EXPLORING TIME

evaluation of learning from the
> television program and
value-add of a companion web site

Submitted by

Rockman et al
Independent · Insightful · Informative

July 2008

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Executive Summary

Overview

Rockman et al (REA) conducted an impact study of the educational, two-hour, television special, *Exploring Time*, and the value-add of its associated web site, www.exploringtime.org. The program's objective is to increase the public's understanding of change over time—the multitude of changes that are occurring in the present, but at rates too slow or too fast to be seen.

This evaluation explored the extent to which the programs and web site met this overall objective by looking at three impacts of the resources: (1) Comprehension of the program's content, (2) Knowledge and understanding gained from viewing *Exploring Time* content, and (3) Further actions and outcomes that emerged after engaging with *Exploring Time.*

Participants were randomly assigned to one of two conditions, DVD-only or DVD-and-web. All participants completed identical pre and post surveys, as well as a follow-up survey. Participants in the DVD-and-web condition were also asked to freely explore the web site and view supplemental videos of their choosing.

The focus of the study was to look at the learning that took place from viewing the videos and any additional learning that was gained by exploring and conducting tasks on the accompanying web site. Researchers did not look at specific reactions to the web site itself, but limited the evaluation to the value-add it provided to those who both watched the television program and explored the web site.

Findings

In general, viewer responses indicate that *Exploring Time* met its educational objectives. The majority of viewers were more aware of longer/shorter timescales and more cognizant of timescales that may not have an immediate impact on their lives. More complex ideas, such as how events on one timescale affect other timescales, were grasped by a smaller proportion of viewers. After watching the video, a majority of participants discussed the program with others and approximately a third investigated topics presented in the program on their own.

Although researchers found no differences in learning between the DVD-only and DVD-and-web conditions, further research is needed to explore the potential impact of having a companion web site. As this study indicates, the ways in which the content of one form of media can be enhanced by another are complex and deserve further study.

Introduction

Rockman et al (REA) conducted an impact study of the educational television special, *Exploring Time*, and the value-add of its associated web site, www.exploringtime.org. The two, one-hour programs air on Discovery's Science Channel and are a co-production of Twin Cities Public Television and Red Hill Studios. The program's objective is to increase the public's understanding of change over time—the multitude of changes that are occurring in the present, but at rates too slow or too fast to be seen.

This evaluation explored the extent to which the programs and web site met this overall objective by looking at the following impacts of the resources:

- **Comprehension of the program's content**

  Do the various audiences "get it?" What is it that they "get," how do they explain it, and can they generalize to other examples or illustrations?

- **Knowledge and understanding gained from viewing *Exploring Time* content**

  What elements do the audiences understand and at what level of complexity? Can they restate what they have learned and distinguish between what they already knew and new ideas that emerged from viewing? Can they apply this new knowledge to other settings? What value does the accompanying web site have in terms of supporting viewer understanding?

- **Further actions and outcomes that emerged in the period following viewing**

  Did they turn to books or the internet for further information? Did they talk with family members, friends, and work associates about the content and ideas from the program? Do different audience attributes lead to different follow-up actions?

The focus of the study was to look at the learning that took place from viewing the videos and any additional learning that was gained by exploring and conducting tasks on the accompanying web site. Researchers did not look at specific reactions to the web site itself, but limited the evaluation to the value-add it provided to those who both watched the television program and explored the web site.

Method

In February 2008, REA researchers recruited participants nationwide through local Craigslist ads around the country. Based on their reported interest in science television, willing respondents were invited to participate remotely in the study as follows:

- Complete an online, **pre-activity survey** (see Appendix A)
- Watch the *Exploring Time* DVD *or* watch the *Exploring Time* DVD and complete a web task[1]
- Complete an online, **post-activity survey** (see Appendix B)
- Complete an online, **follow-up survey** (see Appendix C)

[1] Participant behaviors on the web site were not tracked due to budget constraints.

To assess the value-add of the web site, participants were randomly assigned to one of two viewing conditions: (1) DVD-only or (2) DVD-and-web. Researchers asked participants in both groups to first complete the online pre-survey. Upon completion of the pre-survey, each participant was mailed an *Exploring Time* DVD and a letter outlining instructions for their particular viewing condition.

In addition to watching the *Exploring Time* DVD, participants assigned to the DVD-and-web condition completed a web task after viewing the video and before completing the post-survey. Participants in this condition were asked to spend approximately 15 minutes freely exploring the *Exploring Time* web site. After exploring the site, they were asked to select and view five videos from the supplemental video archive of their choosing and report on the timescales and changes they observed in each video.

Approximately three weeks after the DVDs were mailed, researchers asked participants in both conditions to complete the same online post-survey. Two weeks later, researchers asked participants who had completed the post-survey to fill out the final follow-up survey.

The design of this study sought to understand how additional experiences with the same materials as were presented in the DVDs would extend the learning from the DVDs. The research was not designed to study learning from web-only content.

Participants

One hundred eleven participants submitted useable pre-activity surveys and 88 participants submitted useable post-activity surveys. Of the 88 who completed both the pre and post surveys, 73 submitted the follow-up survey. Participants received incremental cash incentives for completing the pre and post surveys and were entered into a prize raffle drawing for completing the follow-up survey. Table 1 shows overall survey participation:

Table 1: Survey Participation

Survey	n
Pre-Activity	111
Post-Activity	88
Follow-Up	73

For the purposes of this study, researchers only looked at data from the 88 participants who completed both the pre and post surveys[2]. Forty-nine participants were in the DVD-only condition and 39 were in the DVD-and-web condition. Table 2, below, shows participant demographics for those who submitted both the pre and post surveys.

[2] A missing-data analysis was conducted to determine if there were any patterns in the demographics of people who dropped out of the study after completing the pre-survey. Findings of a missing data analysis have implications for the generalizability of the results. The missing data analysis compared the demographics of two groups: (1) the participants who submitted a pre and post-survey and (2) the participants who submitted a pre-survey but were missing the post. The analyses revealed that there were no statistically significant differences between the gender, ethnicity, age, education, and occupation of study participants who only submitted a pre-survey and those who submitted pre and post-surveys. In other words, the population who completed the post survey was similar to the population that submitted the pre survey but not the post. The missing data on the post survey appears to be random.

Table 2: Participant Demographics

n=88

Category	Response	n	%
Age	18-20	3	3.41
	21-30	27	30.68
	31-40	32	36.36
	41-50	25	28.41
	Over 50	1	1.14
Gender	Female	69	78.41
	Male	19	21.59
Race	Caucasian	72	81.82
	African American	10	11.36
	Asian/Pacific Islander	3	3.41
	Other (e.g., mixed race)	1	1.14
	Hispanic	1	1.14
	Native American	1	1.14
Craigslist Location	Portland	55	62.50
	Atlanta	11	12.50
	Boston	15	17.05
	St. Louis	7	7.95
Education Level	Some high school	0	0
	High School diploma	9	10.23
	Some college	30	34.09
	College degree	31	35.23
	Master's degree	11	12.50
	Professional degree	5	5.68
	Doctorate	2	2.27

Participants in this study spend a significant amount of time engaging in different forms of media consumption. Eighty-one percent (71) said that they watch at least 11 hours of television each week. As recruiting was conducted through Craigslist, it is not surprising to find that 73% (64) of participants said that they spend at least 11 hours online each week (not including e-mailing, instant messaging and work-related online activities) with just under half (28) in this group spending more than 21 hours online each week.

Assessment Development

Researchers designed four online surveys: (1) a background and screening survey, (2) a pre test, (3) a post test, and (4) a viewer follow-up survey. Instrument development was guided by a systematic, iterative process of construct identification, question and outcome space (e.g., rubric) creation, and instrument review or validation (Wilson, 2005). All instruments appear in the Appendix.

For the development of the pre and post test, for instance, researchers began by having a conversation with the program's producers about the key ideas that they intended viewers to learn from the *Exploring Time* video and web site. From there, the researchers and producers generated questions that addressed these key constructs. A draft assessment was piloted online

with a national sample of participants to gauge the suitability of question content and wording. Based on this pilot, researchers eliminated some questions and added others.

Finally, researchers selected questions to appear on the pre and post tests. Questions were repeated in order to measure changes directly from pre to post. Two questions were included on the post test only because the pilot tests indicated that respondents had little knowledge on the topics. The post-only questions were therefore intended to measure comprehension of key content and ideas covered in the video and reinforced by the web site.

The pilot responses were used to develop a rubric to score open-ended responses from the pre and post tests (see Appendix E). Rubrics for each question were derived iteratively using a top-down, bottom-up approach (Chi, 1997). With this method, responses were rated with a predetermined rubric of expected levels of response, and that rubric was in turn modified based on respondents' answers. The rubrics were also reviewed internally using criteria of content/coverage, clarity/detail, usability, and technical quality (Arter & McTighe, 2001). For instance, one researcher created the rubrics based on the pilot responses. Two other researchers applied that rubric to a sample of pre-test responses and then revised the ratings scales to accommodate the new responses and facilitate rater agreement.

Four teacher-contractors were hired as raters and participated in a half-day rater training session at the REA office. Raters reviewed the rubric with REA researchers and scored a sample of pre and post items. Raters were randomly assigned a partner against whom all ratings would be compared. Rater pairs were considered "trained" on a question when they achieved 80 per cent exact agreement. Adjustments were also made to the rubrics at this stage based on rater suggestions.

Even after the diligence of creating and assessing the items prior to administration, two items appear to create difficulties for both test takers and analysts. A discussion of both the difficulties and resolution of the items can be found in Appendix F.

Reliabilities

Raters were grouped into two pairs and each pair rated approximately half of the pre and post items. Pre and post items were coded so that raters did not know whether the item was a pre or post survey response, to avoid any rating biases. Rater pairs achieved at least 70% exact agreement on each question, with an average exact agreement of 81%. One rater from each pair was randomly selected as the primary rater whose scores were used in all subsequent analyses.

Analyses

For the quantitative data responses, researchers used independent-samples t-tests and repeated-measures ANOVAs. They used t-tests for questions that were on the pre or post test only, and compared the scores of participants in the DVD-and-web condition to those in the DVD-only condition. Researchers used repeated-measures ANOVAs with a between-subjects factor to compare responses for questions on both the pre and post items for across study conditions.

For the qualitative data, researchers created a set of codes based on themes that emerged from reviews of the responses to each question. The final set of codes included those that were determined *a priori* from knowledge of goals of the project and those that emerged from the review of the data.

Findings

Pre and Post-Activity Test Items

Analysis strategies depended upon the availability of pre and post item data. Items 1a, 1b, 2f, 3, 4v and 5f were included on both the pre and post tests. Questions 2g and 2b, both measures of awareness of changes at concurrent timescales, were randomly assigned to the pre and post test and were therefore matched for analysis (see Table 3 and 4 for list of items and corresponding questions). For all items, a repeated-measures ANOVA was conducted with the within-subjects factor being the test administration (i.e., pre or post) and the between-subjects factor being the study condition (i.e., DVD-and-web or DVD-only).

Table 3: Test Items and Corresponding Questions

Item	Question	Test
1a	Please list some aspects of your life that you perceive as, or count on, as constant on a day-to-day basis.	Both
1b	Please list some aspects of your life that you perceive as, or count on, as being changeable on a day-to-day basis.	Both
2b*	Please describe what is changing in the following scenes (image of a boy eating ice cream)	Post
2f	Please describe what is changing in the following scenes (image of a mountain with flowers)	Both
2g*	Please describe what is changing in the following scenes (image of a girl running through a field)	Pre
3	For each activity below, please select the unit of time from the list of timescales that best describes the activity. More than one activity may align with each timescale. *See Table 4 for activities and associated timescales*	Both
4a	In order to understand why a heart muscle goes into arrhythmia, scientists must drill down to a chain of events lasting only thousandths of a second. Why is this?	Post
4v	In order to understand how a volcano eruption affects winter temperature, scientists must look at a timescale spanning decades. Why is this?	Both
5d	What are some reasons why people get their DNA tested?	Pre
5f	What kinds of things can scientists learn from fossil evidence?	Both
5i	Why do scientists take ice cores from glaciers?	Post

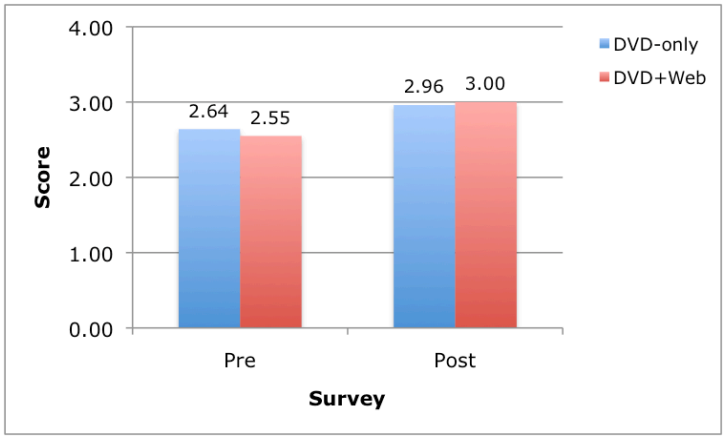
Items highlighted in gray showed a significant difference from pre to post
* Items were matched as pre and post for analysis

Table 4: Question 3 Activities and Associated Timescales

Item	Activity	Correct Timescale
3a	Ocean water travels from the tropics to the Arctic and back.	Centuries
3b	Tides change from high to low.	Hours
3c	Sub-atomic particles move into and out of existence.	Planck time
3d	Proteins fold.	Billionths of a second
3e	Hurricanes form from tropical depressions.	Days
3f	The moon changes phases from new to full	Days
3g	The angle (or tilt) of the Earth shifts.	Thousands of years

For questions 1a (what is constant in your life), 2f, 2g/b (describe what is changing in this scene) and 3 (link the following activities to the correct timescale), respondents scored higher on the post-test than on the pre-test. On question 2f, for instance, mean scores increased 2/5 of a point from 2.6 to 3 (Figure 1).

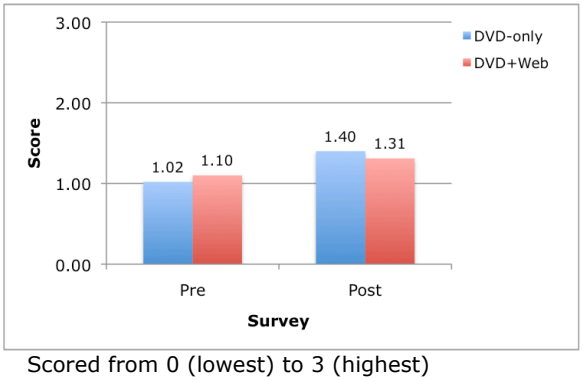
Figure 1: Average Pre-Post Scores for Item 2F



Scored from 0 (lowest) to 4 (highest)

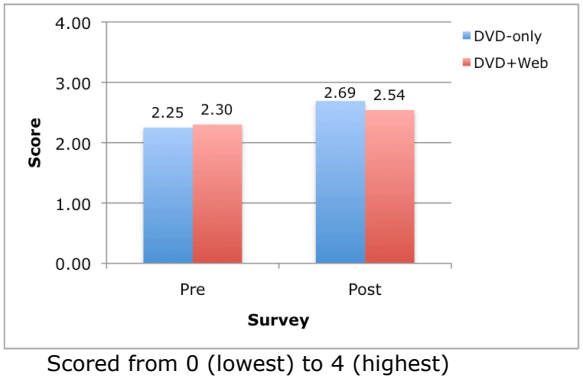
Mean scores for questions 1a and 2g/b are shown in Figures 2 and 3, below. Both showed an increase from pre to post.

Fig. 2: Average Pre-Post Scores for Item 1A



Scored from 0 (lowest) to 3 (highest)

Fig. 3: Average Pre-Post Scores for Item 2G/B



Scored from 0 (lowest) to 4 (highest)

On question 3, (match an activity to a unit of time), the average respondent gave correct answers to 42% of the items on the pre test, and 60% of the items on the post-test (Figure 4). Accuracy for individual items on Question 3 are shown in Table 5, below.

Figure 4: Accuracy Across All Pre-Post Items for Question 3

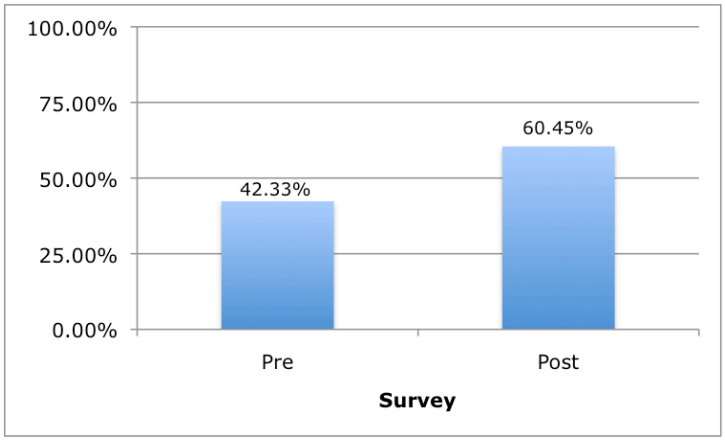


Table 5: Accuracy in Pre-Post Responses for Question 3, by Item

Item	Activity	n	Pre-Survey		Post-Survey	
			Mean	SD	Mean	SD
3a	Ocean water travels from the tropics to the Arctic and back.	82	0.09	0.28	0.22	0.42
3b	Tides change from high to low.	82	0.83	0.38	0.88	0.33
3c	Sub-atomic particles move into and out of existence.	80	0.18	0.38	0.49	0.50
3d	Proteins fold.	81	0.33	0.47	0.58	0.50
3e	Hurricanes form from tropical depressions.	80	0.43	0.50	0.66	0.48
3f	The moon changes phases from new to full.	82	0.87	0.34	0.90	0.30
3g	The angle (or tilt) of the Earth shifts.	81	0.27	0.45	0.54	0.50

The ANOVAs on items 1a, 2f, 2b/g, and 3 indicated a significant difference from pre-test to post-test (Table 6). There were no significant effects of condition (DVD-and-web or DVD-only), and no significant interactions of condition and timing of the survey (e.g., pre or post).

Table 6: Repeated-Measure Analysis of Variance Results for Items with Statistically Significant Pre-Post Differences

Item	Question	Wilks's Lambda	df	F
1a	Please list some aspects of your life that you perceive as, or count on, as constant on a day-to-day basis.	0.75	1, 85	28.49**
2f	Please describe what is changing in the following scenes (image of a mountain with flowers)	0.81	1, 83	19.11**
2g/b	Please describe what is changing in the following scenes (images of a girl running through a field and a boy eating ice cream)	0.84	1, 83	16.76**
3	For each activity below, please select the unit of time from the list of timescales that best describes the activity. More than one activity may align with each timescale. Total percentage of correct responses	0.51	1, 80	76.91**

**p<0.01

Additional repeated-measures ANOVAs of question 3 were conducted by item to determine which items demonstrated significant increases in the percentage of correct responses from pre to post. Researchers employed the Bonferroni approach to control for Type I error across the 7 analyses. In this case, a *p* value of less than 0.007 was required for significance (alpha = 0.05/7).

Analyses indicated that there were significant pre-post differences for the following items: 3a (ocean), 3c (atoms), 3d (protein folding), 3e (hurricane), and 3g (Earth axis tilt). Wilks's Lambda ranged from 0.73 to 0.91, and $F(1, 78)$ ranged from 7.64 to 28.99, with all *p* values being smaller than 0.007.

Although mean scores for question 1b (what is changing in your life) increased from pre to post (Table 7), the ANOVA indicated that there were no significant effects from pre to post, of condition, or of the interaction of condition and timing of the survey. Likewise on questions 4v (connections between adjacent timescales: volcano) and 5f (what kinds of things can scientists learn from studying fossils), mean scores generally decreased on the post test, but there were no significant effects from pre to post, of condition, or of the interaction of condition and timing of the survey (Table 8).

Table 7: Mean Scores in Pre-Post Responses for Items 4V and 5F

Item	Condition	n	Pre-Survey		Post-Survey		Change
			Mean	SD	Mean	SD	
1b	DVD-only	47	2.89	0.89	3.00	0.91	0.11
	DVD-and-web	38	2.89	0.83	3.03	0.91	0.14
4v	DVD-only	45	2.44	0.99	2.36	0.98	-0.08
	DVD-and-web	37	2.51	1.07	2.32	0.97	-0.19
5f	DVD-only	49	2.27	0.49	2.24	0.48	-0.03
	DVD-and-web	38	2.26	0.50	2.39	0.50	0.13

Table 8: Repeated-Measure Analysis of Variance Results for Items without Statistically Significant Pre-Post Differences

Item	Question	Wilks's Lambda	Df	F
1b	Please list some aspects of your life that you perceive as, or count on, as changing on a day-to-day basis.	0.99	1, 77	0.87
4v	In order to understand how a volcano eruption affects winter temperature, scientists must look at a timescale spanning decades. Why is this?	0.98	1, 80	1.35
5f	What kinds of things can scientists learn from fossil evidence?	0.99	1, 85	0.64

There were three items that appeared only on the pre test or only on the post-test: 5d (what do scientists learn by studying DNA) only appeared on the pre test and 4a (explanation of heart arrhythmia) and 5i (what do scientists learn by studying ice cores) both appeared only on the post test. For these three items, independent-samples t-tests indicated that there were no significant differences in scores between participants in the DVD-and-web and DVD-only conditions (see Table 9, below).

Table 9: Differences Between Study Conditions on Pre or Post Test-Only Items

Description	DVD-and-web		DVD-only		df	t
	Mean	SD	Mean	SD		
4a: In order to understand why a heart muscle goes into arrhythmia, scientists must drill down to a chain of events lasting only thousandths of a second. Why is this?	2.77	1.37	2.77	1.27	77	0.04
5d: What are some reasons why people get their DNA tested?	2.63	0.49	2.58	0.50	86	-0.48
5i: Why do scientists take ice cores from glaciers?	2.30	0.46	2.18	0.49	84	-1.10

Viewing Habits and Follow-Up Activities

Of the 88 participants who completed the post-survey, 73 submitted the follow-up survey. To get a better understanding of their viewing habits, researchers asked participants about the level of attention they devoted to watching the *Exploring Time* video. Almost three-fourths (73%) of participants said that they watched *Exploring Time* with full, undivided attention. The remaining 23% watched *Exploring Time* while doing something else (e.g., multitasking, surfing the internet). Most of the multitaskers tended to fall in the 21-30 age range. It is interesting to note that participants who reported watching *Exploring Time* with full, undivided attention scored about half a point higher on question 2b (describe what is changing in a picture of a boy eating ice cream) than those who said they were multitasking as they watched the video (multitask: N=20, M=2.25, SD=0.55; undivided attention: N=51, M=2.73, SD=0.77; $p<0.05$). Note that other research has indicated a decrement in learning while multitasking.

When asked to describe their normal viewing habits when watching a science television program in general, just over half (53%) said that they normally watch with full, undivided attention while 45% said that they normally watch science programs while multitasking. One person said that they would have the program on as background noise while doing other activities.

This group of participants indicated that they are likely to watch a type of program like *Exploring Time*. When given potential scenarios where they might learn about a program like *Exploring Time*, most participants said that they were likely to watch the program after learning about it in any of the given scenarios. Table 10 shows participants' likelihood of watching a program like *Exploring Time*, if mentioned in different scenarios.

Table 10: Likelihood of Watching a Science Program Like *Exploring Time*

Scenario	n	Mean	SD
How likely is it that you would watch a type of program like *Exploring Time*…			
…in general?	73	2.07	0.86
…if you saw a preview/ad for the program?	73	2.11	0.79
…if you came across it while channel surfing?	72	2.22	0.79
…if it came on after another program you were watching?	73	2.10	0.85
…if someone mentioned the program to you?	73	2.12	0.80

Scale: 0 = Not likely, 1 = Somewhat likely, 2 = Likely, 3 = Very likely

After watching the video, 53 out of 73 participants (73%) said that they talked to someone else about the content of the program. While only 24% (17) said that they have further explored the concept of timescales since watching the video, 45% (33) said that they plan to at some point in the future. Just over one-third of participants (35%, 23 of 66) have researched topics presented in the video since watching it.

Participant Learning

When asked to describe what they *learned* from the video, almost half (44%, 32 of 73) participants expressed an increased awareness about the complexity and continuity of time. Some of their responses include:

> *I try to think of the more intricate processes that make up these things and the time spans involved. Before viewing* Exploring Time*, I tended to imagine these sorts of things in a very simplistic way as well as in isolation, rather than their role in larger systems and much greater time spans.*
>
> *It made me think of time concepts in a whole different light.*
>
> *I came away with more questions about time and thinking of it as something that is not fixed.*
>
> *I gained a greater understanding of the vastness of time, both the small and large units. So much can happen in even the smallest units of time that we are not even aware of because they pass so quickly, yet it happens. And so much is happening in the largest units of time, things that are not recognizable or even conceivable unless you view them over those same large units, but still they are happening, ever so slowly.*

Other key points of learning included research involving time (e.g., geological, medical) (15), hurricanes and weather patterns (14), heart functions (12), relevance of time to participant or to their environment (11), effects of time (e.g., on age, universe) (11), and different units of time (5).

Interest and Appeal

When asked to recall the three most memorable things from the *Exploring Time* DVD, 40 out of 88 participants mentioned the heart attack/arrhythmia segment. Other points frequently mentioned that were most memorable or of greatest interest seem to be segments participants could relate to or those that would affect them on a personal level:

- Ideas about time (e.g., time scales, impacts, perception of time, etc.) (35)
- Stress and/or aging process (20)
- Hurricanes (15)
- Ocean currents/Global Conveyor Belt (15)
- Ice cores (13)
- Formation/expansion of the universe (12)
- Earth core research and drilling (9)
- Collection and research of life forms from ocean floor (5)
- Ocean vehicle/glider used to collect information about the ocean's water (5)
- Study of protein folding on computer screensavers (5)
- High quality graphics and animations used in video (5)
- Volcanoes (4)
- Depictions of electron motion (4)

More than half of respondents (45 of 88) responded positively to the video in general. Many found it enjoyable and cited it as "interesting," "educational," and "informative." Others said it was "*fascinating*," "*well done,"* and "*spectacular*".

> *Both videos were very interesting and extremely educational. I enjoyed them immensely and have never, in all the science programs I have watched, seen programs that address the dual aspects of time (both the smallest and largest denominations to measure time) in such a scientifically critical way.*
>
> *I can't overstate how much I enjoyed these programs and will be saving the CD to show to my son when he gets a little older and can understand/appreciate the subject matter.*
>
> *It is the sort of program I would expect and hope to see on the Science channel, or the Discovery channel. If they don't pick it up, I do hope PBS shows it. It deserves to be seen.*

Other Participant Reactions

Although researchers did not specifically ask for feedback on the video, a number of participants shared their thoughts through general comments.

Participants appreciated the visual effects, illustrations, models, and animations used throughout the video. They found the imagery to be high quality and to contribute to their understanding of the concepts discussed in the video:

Excellent models and visuals. Seemed very realistic not hokey.

The video was excellent in demonstrating the concepts with good illustrations and simulations.

I was initially skeptical about the quality when I began watching the first one but it quickly became engrossing and some of the images were amazing.

I enjoyed watching it and. the video effects were especially great.

Some participants (approximately ten percent) commented that the amount of information presented was "overwhelming" and "over [their] head," and had a hard time retaining the concepts presented:

Overall I found the information to be valuable, but at times it seemed a bit overwhelming. I should have watched the films in 30 min. segments to truly retain more of the information.

I found it fascinating as a nonscientist but it tended to go way over my head at times especially near the end of each segment. I watched the segments at 2 different times.

In fact, on some parts, if I didn't understand the concept, I'd "rewind" and listen to the explanation again.

I wish I had been able to retain more information that was presented in the videos...

While I found parts of the series appealing, it really jumped around too much to capture my interest. In fact, by the end of the second hour I sort of felt like maybe I had been through an adrenaline rush and that two hours had stretched into four!

Conclusions

Analysis of the pre and post test data indicated that scores improved significantly on items about: (a) factors that are constant in one's life, (b) things that are changing in an image, and (c) the timescales in which different events occur.

In practical terms, this means that, after watching *Exploring Time*, participants were better able to identify concurrent changes happening around them. On the post test, the average respondent was more likely to describe constant cyclical changes (e.g., tides) that may not be directly related to his/her life. Respondents were also more likely to identify changes that are not immediately visible within a scene after watching the video. Almost half of participants reported an increased awareness of the complexities of time. Other knowledge gains include accurately linking events to their correct timescale.

However, based on responses to item 4v (timescales of a volcano eruption affecting winter temperatures) participants' ability to connect changes on adjacent timescales did not appear to change before and after watching *Exploring Time*. We also found no significant differences in test scores between the DVD-only and DVD-and-web for either items 4v (volcano) or 4a (heart arrhythmia) (See Tables 7 and 9).

While both the DVD-only viewers and DVD-and-web participants were significantly more informed following their experience with *Exploring Time,* we did not find that participants who viewed the television show and then sampled the short, supplemental videos of changes over time on the web site scored higher on the post tests than participants who had only watched the TV show.

The evaluation was not designed to probe for new concepts that the DVD-and-web participants may have taken from their web site experience. For data consistency, all participants in this condition were asked to perform specific web activities; the amount of time participants were asked to freely explore the site (15 minutes) may have limited their exploration of the web site more fully. For example, the web site offered users a chance to replay any section of the broadcast show, but the users in the sample did not indicate they had taken advantage of this feature.

Viewer responses indicate that *Exploring Time* met its educational objectives. The majority of viewers were more aware of longer/shorter timescales and more cognizant of timescales that may not have an immediate impact on their lives. More complex ideas, such as how events on one timescale affect other timescales, were grasped by a smaller proportion of viewers. After watching the video, a majority of participants discussed the program with others and approximately a third investigated topics presented in the program on their own.

Recommendations

Video

The *Exploring Time* project attempted to present science across a vast range of timescales, from billionths of a second to billions of years. While the majority of viewers demonstrated higher levels of comprehension of the overall theme as well as concepts at specific timescales, a small segment of viewers did not. Given the number and complexity of ideas presented in the video, some viewers appear to need more support in understanding the various timescales as they relate to one another. Since the audience recruited for this study was self-reported to have a high interest in science, the comments of this second group may be an indicator of how a broad, general audience would react to the content. The evaluation results suggest that such a great range and variety of content may be more than a general audience can absorb in a two-hour television program.

For future productions of similar complexity, producers should continue to use high quality imagery to illustrate these concepts. The imagery appeared to contribute to both viewer engagement and learning. Producers should also take advantage of any opportunities to repeat complex ideas, such as occurred in the presentations of hurricanes and ocean currents, as these repetitions appear to contribute to a higher level of understanding among viewers.

Web Site

The *Exploring Time w*eb site offers a variety of supplemental videos of change over time, to augment the ideas presented in the television program. Participants in this study indicated that they would have appreciated additional content that further explained and illustrated the scientific concepts presented in the video. By offering additional information on the web site and making the video extensions more explicit, the web site could allow visitors the opportunity to build on the knowledge gained from watching the video.

Further Research

The research strategies used in this study have applicability to other multiple-media projects in informal science. Virtually every science television program now is accompanied by a web site. However, as this study indicates, the ways in which the content of one form of media can be enhanced by another are complex and deserve further study. We would recommend that further studies of the value-add of companion web sites include tracking of viewer web site experiences, which would indicate the relative benefit of specific features and meaningful connections to the viewing experience.

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Appendix A

Television Program Research Study
Pre-Survey

Conducted by Rockman et al

Thank you for your interest in this study. Please complete the following survey completely, to the best of your ability. Please *do not* reference any resources while you are completing this survey. If you don't have a response for a question, please write "I'm not sure" or "I don't know." It is important that you do not leave any fields blank.

Please spend no more than 20 minutes completing this survey.

For questions or comments, please contact Monnette Fung at monnette@rockman.com.

1. For each of the following, please list some aspects of your life that you perceive, or count on, as being...

...*constant* on a day-to-day basis:

...*changeable* on a day-to-day basis:

2. Please describe what is changing in each of the following scenes:

3. For each activity below, please select the unit of time from the list of timescales that best describes the activity. More than one activity may align with each timescale.

Timescales

A. Thousands of years
B. Centuries
C. Decades
D. Days
E. Hours
F. Tenths of a second
G. Billionths of a second
H. Planck time
I. None of the above

Activity	Timescale (A - I)
1. The moon changes phases from new to full.	
2. Hurricanes form from tropical depressions.	
3. The upper or lower chambers of the heart contract.	
4. Sub-atomic particles move into and out of existence.	
5. Ocean water travels from the tropics to the Arctic and back.	
6. Tides change from high to low.	
7. Proteins fold.	
8. The angle (or tilt) of the Earth shifts.	

4. In order to understand how a volcano eruption affects winter temperature, scientists must look at a timescale spanning decades. Why is this?

5. Please respond to the following questions:

What kinds of things can scientists learn from fossil evidence?

What are some reasons why people get their DNA tested?

Please complete the following information in order to receive the honorarium for participating in this part of the study. Your information will only be used to track your participation in this study and will not be shared. Thank you for your participation!

Contact Information

Name:

Email:

Street Address:

City, State, Zip:

Submit Survey

Appendix B

Television Program Research Study
Post-Survey

Conducted by Rockman et al

Thank you for your participation in this study. Please fill out the following survey completely, to the best of your ability. Please *do not* reference any resources while you are completing this survey. If you don't have a response for a question, please write "I'm not sure" or "I don't know." **It is important that you do not leave any fields blank.**

You will have 25 minutes to complete this survey.

For questions or comments, please contact Monnette Fung at monnette@rockman.com.

1. For each of the following, please list some aspects of your life that you perceive, or count on, as being...

...*constant* on a day-to-day basis:

...*changeable* on a day-to-day basis:

2. Please describe what is changing in each of the following scenes:

3. For each activity below, please select the unit of time from the list of timescales that best describes the activity. More than one activity may align with each timescale.

Timescales

A. Thousands of years
B. Centuries
C. Decades
D. Days
E. Hours
F. Tenths of a second
G. Billionths of a second
H. Planck time
I. None of the above

Activity	Timescale (A - I)
1. Ocean water travels from the tropics to the Arctic and back.	
2. Tides change from high to low.	
3. Sub-atomic particles move into and out of existence.	
4. Proteins fold.	
5. Hurricanes form from tropical depressions.	
6. The moon changes phases from new to full.	
7. The angle (or tilt) of the Earth shifts.	
8. The upper or lower chambers of the heart contract.	

4. Please respond to the following questions:

In order to understand how a volcano eruption affects winter temperature, scientists must look at a timescale spanning decades. Why is this?

In order to understand why a heart muscle goes into arrhythmia, scientists must drill down to a chain of events lasting only thousandths of a second. Why is this?

5. Please respond to the following questions:

What kinds of things can scientists learn from fossil evidence?

Why do scientists take ice cores from glaciers?

6. What are the three most memorable things from the video?

7. Do you have any comments or feedback about this study?

Please complete the following information in order to receive the honorarium for participating in this part of the study. Your information will only be used to track your participation in this study and will not be shared. Thank you for your participation!

Contact Information

Name:

Email:

Submit Survey

Appendix C

Television Program Research Study
Follow-Up Survey

Conducted by Rockman et al

We would greatly appreciate it if you would take a few minutes to give us some information about your interest and habits since watching the DVD of *Exploring Time*. Please fill out the following survey completely, to the best of your ability. Please *do not* reference any resources while you are completing this survey. If you don't have a response for a question, please write "I'm not sure" or "I don't know." **It is important that you do not leave any fields blank.**

All responses will be held confidentially and used only for research purposes. For questions or comments, please contact Monnette Fung at monnette@rockman.com.

1. How likely is it you would watch a type of program like *Exploring Time*...

	Likelihood			
	Not likely	Somewhat likely	Likely	Very likely
...in general?	○	○	○	○
...if you saw a preview/ad for the program?	○	○	○	○
...if you came across it while channel surfing?	○	○	○	○
...if it came on after another program you were watching?	○	○	○	○
...if someone mentioned the program to you?	○	○	○	○

2a. Describe your viewing habits while watching the *Exploring Time* DVD, using the following continuum...

Level of Attention Devoted		
Would have the program on as background noise	Would watch it while multi-tasking (i.e., surfing the Internet, etc.)	Would watch it with complete, undivided attention
○	○	○

2b. Describe your normal viewing habits when watching a type of science program like *Exploring Time*, using the following continuum...

Level of Attention Would Devote		
Would have the program on as background noise	Would watch it while multi-tasking (i.e., surfing the Internet, etc.)	Would watch it with complete, undivided attention
○	○	○

3. Describe what you learned from the *Exploring Time* video?

4. Since watching the *Exploring Time* video, have you...

	Frequency			
	No, and I don't plan to	No, but I plan to	Yes, once or twice	Yes, more than twice
...talked to anyone about the content of the program?	○	○	○	○
...further explored the concept of timescales? **If yes, how?** (e.g., at the library, online, etc.)	○	○	○	○
...further explored topics presented in the video? **If yes, which topic(s)?** (e.g., hurricanes, heart arrhythmia, climate cycles, etc.)	○	○	○	○

Contact Information

Name:

Email:

Submit Survey

Appendix D

Rockman et al
Independent · Insightful · Informative

February 25, 2008

Dear Participant,

Thank you for taking part in our television research study. We have received your responses to the online survey for Part 1 of the study and would like you to complete Part 2.

Part 2 of this study will consist of the following activities:

1) DVD
   Watch both **Hour 1** and **Hour 2** segments of the enclosed *Exploring Time* DVD.

2) Web Task
   Complete the attached Web Task on the following page.

3) Online Survey
   The following survey will be available starting Monday, March 10, 2008. Please **complete the survey by midnight on Sunday, March 16, 2008** to be eligible for the compensation:

   http://study.rockman.com/redtime/et_post.html

Please complete the survey (#3 above) only after you have watched both segments of the DVD and finished the Web Task. There is no need to review the DVD or web site as you are completing the survey.

As a reminder, the compensation for this portion of the study will be $50, based on completion of the survey. All compensation will be distributed at the close of the study, around April 2008.

Thank you again for your participation. Your feedback is very important to the development of this program. If you have any questions, feel free to contact me via email or phone from 9am-5pm Pacific time.

Sincerely,

Monnette Fung
monnette@rockman.com

Web Task

Please visit the *Exploring Time* website, http://www.exploringtime.org and spend approximately 15 minutes exploring the site.

When you have finished exploring the site, enter the **video archive** and select five videos to view.

List the videos you watched here.

Name of video	Timescale	Changes observed in clip

Please submit the names of the videos you watched and the changes you observed online at:

http://study.rockman.com/redtime/et_webtask.html

Appendix E

Exploring Time Rubric

*** In cases where the answer does not completely fit the rubric on the rating continuum we've established, please make your best judgment. In cases where this occurs, please make note of a short justification for your rating. ***

Question 1A (Q1A):

Please list some aspects of your life that you perceive as, or count on, as constant *on a day-to-day basis?*

Score:	**0**	**1**	**2**	**3**
Description:	Blank or Missing Data	Identifies **any non-cyclical** incident(s) as constant	Identifies any **cyclical** incident(s) as constant	Responds that **nothing is constant** or **everything changes**
Example:	No response	Driving Eating Family Working	Life cycles Moon phases Tides (ebb & flow) Sunrise/Sunset Changing seasons Circadian cycles	"Nothing is constant" "Everything changes"

Question 1B (Q1B):

Please list some aspects of your life that you perceive as, or count on, as changeable *on a day-to-day basis?*

	0	1	2	3	4
Description:	Blank or Missing Data; or respondent does not know.	**Non-answer/Non-sequitur**, or answer does not describe a change or answer the question. Respondent replies that **nothing is changing** (as opposed to leaving a blank)	Respondent only identifies **immediately visible changes**.	Respondent identifies **one non-visible change**.	Respondent identifies **two or more non-visible changes**. Each reasonably distinct thought is counted as one change.
Examples:	"I don't know." "I'm not sure."	"It's a sunny day." "Nothing is changing."	Food/eating/drinking Clothes Transportation Physical location Physical appearance Voluntary physical activity TV shows Wind Weather/temperature Amount of exercise Amount of money Prices Stocks Time (e.g., spent doing something, free time, time of day)	Moods/emotions Level of motivation Relationships Conversations Opinions Perceptions Politics Economy Commitments Financial situation Weather patterns Climates Appetite	"The flower blooms and grows" is should be counted as one distinct thought. See List for 3

Question 2 (Q2G/Q2F/Q2B):

Please describe what is changing *in the following scenes.* (Images)

	0	1	2	3	4
Description:	Blank or Missing Data; or respondent does not know.	**Non-answer/Non-sequitur**, or answer does not describe a change or answer the question. Respondent replies that **nothing is changing** (as opposed to leaving a blank)	Respondent only identifies **immediately visible changes**.	Respondent identifies **one non-visible change**.	Respondent identifies **two or more non-visible changes**. Each reasonably distinct thought is counted as one change.
Examples:	"I don't know." "I'm not sure."	"It's a sunny day." "The boy is happy." "The girl is having fun." "Nothing is changing."	Wind (and things affected by wind) Weather/temperature Motion (e.g., clouds, grass, ribbon, girl, girl's hair) Position/Appearance of objects in image Cloud motion or shape Sky Landscape difference within the image (e.g., vegetation vs. rocky) Ice cream (melting/eating) Face (expression, position of eyes, mouth) Day to night	Climate change Seasons Erosion Growth (e.g., flower, grass, girl/boy, hair) Aging Blooming Life cycles Ecosystems Camera focus Earth's rotation Digestion Mood/feeling Absorbing light	"The flower blooms and grows" is should be counted as one distinct thought. See list for 3

Question 4 (Q4V/Q4A):

Q4V: *In order to understand how a volcano eruption affects winter temperature, scientists must look at a timescale spanning decades. Why is this?*

Answer: You need to look at decades to get an idea of what average temperatures are and when there are fluctuations (and any events that may cause those fluctuations). Specifically, sulfur spewed from the volcano takes a few years to dissipate. This sulfur combines with water vapor in the stratosphere to form dense clouds of tiny sulfuric acid droplets. These droplets take several years to settle out and they are capable of decreasing temperatures because they absorb solar radiation and reflect it back to space.

Q4A: *In order to understand why a heart muscle goes into arrhythmia, scientists must drill down to a chain of events lasting only thousandths of a second. Why is this?*

Answer: An arrhythmia is a problem with the speed or rhythm of the heartbeat. The heart has an internal electrical system that controls the speed and rhythm of the heartbeat. Each heartbeat lasts approximately 1 second and, with each beat, an electrical signal spreads from the top to bottom of the heart. As it travels, the electrical signal causes the heart to contract and pump blood. A number of systems on smaller scales running in cycles of tenths, thousandths, even millionths of a second, keep the process moving in a healthy heart. A problem with any part of this process can cause a disruption to the cycle and throw off the heart's rhythm, causing an arrhythmia.

	0	1	2	3	4
Description:	Blank or Missing Data; or respondent does not know.	**Non/wrong answer** or answer **repeats the question**, or gives a non-sequitur	Response answers **why scientists study** the phenomena (response may not be correct but is not incorrect) *without* making link(s) between timescales. *OR* Response talks about just the 1000^{th}s of a second (detail is from the question)	Response is plausible and recognizes that: • events on one scale create patterns that are visible on another scale (links timescales) **OR** • that there are cumulative effects of shorter changes *in a general sense*	Response is plausible and recognizes that: • events on one scale create patterns that are visible on another scale (links timescales) **OR** • that there are cumulative effects of shorter changes **AND** provides a *specific example/scenario with **heart-related terminology***.
Volcano Example:	"I don't know." "I'm not sure." "I don't remember."	"It takes a long time for the volcano to heat up (or cool down)" "Because the volcano moves during this time" "It shows the levels of earth with each volcanic eruption and how they grow and change."	"Because the ash goes into the air and effects clouds." "Because the particles spewed into the air and the elements that were released have a part of why our atmosphere is the way it is."	"Because some of the effects won't happen in nature for many years. The natural effects will change temperatures, and because of that you need to be able to see how that will change over decades. "Changes that happen so slowly on a small scale affect things. When they study	"Volcanic eruptions throw tons of ash and particles into the atmosphere, these particles, especially the small ones, will help reflect some sunlight. It can take awhile for these particles to move around the earth's atmosphere, but by reflecting sunlight, and therefore preventing the sunlight from reaching into the atmosphere and warming it, these

				decades of information they are able to see the effects of the small changes."	particles can lower the temperature of the earth. The lower temperatures can cause a 'mini ice age' or lower winter temperatures (more snow colder weather etc.)"
Arrhythmia Example:	"I don't know." "I'm not sure." "I don't remember."	"Time is critical." "To figure out how often the heart beats normally."	"The chemicals that control the heart move in a very quick period of time. Tiny protein pumps turn at this rate." "Because the arrhythmia is caused by electrical pulses that occur on this time frame, and they need to be measured and studied in order to figure out what went wrong."	"…the events act like a **chain reaction** and when one thing goes wrong, then it affects the other actions of the heart muscle..." "They all have a **ripple effect** on the next thing to happen." Buzzword: **timescale**	"The heart is made of many small muscle cells all working together. Each cell works on a microscopic level with electrical stimuli to cause the heart to beat as a whole. Genetic anomalies or electrical stimuli that affect the heart muscle can cause these cells to misfire causing a **cascade of events** where these cells no longer work together. This is the cause of arrhythmia."

Question 5 (Q5F/Q5D/Q5I):

Q5F: *What kinds of things can scientists learn from fossil evidence?*

Q5D: *What are some reasons why people get their DNA tested?*

Q5I: *Why do scientists take ice cores from glaciers?*

	0	1	2	3
Description:	Blank or Missing Data; or respondent does not know.	**Non/wrong answer** or answer **repeats the question**, or gives a non-sequitur	Response includes **one or more** isolated phenomena focused in a single timeframe—past, (implied) present, or future—but **does not make link(s)** between timeframes.	Response **makes a link** between timeframes (e.g., addresses the past and makes a link to present/future).
Fossil Example:	"I don't know." "I'm not sure."	"Archeologist"	[Past] "They can learn the size and shapes of creatures from billions of years ago. Fossils also help determine how the creatures died and what their environment was like."	"They can learn about life forms and **evolution**." "They can learn how this earth came to be the way it is today and possibly the way it will become." "They can see what diseases have happened, how bones and creatures have evolved, and the weather **patterns** from how those fossils have weathered.
DNA Example:	"I don't know." "I'm not sure."		[Present] "To prove parenthood or blood relationships, to be matched or rejected from a crime, to find out if they have a **disease** [but not specified as **genetic disease**] or condition"	"People get their DNA tested to determine **ancestry**/parenthood, identify **genetic conditions** such as **predispositions** to diseases."
Ice Cores Example:	"I don't know." "I'm not sure."	"Because they are the coldest." "To see if the ice is different in the two poles."	[Past] "Ice cores are collected from ancient glaciers to research about the conditions of past climates thousands of years ago. They are like time capsules that can show exactly when certain events happened. Scientists can use ice cores from glaciers to determine when past ice ages occurred."	"To tell us about climate history and what we could expect from our current state of living." "To understand weather patterns of the past, and see how they affect our weather patterns today."

Appendix F

Problem Items and Scoring Resolution

During the training, it became apparent that the rubric for question 4A, about why scientists have to look at a timescale of thousandths of a second to understand heart arrhythmia, did not result in consistent ratings of items among raters. The rubric was therefore revised by the researchers, who sorted all responses into categories based on the answers' content and accuracy (e.g., responses that discussed electrical impulses only, responses that linked electrical impulses to heart contractions). Researchers then ranked the response categories to create a progression of ratings. All categories and ratings were derived through consensus. Researchers did not ask raters to reanalyze the responses in order to avoid bias that might be caused by familiarity with the earlier rubric and exposure to the same or similar responses. Researchers considered themselves the primary raters for this question.

During the analysis of question 3 on the post test ("For each activity below, please select the unit of time from the list of timescales that best describes the activity"), it became apparent that the construction of the test may have influenced responses on one of the items. Respondents were asked to identify the timescale in which the upper and lower chambers of the heart contract. Because this was the only item in question 3 in which the percentage of correct responses decreased, researchers looked at the incorrect responses to determine if there were patterns. Most of the incorrect responses identified billionths of a second, not tenths as the timescale in which the heart chambers contract. Because a later question that appeared only on the post test linked heart arrhythmia to the study of timescales in the thousandths of a second, researchers concluded that respondents could have used that information to narrow down their choices to timescales that were smaller than thousandths. Because it was plausible that the arrhythmia item could have influenced respondents and threatened the validity of the earlier heart contraction item, that item was eliminated from the analyses.