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Program Evaluation • Consultation • Market Research

Front End Evaluation of *EarthScope Panorama*

Prepared by
Marianne E. McPherson, M.S., M.A.
Laura Houseman, B.A.
Irene F. Goodman, Ed.D.

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EXECUTIVE SUMMARY

In 2007, Goodman Research Group, Inc. (GRG) conducted front end evaluation of the *EarthScope Panorama* project for the Harvard-Smithsonian Center for Astrophysics, Smithsonian Astrophysical Observatory (SAO). SAO received a grant from NSF to develop a pilot program in 2007-2008, as part of EarthScope's Education and Outreach (E&O) program.

SAO is laying the groundwork for an informal educational program, in the form of an interactive Earth science game, for middle school youth. Through this outreach initiative, SAO hopes to teach a finite EarthScope-related concept to students, to relate that concept to the larger EarthScope initiative, to educate students about the scientists involved in EarthScope, to teach science process skills, and to instill in students the value of science.

The full evaluation report describes results from the two focus groups that GRG conducted with middle-school youth. The specific objectives were to determine: (1) What students already know about EarthScope-related themes and content, as well as what geoscience questions they have; and (2) The types of games students enjoy, including what they find challenging, fun and exciting, as well as what formats and content do not interest or excite them.

METHODS

To assess the four product prototypes from SAO, GRG conducted two focus groups with middle-school students with a total of 21 youth. One group had 11 fifth and sixth graders and the other group had 10 seventh and eighth graders. The focus group protocol and brief surveys included questions about students' background; interest in and knowledge about Earth science; preferences for video, computer, or web-based games; specific content and format-related questions for each of the four prototype games; suggestions for improving each of the four prototypes in subsequent stages of development; cross-game comparison questions; and possible game locations.

KEY FINDINGS

Volcano Island was the most exciting game.

- In both focus groups, across all phases of the discussion, Volcano Island was the students' favorite game.
- Students particularly liked the multiple elements of the game (e.g., balancing scientific and political data of many types).
- Although they recognized that outfitting the mayor character was not linked to the objective of the game, students were very interested in keeping this element in the game.
- Living in an Earthquake Zone was the runner-up game in both focus groups.

Students were most interested in the Earth science topic of volcanoes.

- It was difficult to disentangle students' favorite game from the topic they found most interesting. The interest in content was linked to the prospective enjoyment of the game.
- In general, students were more interested in topics with which they had baseline familiarity. For example, there was more interest in earthquakes than in tsunamis, as some students had visited or lived in California.

Students had heard of many Earth science topics.

- Students knew of Earth science topics including volcanoes, earthquakes, and landforms.
- Youth in the older age group (grades seven and eight) knew markedly more science content than did younger students (in grades five and six).

All of the students play video, computer, or Web-based games and they have clear opinions about what makes games fun versus boring.

- Fun games are those with many levels, that are not too easy (but not too difficult, either), while repetition or monotony make games boring.
- Keeping score was more important to students than was winning. They stressed that games needed a goal, and keeping track of their progress towards that goal was extremely important.

Students were interested in soliciting additional help from a scientist within the game.

- They did not want a video scientist to appear without selecting that option, but they were interested in having the option available.

Most students did not see themselves playing the game at a museum or national park; students often feel pressed for time at such venues.

- Students most often envisioned playing a game at school or at home.
- Students tended to play games alone rather than with a friend.
- Students were more eager to play a game to learn about an Earth science topic than to watch a 5-minute video about a topic.

Most students were interested in playing these games and had suggestions for potential revisions and improvements.

- Some students suggested combining all four prototypes in one game.
- Students in both groups suggested ways to make each game more challenging, exciting, and have more levels. They were eager for more.

KEY RECOMMENDATIONS

Considering the results of the front end evaluation, GRG offers the following recommendations for SAO to consider during further project development:

- Continue to develop the Volcano Island game, or one that keeps many of its elements (many challenges, a character with features to select, content with which students have baseline familiarity).
- Focus as much on making the game exciting as incorporating relevant Earth science content. As results show, students will be more interested in the science content of exciting games.

- Consider the science content as the overall important context for the game, so youth don't feel "hit over the head" with science.
- Include components where additional science content is available and advertised. Allow the player to select this feature.

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Front End Evaluation of *EarthScope Panorama*

Full Report

INTRODUCTION

Goodman Research Group, Inc. (GRG) was contracted by the Harvard-Smithsonian Center for Astrophysics, Smithsonian Astrophysical Observatory (SAO) to conduct formative evaluation, including front end evaluation and Alpha testing, of *EarthScope Panorama* during the project's development year. This report concerns the front end evaluation results.

SAO received a grant from NSF to develop a pilot program in 2007-2008, as part of EarthScope's Education and Outreach (E &O) program. When fully implemented, *EarthScope Panorama* seeks to achieve the goals of EarthScope Education and Outreach, "to ensure the EarthScope experiment creates as its legacy a public more knowledgeable of basic Earth science concepts and that has a deep understanding of the scientific and societal contributions made by the EarthScope experiment." *EarthScope Panorama* will work towards this goal "by reaching large numbers of young people in a way that is accessible, exciting, and engaging."

SAO is laying the groundwork for an informal educational program, in the form of an interactive Earth science game, for middle school youth. During the project year, the SAO team will develop the Earth science content for this module as well as the teaching platform (some options include stand-alone or handheld kiosks and cell phones). Through this outreach initiative, SAO hopes to teach a finite *EarthScope*-related concept to students, to relate that concept to the larger *EarthScope* initiative, to educate students about the scientists involved in *EarthScope*, to teach science process skills, and to instill in students the value of science.

The front end evaluation was conducted in September 2007 and focused on the prospective content, format, and platform of the *EarthScope Panorama* interactive Earth science game. The broad goal of GRG's evaluation was to assess four different game prototypes in a population of middle-school students (the target population for the final product).

The specific objectives were to document (and assess, as feasible):

- What students already know about EarthScope-related themes and content, as well as what geoscience questions they have;
- The types of games students enjoy, including what they find challenging, fun, and exciting, as well as what formats and content do not interest or excite them.

In this report, the focus group methods are presented, followed by the results from both focus groups. The final section consists of our conclusions based on the results and our recommendations for further stages of product development.

METHODS

In order to assess the initial four prototypes, GRG conducted two focus groups with a total of 21middle-school students. One group had 11 students in grades five and six, while the other group had 10 students in grades seven and eight.

Participants were recruited based on grade level. GRG recruited students via school parent list-servs, professional contacts, and snowball sampling. Twenty-one students from three cities and towns in Massachusetts participated in the evaluation, and students represented a cross-section of demographic characteristics such as socioeconomic status, school, gender, and grade level. Students' participation in the evaluation included attending a one-hour focus group, participating in the group discussion, and completing seven brief surveys during that hour. Each student received $10 cash at the end of the focus group session.

The focus group protocol and brief surveys included questions about the following topics:

- Demographic information;
- Interest in Earth science;
- Knowledge about Earth science;
- Preferences for video, computer, or web-based games (including favorite and least favorite, features that make games fun or boring, and frequency of game play);
- Specific content and format-related questions for each of the four prototype games;
- Suggestions for improving each of the four prototypes in subsequent stages of development;
- Cross-game comparison questions (e.g., favorite game and why, most interesting science topic); and
- Locations where students might envision playing the games (e.g., museum, visitor center, home, school).

RESULTS

Results presented below represent data from the 21 students who participated in the front end evaluation. Throughout the report, data are presented in terms of number of participants rather than percentages, as is the custom when the total number of participants is less than 50.

DEMOGRAPHIC INFORMATION

Table 1 presents a profile of participants in terms of gender and grade level. There were slightly more girls than boys, and there were fewer seventh-graders compared to students from other grades. Students were from three cities and towns in the Greater Boston area (Belmont, Cambridge, and Somerville), and they attend seven different public schools in those communities.

Table 1
Profile of Participants

		Participants
Gender	Girl	13
	Boy	8
Grade	5th	5
	6th	6
	7th	3
	8th	7

N=21

EARTH SCIENCE CONTENT KNOWLEDGE AND INTEREST

During an initial warm-up exercise, students were asked to call out words or phrases that came to mind when considering the phrase "Earth science." In both groups, students presented a wide variety of words. For a complete list of the words mentioned in the exercise, see Appendix A. The exercise showed that students were familiar with the general aspects of the content featured in the games. In both groups, students spontaneously mentioned earthquakes, volcanoes, and tsunamis, along with a variety of other words.

As each game was introduced, students discussed what they knew about the Earth science content addressed in those games (see sections for each game option for specific results). Students in both focus groups reported general familiarity with the concepts presented in the games, although no students had heard of drilling into the Earth (e.g., in Drill SAFOD). In general, students reported being more interested in topics with which they were somewhat familiar (see "Cross-Game and Cross-Topic Comparisons" section). Students in the older grades knew markedly more science content than did youth in the younger grades. Older students often knew more specific details about content (e.g., being able to describe the action of tectonic plates) than did younger students.

GENERAL VIDEO/COMPUTER/WEB GAME PREFERENCES

A majority of students noted that they play video, computer or Web-based games a few times per week, and all but two students usually play for between 15 minutes and one hour (see Table 2).

Table 2
Frequency and Duration of Game Play

		Participants
Frequency of play	Less than 1 time per week	5
	A few times per week	11
	Almost every day	4
	More than 1 time per day	0
Duration of play per session	A few minutes	1
	15 – 30 minutes	10
	30 – 60 minutes	7
	> 60 minutes	1

N=19 – 21

Students provided lists (written and verbal) of their favorite and least favorite computer/video/Web-based games, as well as a list of Web sites they like to visit (see Appendix A for complete lists). Students reported on a wide variety of games they enjoyed; there was no clear winner, although from group discussion, Web-based games emerged as somewhat more popular than console-based games.

Additionally, students wrote about and discussed what makes video/computer/Web-based games fun to play as well as what inspires continued game play. Some students offered more than one opinion, for a total of 44 responses:

- 15 students would play if the game was fun, entertaining or gave them something to do;
- 11 students would want to keep playing if they felt challenged;
- 6 would keep playing if there were multiple levels;
- 4 would keep playing if there were interesting graphics; and
- 8 students gave other reasons including if the game gave them a real life association (e.g., playing soccer), getting the most points in their online account and using different technology.

"Having you think about how to do something, not just trying again and again, until you get better at them."

"There are new levels and other things to unlock."

"Cute graphics, fast system, fun games, good story/plot and good sound effects."

After describing what makes games fun, students noted (in discussion and on paper) what makes them stop playing a game. Some students offered more than one opinion, for a total of 45 responses:

- 19 students would stop playing if the game was too hard or too easy;
- 7 would stop if the game became boring;
- 7 would stop playing if there was repetition;
- 7 would stop if they were playing too much or if they were told to stop; and
- 5 gave another reason they would stop including malfunctioning equipment, losing points, and bad graphics or sound effects.

"When it's way too hard or it's really boring."

"If it's impossible and there's no hope in succeeding."

"Takes too long, is too simple, has too many repetitive tasks."

GAME OPTION ONE: BUILD EARTHSCOPE

In Game 1, Build EarthScope, the player is chief scientist for a natural hazard-monitoring experiment within the EarthScope project. The task is to use the Earth science tools of EarthScope to build an experiment to gather and analyze geophysical data in the western U.S. A player chooses whether to monitor an earthquake, tsunami, or volcano and uses data acquisition tools including Global Positioning System (GPS) receivers and seismometers. The prototype walked through an example of monitoring a tsunami.

Students were moderately enthusiastic about this game. They had difficulty engaging with the game, and they wished that there were more ways to feel "a part" of the game's action. As they suggested with subsequent games, students included ideas for how to add complexity to the game (e.g., more levels, including a points system, having more tasks to complete or monitor simultaneously). For specific feedback, see bullet points below and Table 3.

Overall impressions of the game:

- An in-game scientist might be helpful once in a while (when the player can ask for help, not simply having the scientist appear); it seemed a bit "weird, like school" to some of the students
- The game seemed to some students fun at first but would become dull

Science content students knew:

- Tsunamis are large waves/giant tidal waves
- Tsunamis are started by plates shifting
- Earthquakes may trigger tsunamis
- Tsunamis are more likely near: Ring of Fire, Indonesia, oceans, and fault lines

Suggestions:

- Make the monitoring screen bigger
- Add more first-person activity within the game
- Add a view from the ground where the monitoring is taking place
- Include the capability to monitor all three hazards at once (tsunamis, earthquakes, and volcanoes)
- Include a points-driven system, whereby if players have more points, they are allowed to buy more sensors. If a player takes too long, they lose points.
- Having more than one level in the game would be fun

"I think it would be better if you had to like buy all those different tools and like do something to get money." (Younger group)

"Maybe a little more action, more first person stuff… Yeah, if you were building it but the tsunami is coming or something." (Older group)

"It would be a little better if you get a view from the ground. That would make it more 3-D." (Older group)

"There also should be more than one level… so that each level you would learn something new to what you had last." (Younger group)

"It'd be cool if you could have all three of them at once so it wouldn't just be tsunamis. So at first you'd be dealing with 1 then you'd be dealing with 2 then you'd be dealing with three…. If you're taking too much time on the tsunami or something there is suddenly an earthquake." (Older group)

Table 3
Ratings for Game One: Build EarthScope

	1 (Not at all)	**2**	**3**	**4**	**5 (Very)**
How interesting, overall **Mean = 3.05**	0	2	17	1	1
How interesting, topic **Mean = 3.43**	0	2	9	9	1
How fun to play **Mean = 3.00**	0	3	15	3	0
Would you play this game? 1(No Way) to 5(Yes, definitely) **Mean = 3.19**	0	4	11	4	2

N=21

GAME OPTION TWO: DRILL SAFOD

The game player is a drill operator for San Andreas Fault Observatory at Depth (SAFOD) in game option two, Drill SAFOD. The player must operate the SAFOD drill to simultaneously accomplish three tasks: 1) guide the drill through different layers of the Earth; 2) finish drilling the core in time; and 3) finish drilling the core under budget.

None of the students had heard of drilling into the Earth, so this game's topic was the least familiar to them. They did have some familiarity with earthquakes and fault lines (see section for game option four regarding those topics). Students understood the goals of the game, and they were somewhat, though not overly, interested in it. See Table 4 for game ratings.

Overall impressions of the game:

- Help within the game (e.g., from a scientist on video) should be optional. Some noted that a scientist in the game might bother them or be distracting. However, there was no specific example in the prototype on which students could base this reaction.
- Students knew that the goal was to drill to the San Andreas Fault, in time, within budget.

Science content students knew:

- Generally, students knew very little about drilling and had not heard of this before (they did have knowledge of earthquakes; see section for game option four).

Suggestions:

- The drill might shift during a game (without the player moving it, as an extra challenge).
- If the game included animation or had more interesting graphics, students would have been more excited about it.
- Make it clearer what types of rock are involved.
- Include the use of the arrow keys to allow for speed and direction.

"I'd like to have the help optional." (Younger group)

"It might shift as you go down, you might want to see what direction it's shifting in." (Older group)

"I think if the graphics were better, if it wasn't just a brown box and gray lines. Like maybe get more detail and more looking like a drill." (Older group)

"If there is more detail about what type of rock you're on and the layers." (Older group)

Table 4
Ratings for Game Two: Drill SAFOD

	1 (Not at all)	**2**	**3**	**4**	**5 (Very)**
How interesting, overall **Mean = 3.52**	0	4	4	11	2
How interesting, topic **Mean = 3.48**	1	2	6	10	2
How fun to play **Mean = 3.52**	0	3	7	8	3
Would you play this game? 1(No Way) to 5(Yes, definitely) **Mean = 3.48**	0	2	10	6	3

N=21

GAME OPTION THREE: VOLCANO ISLAND

In Volcano Island, game option three, the player takes the role of the mayor of Pumice Island. On the initial game screen, the player may choose the mayor's appearance (including features, clothing, etc.) When the mayor is notified that Mt. Leakytop is about to erupt, s/he must decide whether and when to evacuate the island. The mayor must weigh scientific data (e.g., GPS) alongside political (e.g., approval rating) and financial data to keep the citizens both safe and satisfied. At the Volcano Monitoring Office, the mayor has numerous aids including scientific instruments, a window to the volcano, a television with video hookup to scientists, a telephone, a popularity rating monitor, and an indicator of the money remaining in the bank.

In both focus groups, there was an instant, positive reaction to this game ("Really cool!") when the slides appeared on-screen. The game seemed more interesting to the students than did the first two. Students also felt more a part of this game and more in control of what was unfolding. They were quite familiar with the content material of volcanoes. Some students had visited volcanoes, and many students had ideas about potential warning signs preceding eruption. They enjoyed the option to configure the appearance of the mayor and recommended keeping this feature in the game. Students rated this game quite positively (see Table 5).

Overall impressions of the game:

- Students understood the objective of the game even before they saw the screen with the volcano monitoring office.
- Students did understand that they were weighing several types of data, that they had to account for science and politics, and that there was no one right answer to allow them to easily win the game.

- In both groups, students were very interested in selecting the features of the mayor, and in both groups they recognized that this function did not impact the rest of game play. Still, it was an important feature of the game and their prospective enjoyment of it.
  "I don't think it's important to the game I just think… I want to do it." (Older group)
- Nearly all students would use multiple sources of information to make the decision of when to evacuate.
- Students were less likely to want to play the game a second time if they had won the first time.

Science content students knew:

- Names and locations of volcanoes that have erupted (e.g., Mt. St. Helens, volcanoes in Hawaii)
- Certain indicators of eruption (smoke, rumbling, loud noises, haze)

Suggestions:

- Have the game double-check before the final evacuation phone call happens. Students were concerned about accidentally hitting the phone before they were ready to evacuate the island.
- To make the game more challenging, have the mayor conducting other activities at the same time s/he is making the evacuation decision. Allow the mayor to go around town, do an activity, see more things, or fundraise to put more money in the bank.
- To make the game more challenging, do not show the number of days until the volcano erupts. Rather, players could guess at the number of days (e.g., in higher levels of the game).
- Students were not sure how to use the money while playing the game (to buy equipment? Food?).
- The language on the welcome screen beginning with "Congratulations!" felt to some students like a question from the Massachusetts Comprehensive Assessment System (MCAS) exam. Others remarked that it made it too obvious that something major was about to happened, and they preferred to be surprised.

"I'd basically try to stay until the last single time because I may have a less chance of surviving but also a higher approval rating." (Older group)

"I would actually go a little before; I would go if I had a little time left because if I were a villager I wouldn't want to be pushed out at the very last second, I'd want to know a little ahead." (Older group)

"It would sort of be more a challenge but like if it just kind of counted how many days you had…. If you just kind of try to guess how many days you had left before you had to evacuate." (Younger group)

"I think it's kind of obvious that something is going to happen." (Older group)

Table 5
Ratings for Game Three: Volcano Island

	1 (Not at all)	2	3	4	5 (Very)
How interesting, overall **Mean = 4.33**	0	0	1	12	8
How interesting, topic **Mean = 4.24**	0	0	1	14	6
How fun to play **Mean = 4.24**	0	0	2	12	7
Would you play this game? 1(No Way) to 5(Yes, definitely) **Mean = 4.29**	0	0	1	13	7

N=21

GAME OPTION FOUR: LIVING IN AN EARTHQUAKE ZONE

In the final game option, Living in an Earthquake Zone, players must site and build a virtual house in an earthquake zone (near the San Andreas fault). Working with a set budget, they must purchase a lot and type of home and then design and outfit their home, weighing luxury features such as swimming pools against safety features such as bolting down the foundation and earthquake insurance. Once they have designed their house, players use computer software to subject the virtual house to simulate earthquakes to assess potential damage.

Students were quite positive about this game and the content it teaches (see Table 6). As with game option three, students felt in control of the game as they were weighing different information in decision making. Students, especially older students, had content knowledge about earthquakes and earthquake zones.

Overall impressions of the game:

- There was not consensus about which lot to buy. Students were weighing options and reaching different decisions.
- The game reminded them of the game *Sims*.

> *"Well I'd buy one that was kind of far away from the San Andres fault but not as far as like lot C that would be as expensive."* (Older group)

Science content students knew:

- An earthquake zone is an area where earthquakes are likely to occur or are frequent
- San Francisco is an example of an earthquake zone
- Earthquakes involve tectonic plates
- Earthquakes involve two plates under the earth that slide
- Scientists can, to some extent, predict earthquakes

"It's when two plates under the earth they slide on top of each other so the earth kind of goes up." (Younger group)

Suggestions:

- Provide information on how much it would cost to rebuild the house in the event it is destroyed by an earthquake
- Luxury features might include a gym, bowling alley, swimming pool, library, music room, maze, tennis court, golf course, secret garden
- The older students were unlikely to want to play the game more than once unless it had more complexity/challenge

"Yeah, I was thinking [Lot] B but it depends because you would need to know how much it would cost to put your house back together because if the costs to build it back together would be more than the cost to buy it wouldn't be worth it but if it was lower then it would be worth it because then you would actually benefit from your house getting destroyed and you'd also get a new house." (Older group)

Table 6
Ratings for Game Four: Living in an Earthquake Zone

	1 (Not at all)	**2**	**3**	**4**	**5 (Very)**
How interesting, overall **Mean = 3.81**	0	1	5	12	3
How interesting, topic **Mean = 4.14**	0	1	2	11	7
How fun to play **Mean = 3.86**	0	0	8	8	5
Would you play this game? 1(No Way) to 5(Yes, definitely) **Mean = 3.70**	0	3	3	11	3

N=21

CROSS-GAME AND CROSS-TOPIC COMPARISONS

The individual game ratings presented in the previous section are included together below (see Table 7). Students provided these ratings at the end of the set of slides for each particular game, before moving on to the next game's set of slides.

Table 7
Compiled Average Ratings for Each Game

	Interesting, overall	**Interesting, topic**	**Fun to play**	**Would you play?**
	Scale: 1 (Not at all) to 5 (Very)			
Game 1: Build EarthScope	3.05	3.43	3.00	3.19
Game 2: Drill SAFOD	3.52	3.48	3.52	3.48
Game 3: Volcano Island	4.33	4.24	4.24	4.29
Game 4: Living in an Earthquake Zone	3.81	4.14	3.86	3.70

N=21

Independent samples t-tests were used to compare potential differences in ratings between demographic subgroups. On the rating sheets (those completed as each game was presented and discussed individually), the younger group provided more positive ratings than did the older group to three of the four game options (see Table 8). The younger youth rated Drill SAFOD significantly more positively across all four categories than did the older youth, and they also rated Living in an Earthquake zone significantly more positively in three of four categories. Finally, the younger group rated Volcano Island as significantly more interesting overall and more fun to play than did the older group.

Table 8
Compiled Average Ratings for Each Game, Separated by Focus Group

	Interesting, overall		**Interesting, topic**		**Fun to play**		**Would you play?**	
Grade of Participants	5-6	7-8	5-6	7-8	5-6	7-8	5-6	7-8
	Scale: 1 (Not at all) to 5 (Very)							
Game 1: Build EarthScope	2.91	3.20	3.36	3.50	2.91	3.10	3.36	3.00
Game 2: Drill SAFOD	**4.09**	**2.90**	**3.91**	**3.00**	**3.91**	**3.10**	**4.00**	**2.90**
Game 3: Volcano Island	**4.64**	**4.00**	4.36	4.10	**4.55**	**3.90**	4.36	4.20
Game 4: Living in an Earthquake Zone	**4.09**	**3.50**	4.36	3.90	**4.27**	**3.40**	**4.10**	**3.30**

N=21. Means in bold indicate significant differences ($p < 0.05$) between the two focus groups (i.e., age groups).

With one exception, there were no significant gender differences in the ratings. Girls rated Volcano Island as significantly more fun to play ($p < 0.05$) than did boys.

Group Discussion

After students saw and discussed each individual game, but before they discussed and compared the games together, they rated their choices for most and least exciting game and most and least interesting science topic. Volcano Island was the clear winner for most exciting game (16 votes, including all students in the older focus group), with Living in an Earthquake Zone as runner-up (5 votes from the younger group; see Table 9 and Appendix A for detailed ratings).

Perhaps not coincidentally, volcanoes and earthquakes were rated as the most interesting science topics. Additionally, students reported being more interested in the topics about which they had more familiarity. For example, several students had visited volcanoes and others had visited earthquake zones, and those topics were more highly rated.

The games rated as least exciting were Build EarthScope (12 votes, mostly in the older group) and Drill SAFOD (9 votes, mostly in the younger group), and drilling was rated the least interesting topic. This also was the topic with which students had the least prior familiarity.

Throughout the discussion, it was clear that most students were interested in playing these games. They most often envisioned playing a game at school or at home, and they reported that they tend to play games alone rather than with a friend. They had difficulty envisioning playing them at a museum, visitor center, or national park, because they often feel pressed for time in those venues (either by parents or school teachers). Students were more eager to play a game to learn about an Earth science topic than to watch a five-minute video about a topic. During both focus groups, students provided many suggestions for how to make each game more challenging, exciting, and have more levels. Additionally, some students suggested combining all four prototypes into one large game.

At the end of the discussion, to conclude the focus groups, students completed a final rating sheet on which they ranked their top three choices for games and science topics. All but one student rated Volcano Island as their first or second choice game (see Table 9). Living in an Earthquake Zone was a runner-up, with ten students rating it as their second-choice game. Volcanoes and earthquakes were rated as the most interesting topics, both before and after the full group discussion.

Table 9
Ratings of Most Exciting Game and Most Interesting Topic

	Pre-Group Discussion Rating (younger, older)	**Final post-discussion rating (younger, older)**
Most Exciting Game		
Volcano Island	16 (6, 10)	12 (3, 9)
Living in an Earthquake Zone	5 (5, 0)	8 (7, 1)
Drill SAFOD	0	1 (1, 0)
Most Interesting Science Topic		
Volcanoes	14 (5, 9)	13 (3, 10)
Earthquakes	7 (7, 0)	7 (7, 0)
Drilling	0	1 (1, 0)
Tsunamis	1 (1, 0)	0
Monitoring	1 (0, 1)	0

N=21 – 22; totals add to more than 21 because some students listed more than one choice on the pre-discussion form.

CONCLUSIONS AND RECOMMENDATIONS

Considering results from the front end evaluation phase of formative evaluation, GRG offers the following recommendations that SAO may wish to consider in future stages of product development.

CONTENT

Students reported being most interested in the Earth science topics of volcanoes and earthquakes. Those are the topics with which students reported the most familiarity (e.g., having visited volcanoes or earthquake zones). Additionally, those were the topics addressed in their favorite games (Volcano Island and Living in an Earthquake Zone). Thus, an exciting game seems likely to stimulate greater interest in the topic. Not all students had visited a volcano, but many students rated volcanoes as the most interesting topic.

> ***Recommendation:*** *Focus the product on a topic with which students have baseline familiarity. They may not have extensive knowledge of this topic, but previous exposure to the topic appeared to inspire more interest in the game.*

> ***Recommendation:*** *Continue to focus on creating a game that is exciting to the target population of middle-school students, as exciting games inspire interest in the topics addressed.*

Students had heard of many Earth science topics. Younger students had less content knowledge than older students. Students seemed interested in learning more about Earth science in the context of exciting games with compelling goals.

> ***Recommendation:*** *Consider the science content as the overall important context for the game, so youth do not feel "hit over the head" with science.*

GAME FORMAT AND PLATFORM

In the Volcano Island game, students were eager to customize the mayor's appearance, even though they recognized that this was not linked to the objective of the game. Students were also eager to customize their house in Living in an Earthquake Zone. Options to customize make the game players feel as though they have more control over and ownership of the game.

> ***Recommendation:*** *Include game elements that allow players to customize features such as characters' appearance or other design components.*

All of the students play video, computer, or Web-based games, and they have clear opinions about what makes games fun versus boring. Fun games are those with many levels, that are not too easy (but not too difficult, either).

Keeping score was more important to students than was winning. They stressed that games needed a goal, and keeping track of their progress towards that goal was extremely important. Boring games are those with too much repetition or monotony.

> ***Recommendation:*** *In the next stage of development include game features such as multiple levels and ways to chart progress.*

OVERALL

Volcano Island was rated as the most exciting game across all phases of discussion and both age groups. Students particularly liked the multiple elements of the game (e.g., balancing scientific and political data of many types). Living in an Earthquake Zone was the runner-up game.

> ***Recommendation:*** *Continue to develop the Volcano Island game, or one that keeps many of its elements (many challenges, a character with features to select, content with which students have baseline familiarity).*

Students were interested in soliciting additional help from a scientist within the game. They did not want a video scientist to appear without selecting that option, but they were interested in having the option available.

> ***Recommendation:*** *Include components where additional science content is available and advertised. Allow the player to select this feature.*

APPENDIX A: SUPPLEMENTARY DATA

Ideas Generated in Mind Map Exercise for Prompt "Earth Science"

5th & 6th Graders	7th & 8th Graders
Atoms	Animals
Earth's volcanic core	Continents
Earthquake	Dirt
Galaxies	Disasters
Grey matter	Earthquakes
Hurricane	Elements
Land	Geology
Landmass	Hurricanes
Magnetic pole	Jupiter
Nature	Landforms
Ocean	Lava
Particles	Mountains
Planets	Outer Space
Plateaus	Rocks
Science about the earth	School
Science class	Squirrels
Shelter	The Atmosphere
Soil	The Earth
Studying	The poles (North and South)
Tidal wave	Tornadoes
Tsunamis	Tsunamis
Volcanic eruptions	Volcanoes
Water	Water
	Weather

Favorite Video, Computer, or Web-based Games

Students listed their three favorite games. Numbers in parentheses indicate that more than one student listed the game as a favorite.

1. Age of Empires (2)
2. Balloon pop
3. Baseball
4. Battle on
5. Battlefront ½
6. Burn Out: Takedown
7. Chick flick (nitrome.com)
8. Club Penguin (2)
9. Coconut Cards
10. Dangle (nitrome.com)
11. EV Nova
12. FIFA Soccer Street
13. Freddi Fish
14. Ghost Recon 2: Advanced warfighter
15. Grand Theft Auto
16. Halo 1 (2)
17. Halo 2 (2)
18. Hot air
19. Hot Shoot Checkers
20. I Spy
21. Ice Cream Truck
22. Impossible Quiz
23. Kirby
24. Madden 07
25. Maple Story
26. Marbleblast Gold
27. Mario Kart (2)
28. Mario Party 8
29. Mario Sunshine

30. Monkey Shines
31. Mystery of the True Hart
32. Naruto Clash of Ninja 2
33. Need for Speed
34. Neopets.com
35. Nintendo DS
36. Nintendogs
37. Pacman (2)
38. Paper Dolls
39. Pillball (2)
40. Pokemon
41. Pokemon Crater
42. Pokemon Diamond &Pearl (2)
43. Poppit
44. Red Beard (miniclip.com)
45. Roller Coaster Tycoon
46. Rollercoaster Tycoon 3
47. Runescape (3)
48. Sims (3)
49. Sims 2
50. Sky wire (nitrome.com)
51. Snow Line
52. Stick-O-Rama
53. Stronghold Legends
54. Super Mario Brothers (2)
55. Super Smashbros Meelle
56. The Impossible Quiz
57. The Impossible Test
58. The New Prophesy Quest
59. Toxic
60. UFO Joe
61. Wii sports games (including bowling, golf, Wii sports) (5)
62. Wow
63. Ying Yang
64. Yu-gi-oh
65. Zelda (2)
66. Zeus
67. Zoo Tycoon

Least Favorite Video, Computer, or Web-based Games

Students listed up to three least favorite games.

1. Age of Empires
2. Age of Mythology
3. AQ
4. Barbie games (2)
5. Basketball
6. Bowmen 2
7. Clash of Ninja 1
8. Dragon Fable
9. Feed me (nitrome.com)
10. Football
11. Halo
12. Halo 2
13. Hot air (nitrome.com)
14. Hot air 2 (nitrome.com)
15. Interactive buddy
16. Nintendogs
17. Nintendogs 2
18. Old Games
19. Rock
20. Tanks
21. War games (any)
22. Warcraft

Web Sites Kids Visit

Students listed Web sites they like to visit. Numbers in parentheses indicate that more than one student listed the game as a favorite.

1. Addictinggames.com (7)
2. American Girl
3. armorgames.com
4. battleon.com
5. Cartoonnetwork.com (2)
6. Club Penguin
7. disneychannel.com (2)
8. gmail.com
9. Google games
10. Lego Pokemon
11. mac.com
12. mc.com
13. miniclip.com (7)
14. neopets.com
15. nick.com (2)
16. nitrome.com (2)

17. pokemoncrater.com
18. poppit.com
19. runescape.com (3)
20. VGO
21. warriorcats.com
22. webkinz.com
23. yahoo.com
24. youtube.com (2)

Table A1
Pre-Discussion Ratings of Most Exciting Game and Most Interesting Topic, Groups Combined and by Grade Level

	Groups combined	**5th grade**	**6th grade**	**7th grade**	**8th grade**
GAMES					
Volcano Island	16	2	4	3	7
Living in an Earthquake Zone	5	3	2	0	0
SCIENCE TOPICS					
Volcanoes	14	2	3	2	7
Earthquakes	7	5	2	0	0
Tsunamis	1	1	0	0	0
Other*	3	1	1	1	0

N=21 – 25; some totals add to more than 21 because some students listed more than one choice.
* "Other" topics included the poles, weather, and "building houses to be safe in that area."

Table A2
Pre-Discussion Ratings of Least Exciting Game and Least Interesting Topic, Groups Combined and by Grade Level

	Groups combined	**5th grade**	**6th grade**	**7th grade**	**8th grade**
GAMES					
Build EarthScope	13	4	5	2	2
Drill SAFOD	9	1	1	2	5
SCIENCE TOPICS					
Drilling	10	2	2	2	4
Tsunamis	7	3	3	0	1
Earthquakes	5	1	0	1	3
Other*	1	0	0	0	1

N=22 – 22; totals add to more than 21 because some students listed more than one choice. "Other" topics included monitoring.

Table A3
Final Rankings of Top Three Games

	1st choice (younger, older)	2nd choice (younger, older)	3rd choice (younger, older)
Game 1: Build EarthScope	0	2 (1, 1)	5 (3, 2)
Game 2: Drill SAFOD	1 (1, 0)	0	6 (3, 3)
Game 3: Volcano Island	12 (3, 9)	8 (7, 1)	1 (1, 0)
Game 4: Living in an Earthquake Zone	8 (7, 1)	10 (3, 7)	2 (1, 1)

N=20 – 21

Table A4
Final Rankings of Interesting Science Topics

	1st choice (younger, older)	2nd choice (younger, older)	3rd choice (younger, older)
Earthquakes	7 (7, 0)	8 (2, 6)	5 (1, 4)
Drilling	1 (1, 0)	0	3 (2, 1)
Tsunamis	0	4 (1, 3)	11 (6, 5)
Volcanoes	**13 (3, 10)**	8 (8, 0)	0
Other*	0	1 (0, 1)	0

N=19 – 21; "Other" topic was hurricanes.

APPENDIX B: PROTOCOL AND SURVEYS

1. Hello and welcome (5 minutes)

2. Introductions (5 minutes)
I'd like to let everyone introduce themselves. Please say your name, what grade you're in, what school you go to, and what your favorite hobby is.

3. Mind Map exercises (10 minutes)
To begin our discussion -- I have the words "Earth science" written on this paper in a circle. I'd like you to take a moment to think about what you think of when you see this word. When you think of a word or phrase, please just say it out loud. I'd like to hear at least one idea from all of you. I'll write down your ideas as you call them out.

Probe: Who else has a word or phrase?
Probe: Let's get 3 more ideas down.
Probe: Any more?

Since we're going to be looking at Earth science games, I'm interested in learning more about the types of games you play and what makes games fun. When I ask you about games, I'll be interested in computer games or video games.

What are your favorite video games or computer games?

- What makes a game fun to play?
- What makes you want to keep playing video or computer games?
- What makes you want to play a game again?

What is your least favorite game?

- What makes a game boring? Frustrating?
- What makes you stop playing a game?

What Web sites do you like to visit?

4. What is EarthScope? (5 minutes)
In a minute, I'll describe what EarthScope is. But I'm wondering whether any of you have any ideas about what it might be?

The project for which this game is being developed is a piece of a much larger project called EarthScope. EarthScope is a $200 million National Earth Science Program where scientists from around the country are exploring the North American continent and learning about the science behind natural hazards caused by motions of the Earth, like volcanoes, earthquakes, and tsunamis. A part of this project is to teach the public—you and me—about Earth Science and get us excited about the work these scientists are doing. The game developers are hoping to get kids like you excited about and learn more about Earth science through a game. They hope that when you visit a museum or park visitor center that these games may be a fun way to learn about EarthScope and the science that EarthScope studies. That's why they've given us 4 game options and are so eager for your feedback. They want to learn how to make the most fun, interesting game possible, and your responses today will help them do that.

I'm now going to show you each of the 4 game options, and I'll be asking you questions about what you think as we go along. Also, please know that these games aren't going to take the place of the games you play at home.

When you see the games, you'll be seeing still pictures on the screen. The actual games will not really look like these slides. What you're about to see are guides, but you'll need to use your imagination to see what the games might really be like. The actual games will have noises, animation, for instance. As we look though these, think about how the games could look, imagine what might make them better, and please let me know what you're imagining—that's exactly the kind of information the game developers want to get.

5. Game Option 1: Build EarthScope (6 minutes)
Title slide: Will someone please read aloud the title of this game?
In Game 1, you are a chief scientist for a natural hazard-monitoring experiment within the EarthScope project. You job is to use the Earth science tools of EarthScope to build an experiment to get and analyze geophysical data in the western U.S.

Slide 1 shows you the types of hazards you might monitor. Can anyone tell me what the choices are? (earthquake, volcano, or tsunami).

This **slide** shows what the game might look like if you picked tsunami. When you look at this picture, what words come to mind? The tools you'll have to monitor the tsunami are Global Positioning System receivers (GPS, shown here in blue) and seismometers (shown here in pink). As you play the game, real scientists will appear on video to help you make choices and give you information about your task. If you saw this game screen, how do you think you would play it? By dragging and dropping the seismometer or GPS receiver into the brown box, you would monitor the hazard.

You'll be able to build up your monitoring system by adding sensors, wireless links, and a headquarters building. The **final slide** shows what your completed monitoring system might look like.

Questions & Probes for Game 1 *(see separate sheet)*
Administer Game 1 ratings sheet

6. Game Option 2: Drill SAFOD (6 minutes)
Alex is sending me a few more slides for this game.
Title slide: Will someone please read aloud the title of this game?
What do you think this is a picture of?

When you look at this picture, what words come to mind? How interesting does this look?

In game option 2, you are the drill operator for SAFOD, San Andreas Fault Observatory at Depth, one of the actual projects in the overall EarthScope project. You must operate SAFOD drill to simultaneously accomplish three tasks: 1) Guide the drill through different layers of the Earth; 2) Finish drilling the core must be completed in time; and 3) Finish drilling the core under budget.

Can anyone tell me where on the picture you need to get the drill to in order to win?
Next slide: What does this drill seem to do? Do the words in the bubble give any clues?

Next slide: There are several tools on the screen to help you with the drilling task. Please call out what some of those might be:

- current drill location
- current drill speed
- current drill direction
- the planned location of the borehole
- the type of rock at the current drill location
- an image of the core that has been drilled
- remaining time, and
- remaining funds. The drill speed indicator is coded red (too fast, the bit will break), yellow (too slow, you'll run out of money and time), and green (speed good). There is also a "start" button.

Next slide: What are some ways you can get help while in the game? Would you want to do that? During the game, you would be able to mouse over any of the screen elements and get a short description. Over some of the elements, there may be a longer description, perhaps with a video scientist. You control the drill speed and direction and have to drill down to the fault before your time and money run out.

Questions & Probes for Game 2 *(see separate sheet)*
Administer Game 2 ratings sheet

7. Game Option 3: Volcano Island (6 minutes)
Title slide: Will someone please read aloud the title of this game?

Read Slide 1 (or ask one of the kids to)
When you look at this picture, what words come to mind? How interesting does this look? Notice, on this slide, that you can pick out features of your character.

Read Slide 2 (or ask one of the kids to)
In the real game, this would be an animation, not a single picture.

On the NEXT SLIDE, we see that you have scientific tools and other aids to help you make your decision about when to evacuate. What do you see that you might use?

- Computer screens showing real-time seismic (number of earthquakes) and GPS data.
- A window from the office gives you a good view of the volcano, so you can watch for signs of smoke, etc.
- A TV allows you to watch news flashes and to hook up to video conferences with scientists who can give you advice.
- A telephone is available for the mayor to either broadcast a volcano watch (color code orange) or order an evacuation/warning (color code red).
- There are counters in the corner of the game screen that show the money remaining at the Bank of Pumice Island, the popularity rating of the mayor, and the time left to play.

In the game, holding the mouse pointer over any of the objects will bring up a box explaining the purpose of that piece of equipment. What do you think you would do if you were playing this game?

To win the game, you would need to broadcast a volcano warning when the computer monitors start showing activity and we see some puffs of smoke from the volcano. The game is 'lost' if the

mayor runs out of money, gets a popularity rating so low that everyone ignores his/her notices, or fails to evacuate the island in time. So what are the ways that someone could win or lose this game?

Questions & Probes for Game 3 *(see separate sheet)*
Administer Game 3 ratings sheet

8. Game Option 4: Living in an Earthquake Zone (6 minutes)
Title slide: Will someone please read aloud the title of this game?
Can anyone describe what an earthquake zone might be? Can anyone guess where in the United States people worry about earthquakes where they live?

Read Slide 1 (or ask a student to)
When you look at this picture, what words come to mind? How interesting does this look? Notice, on this slide, that you can learn more about the San Andreas Fault and learn about how faults and earthquakes are related.

Read Slide 2 (or ask a student to)
If you were going to decide where to build a house, what might help you make your decision?

On the NEXT SLIDE, we see three possible lots you could buy. What do you notice about the picture? Some lots are closer to the fault, and some are farther away. Lots that are closer to the fault are less expensive than the ones farther away. Remember, there is no right answer, just what you decide: Please raise your hand if you would choose lot A. What made you decide to buy it? (*repeat for lots B and C*) The NEXT SLIDE shows what happens if you choose Lot B.

Read next slide. As we see from what I just read, you would be able to choose different types of house, different features to add to your house such as swimming pool or indoor basket ball court. What are some things you might want to add to your house if you were building one? In addition, you can buy structural elements that would help in case of an earthquake. Do you have any idea of what those might be? You'll have to make choices, within a budget about what kind of features you add as well as what kinds of things you buy to protect your house against an earthquake.

On this NEXT SLIDE, we see that you then have to test your house against an actual earthquake before you build it. What do you think determines whether the house survives the earthquake? (probe for lot location, house size, earthquake protection, etc.) *Read slide*. You can pick a low, medium, or high intensity earthquake and see how much damage your house might have received. You then can go back and make any changes to your house and re-test it. Once you've made your final decision, your house gets tested one more time. You win if your house can sustain damage from an earthquake or be covered by insurance. What does insurance do?

Questions & Probes for Game 4 *(see separate sheet)*
Administer Game 4 ratings sheet

9. Comparing and Contrasting the Games (10 minutes)
Let's review some of the Earth science topics the games were about. Can anyone call out some of those topics? (*Probe for volcanoes, tsunamis, earthquakes, fault lines, etc., write on board)*

Hand out sheet listing "most interesting topic: _____" and "least interesting topic: _____"

On the sheet of paper we just handed out, write down the topic (from the list on the board) that is MOST interesting to you. Now write down the topic that is LEAST interesting to you.

Which topic is the most interesting to you?

- What about that topic is most interesting?
- Did you already know anything about it?

Which topic is the least interesting to you?

- What about that topic is least interesting?
- Did you already know anything about it?

Let's review the four game choices we had.

1. First was Build EarthScope, where you would use Earth science tools of EarthScope to build an experiment involving a volcano, earthquake, or tsunami.
2. In Drilling SAFOD, you had to guide a drill down to the San Andreas Fault.
3. In Volcano Island, you were the mayor responsible for deciding when to evacuate Pumice Island before the volcano erupted.
4. Finally, in Living in an Earthquake Zone, you had to decide where to build a house, decide what kind of house to build, and test your house against an earthquake.

Hand out sheet listing "most exciting game: _____" and "least exciting game: _____"

On the sheet of paper we just handed out, write down the game that is MOST exciting to you. Now write down the game that is LEAST exciting to you.

Which game would you be most excited to play?

- What about that game is most exciting?

Which game would you be least excited to play?

- What about that game is least exciting?

How do these game ideas compare to your favorite games?

Where might you imagine playing these games? Would you want to play them at home? At school? At a museum?

If you were visiting a museum or a national park, would you want to play a game to learn about EarthScope science? Would playing a game about science be more interesting to you than watching a video?

Would you want to follow-up with a scientist after playing a game? Would you visit a Web site after playing a game?

We're coming to the end of our discussion.
How do scientists find out about the earth? How they learn about the history of the Earth? What tools do they have or information do they need?

Final thank you and final survey.

Pre-Group Survey
We're interested in learning about the video and computer games you like to play. There are no right or wrong answers to these questions.

What are your favorite video games or computer games? If you have more than five favorites, feel free to write them, too.

1._____

2._____

3._____

4._____

5._____

What makes a video or computer game fun to play? _____

_____

_____

_____

Think about the video and computer games you like to play the most. What makes you want to keep playing these video or computer games?

_____

_____

_____

What are your LEAST favorite video or computer games?

1._____

2._____

3._____

4._____

5._____

What makes a game boring or frustrating? _____

_____

_____

_____

What makes you stop playing a game? _____

_____

_____

_____

How often do you play video or computer games? *(check one)*

- ❑ Less than once a week
- ❑ A few times a week
- ❑ Almost every day
- ❑ More than once a day

For how long do you usually play a video or computer game you like? *(check one)*

- ❑ A few minutes at a time
- ❑ 15 – 30 minutes at a time
- ❑ 30 minutes – 1 hour at a time
- ❑ More than 1 hour at a time

What Web sites do you like to visit?

_____

Rating Sheet for Game 1

For the questions below, circle a number from 1 through 5.

How interesting is this game idea, overall?

Not at all interesting				Very interesting
1	2	3	4	5

How interesting is the topic of this game (monitoring volcanoes, tsunamis, or earthquakes)?

Not at all interesting				Very interesting
1	2	3	4	5

How fun do you think it would be to play this game?

Not at all fun				Very fun
1	2	3	4	5

Would you play this game?

No way				Yes, definitely
1	2	3	4	5

Write any comments below:

Rating Sheet for Game 2

For the questions below, circle a number from 1 through 5.

How interesting is this game idea, overall?

Not at all interesting				Very interesting
1	2	3	4	5

How interesting is the topic of this game (earthquakes, fault lines, drilling)?

Not at all interesting				Very interesting
1	2	3	4	5

How fun do you think it would be to play this game?

Not at all fun				Very fun
1	2	3	4	5

Would you play this game?

No way				Yes, definitely
1	2	3	4	5

Write any comments below:

Rating Sheet for Game 3

For the questions below, circle a number from 1 through 5.

How interesting is this game idea, overall?

Not at all interesting				Very interesting
1	2	3	4	5

How interesting is the topic of this game (monitoring volcanoes, deciding to evacuate)?

Not at all interesting				Very interesting
1	2	3	4	5

How fun do you think it would be to play this game?

Not at all fun				Very fun
1	2	3	4	5

Would you play this game?

No way				Yes, definitely
1	2	3	4	5

Write any comments below:

Rating Sheet for Game 4

For the questions below, circle a number from 1 through 5.

How interesting is this game idea, overall?

Not at all interesting				Very interesting
1	2	3	4	5

How interesting is the topic of this game (earthquakes, building houses, balancing safety and house “extras”)?

Not at all interesting				Very interesting
1	2	3	4	5

How fun do you think it would be to play this game?

Not at all fun				Very fun
1	2	3	4	5

Would you play this game?

No way				Yes, definitely
1	2	3	4	5

Write any comments below:

SCIENCE TOPIC

Most Interesting Science Topic: _____

Least Interesting Science Topic: _____

GAME

Most Exciting Game:_____

Least Exciting Game:_____

Final Survey

Which of the Earth science topics we discussed today are most interesting to you (earthquakes, volcanoes, tsunamis)? Write your first choice, second choice, and third choice. If you're only interested in one or two topics, leave the other lines blank.

First choice (most interesting): _____

Second choice: _____

Third choice (least interesting): _____

Which of the game ideas you saw today would you want to play? Write your first choice, second choice, and third choice. If there are only one or two games you'd want to play, leave the other lines blank.

First choice: _____

Second choice: _____

Third choice: _____

Write down the top 3 things that make a video or computer game fun to play:

1. _____

2. _____

3. _____

Goodman Research Group, Inc.

Main Office
955 Massachusetts Avenue, Suite 201
Cambridge, Massachusetts 02139

Tel: (617) 491-7033
Fax: (617) 864-2399

West Coast Office
P.O. Box 361599
Los Angeles, CA 90036

Tel: (323) 939-2065
Fax: (323) 939-2065

info@grginc.com

www.grginc.com