in this research can be divided into two categories: learning influences (nature of science, science identity, presence) and learning outcomes (knowledge). For learning influences, demonstrating that students understood the nature of science and had a sense of science identity reflected the potential to recognize Bates'

work in the Amazon as scientific process, and could see themselves or have an interest in learning about science through the film. Examining change over time in these variables as a function of format would demonstrate whether giant screen could promote positive change to promote possible interest in science as a career or avocation. Determining whether sense of presence varied by format would support the use of giant screen in formal and informal learning programs, similar to that for learning outcomes, where demonstration of change over time as a function of format would also support the use of giant screen in formal and informal learning programs.

Nature of science, science identity and presence. An understanding of the nature of science is fundamental to research on promoting science learning. The National Science Teacher Association (NSTA) recognizes that science is a process that

> is characterized by the systematic gathering of information through various forms of direct and indirect observations and the testing of this information by methods including, but not limited to, experimentation. The principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts (NSTA, 2019).

If students did not understand how science worked, it could potentially indicate a potential to misinterpret Bates' work in the Amazon—why would he be spending time there observing? Why would looking at patterns in wing coloration be valuable?

Fundamentally, we saw that students had a strong prior understanding of the nature of science and science identity and post intervention (film, classroom lesson), showing significant negative response only to the question "I want to be a scientist" after six weeks (Tables 9 a,b). Though not examined, this may be related to the unvarnished emphasis on Bates' health, financial and disasters while in the Amazon. These emotional episodes may have stayed with participants well past the initial intervention and influenced their desire to be a scientist.

Presence is key to the proposal that giant screen films are important learning tools, as noted by Fraser et al. (2012) when they wrote, "There is a growing consensus that GS experiences have unique attributes with direct impact on science learning, and a slowly emerging body of evidence suggesting that immersion, presence, and narrative are the key components necessary for ensuring effective learning outcomes." Significant differences between format shown here support the to-date assumed belief (not empirically tested) that giant screen, and more importantly, different giant screen formats engendered differential sense of presence. In this study, we did see that sense of presence differs by format. Dome is the only format significantly different from all other formats and means analysis (Table 13) shows this as higher means (based on the Likert scale 1=disagree a lot…5=agree a lot) indicate greater agreement in the format having a sense of presence.

Table 13. Means analysis of presence questions.

Report

format		touchedplantsanimals	actuallythere	actuallyhappening
classroom	Mean	2.38	2.57	2.06
	N	63	63	63
	Std. Deviation	1.313	1.434	1.281
small screen	Mean	2.22	2.81	2.39
	N	135	135	135
	Std. Deviation	1.144	1.328	1.160
flat 2d	Mean	3.25	3.36	2.94
	N	141	143	142
	Std. Deviation	1.178	1.090	1.141
flat 3d	Mean	3.82	3.36	3.08
	N	94	95	95
	Std. Deviation	1.218	1.175	1.269
dome	Mean	4.00	3.87	3.63
	N	102	102	102
	Std. Deviation	1.072	1.140	1.168
Total	Mean	3.13	3.23	2.86
	N	535	538	537
	Std. Deviation	1.369	1.288	1.289

Taken together, these results for learning influences demonstrate that giant screen sense of presence differs by format, and that although we did not see a change over time in science identity or nature of science, that these participants came with understanding key to being able to learn from *Amazon Adventure*, and that if presence does play a role in learning, that dome outcomes should be greater than other formats.

Learning outcomes. In the film *Amazon Adventure,* Henry Bates works through the problem of finding evidence for the theory of natural selection as proposed by Charles Darwin in *On the Origin of Species* (1859). As viewers follow Bates' experiences in the Amazon, they hear his inner thoughts attempting to work out the problem as monologue, and in essence, were part of his working out the evidence ("beautiful proof") for natural selection. Unfortunately, what we saw here are some significant, but inconsistent changes in learning after intervention (Table 12), and not the expected changes given the sense of presence does differ by format. There did not appear to be any significant relationship between taxonomic class and mechanism of action across the timeline of the study. This does not preclude the potential for giant screen to have value as a learning tool. If we can equate

presence with potential for learning, we could assume that future studies would show greater learning from dome than other formats. The question is, why not here?

Limitations and conclusions

The study presented here faced some unexpected difficulties with recruitment over the course of the study. Schools and institutions that agreed to participate withdrew due to multiple issues not related to the study or study objectives, requiring the team to re-work the study schedule. Although this likely had no effect on the study, it did mean that our planned regional-focus had to be rethought, and may have introduced unexpected bias in population characteristics.

We went into the study with an assumption that the majority of fifth grade students would not have a strong science identity or understanding of nature of science or concept knowledge of natural selection. This was based on both literature reviews and discussions with various content experts. Pretesting for more than readability and timing would likely have demonstrated this and allowed for instrument redesign before going into the field.

A reliance on questionnaire assessments also limited our ability for deeper examination of participant's knowledge and responses. We were limited financially to this assessment; inclusion of multiple methods such as focus groups or interviews would have allowed us to closer examine participant's responses.

Regardless, this first study does demonstrate that there should be further evaluation of the role of format in giant screen. We have demonstrated that there is a gradation in presence by format. Future studies should take this into consideration whether with this film or other films.

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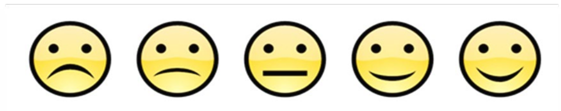
Appendix A: Pre assessment instrument

NOTE: *Likert scales used a combination of word and SmileyFace scales, as shown here:



Disagree a lot	Disagree	Neutral	Agree	Agree a lot

*1. A scientist must have a good imagination to create new ideas.

*2. Scientists have to study too much.

*3. Scientific questions are answered by observing things.

*4. Science is one of my favorite subjects.

*5. Working in a science laboratory would be fun.

6. Scientists do research to answer questions about the world. What is the most important thing that scientists need to answer those questions? Circle your answer.
    a. They need to be smarter than anyone else.
    b. They need to get evidence to answer the questions.
    c. They need to work all the time.

7. In a stream there were small fish called guppies. Some male guppies had bright black, red and blue spots. Other male guppies did not have any spots. If the males are too brightly spotted they will be eaten by bigger fish, but if they are too plain, females will choose other males. Scientists looked at the guppies in one stream where there were many big fish. The guppies in that stream were mostly plain. Why do you think the guppies in the stream with the big fish were mostly plain?   Circle the best answer to explain why most guppies in the stream with big fish were plain.
    a. The guppies wanted to be plain, because they didn't like to be eaten by the big fish.
    b. The big fish ate the spotted guppies and the plain guppies lived and had babies without spots.
    c. Guppies can't change colors. There were mostly plain guppies because the spotted guppies were all eaten by the big fish.
    d. Someone or something made the guppies become mostly plain, with no spots.

8. When scientists study dinosaur fossils they find some smaller dinosaur fossils with feathers. They now think that these dinosaurs were the ancestors of birds. Circle the best answer to explain how birds are related to dinosaurs.

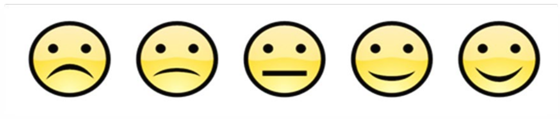
a. The dinosaurs wanted to fly so they became birds.
b. The weather became really cold and many dinosaurs died. The feathers helped the smaller dinosaurs keep warm, so the dinosaurs with feathers survived.
c. One kind of animal can't change into another kind of animal, so birds are not related to dinosaurs.
d. Something or someone made the birds and dinosaurs separately.

9. Scientists measured the beaks of birds on a remote island. Most of the birds had small beaks and could eat the small seeds from plants. All the plants that had small seeds died. All that was left were plants with big tough seeds. When the scientists came back to the island after many years, most of the birds had big beaks. Why did most of the birds have big beaks? Circle the best answer to explain why most birds had big beaks.

a. The birds wanted to eat the big tough seeds so they grew big beaks.
b. The birds with big beaks ate the big seeds so they survived and had baby birds who were born with big beaks.
c. The birds with small beaks flew away to find food on a different island.
d. Something or someone made the birds with the big beaks.

Appendix B: Post assessment instrument

NOTE: *Likert scales used a combination of word and SmileyFace scales, as shown here:



Disagree a lot	Disagree	Neutral	Agree	Agree a lot

*1. I felt I could have reached out and touched the plants and animals in the film.

*2. I felt like I was actually there in the Amazon.

*3. When I watched the film I was sure that things were actually happening around me.

*4. I like discovering new things.

*5. Science is easy for me.

*6. Most people can understand science.

*7. I would like to be a scientist.

*8. A scientist's job would be boring.

9. In a forest there were small birds called finches. Some male finches were bright red. Other male finches were plain. If the males are too bright red they will be eaten by bigger birds, but if they are too plain, females will choose other males. Scientists looked at the finches in one forest where there were many big birds. The finches in that forest were mostly plain. Why do you think the finches in the forest with the big birds were mostly plain? Circle the best answer to explain what happened.

a. The finches wanted to be plain, because they didn't like to be eaten by the big birds.
b. The big birds ate the red finches and the plain finches lived and had babies that were not red.
c. Finches can't change colors. There were mostly plain finches because the red finches were all eaten by the big birds.
d. Someone or something made the finches become plain, with no red feathers.

10. In a forest lived a herd of horses that had mostly brown coats, but a few horses were born with striped coats. The striped horses were easy for lions to see and kill in the forest. The herd moved to live on the grassy plains where the brown horses were easier for the lions to see and kill. What would happen to the herd of mostly brown horses that moved to the grassy plains? Circle the best answer to explain what you think would happen.

a. The brown horses would want to change to striped coats so they would be protected from the lions.

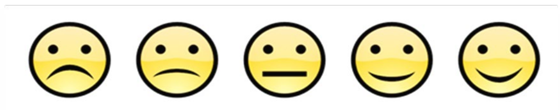
b. The big lions would eat the brown horses and the striped horses would live and have striped babies.

c. The horses would not change color. There would be mostly striped horses because the brown horses would all be eaten by the lions in the forest.

d. Something or someone would make the horses striped.

Appendix C: Longitudinal instrument

NOTE: *Likert scales used a combination of word and SmileyFace scales, as shown here:



Disagree a lot	Disagree	Neutral	Agree	Agree a lot

1. In a forest there were small birds called finches. Some male finches were bright red. Other male finches were plain. If the males are too bright red they will be eaten by bigger birds, but if they are too plain, females will choose other males. Scientists looked at the finches in one forest where there were many big birds. The finches in that forest were mostly plain. Why do you think the finches in the forest with the big birds were mostly plain? Circle the best answer to explain what happened.

    a. The finches wanted to be plain, because they didn't like to be eaten by the big birds.
    b. The big birds ate the red finches and the plain finches lived and had babies that were not red.
    c. Finches can't change colors. There were mostly plain finches because the red finches were all eaten by the big birds.
    d. Someone or something made the finches become plain, with no red feathers.

2. In a forest lived a herd of horses that had mostly brown coats, but a few horses were born with striped coats. The striped horses were easy for lions to see and kill in the forest. The herd moved to live on the grassy plains where the brown horses were easier for the lions to see and kill. What would happen to the herd of mostly brown horses that moved to the grassy plains? Circle the best answer to explain what you think would happen.

    a. The brown horses would want to change to striped coats so they would be protected from the lions.
    b. The big lions would eat the brown horses and the striped horses would live and have striped babies.
    c. The horses would not change color. There would be mostly striped horses because the brown horses would all be eaten by the lions in the forest.
    d. Something or someone would make the horses striped.

*3. I like discovering new things.

*4. Science is easy for me.

*5. Most people can understand science.

*6. I would like to be a scientist.

*7. A scientist's job would be boring.

Appendix D: Site demographics and information

Site	Location	Intervention dates	Research condition	Number of students Pre	Post	Longitudinal
CH (school)	Somerset, NJ	March 11/May 6 2019	classroom	25	25	24
JM (school)	Edison, NJ	February 8/March 29 2019	classroom	38	38	36
Rutgers University	New Brunswick, NJ	February 11/March 25 2019	Small screen (at Rutgers)	53	53	49
Rutgers University	New Brunswick, NJ	February 4/March 25 2019	Small screen (at Rutgers)	48	48	47
Rutgers University	New Brunswick, NJ	February 25/May 6 2019	Small screen (at Rutgers)	34	34	34
Esquire Theater	Sacramento, CA	October 22/December 3 2018	flat 2d	114	114	110
Pacific Science Center (2D)	Seattle, WA	December 11 2017/January 2018	flat 2d	29	29	27
Pacific Science Center (3D)	Seattle, WA	December 11 2017/January 2018	flat 3d	96	96	87
Museum of Science Boston	Boston,, MA	February 28/April 12 2019	dome	45	45	42
Science Center Minnesota	St. Paul, MN	October 16/December 2017	dome	57	57	51