

The Fabric of the Cosmos

SUMMATIVE EVALUATION REPORT

Pam Castori, Ph.D.
Becky Carroll
Laura Stokes, Ph.D.

with assistance from
Judy Hirabayashi
Laurie Lopez

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The Fabric of the Cosmos

Summative Evaluation Report

EXECUTIVE SUMMARY

The Fabric of the Cosmos NOVA series, a four-part PBS television series based on the book of the same name by Dr. Brian Greene, aired in November 2011. NOVA designed and produced accompanying web-based materials and outreach events (science cafés themed as “Cosmic Cafés,” offered in collaboration with the Society of Physics Students). These web-based materials and outreach events were designed to add value to public audiences’ viewing experiences and promote community-based face-to-face engagement of public audiences around the program and its associated topics (space, time, quantum physics, the universe and multiverse).

Inverness Research was commissioned to do the summative evaluation of the NOVA series and outreach strategies. The aim of the evaluation was to assess the ways in which and the extent to which *The Fabric of the Cosmos* project developed the public’s awareness of and interest in the science topics and the work of scientists, and enhanced their knowledge and understanding of the key concepts. The evaluation focused on the television series, the Cosmic Cafés, and the web-based materials, asking about the effectiveness of each and the extent to which they interacted to enhance the experience and impact of engaging in the science topics central to *The Fabric of the Cosmos*. Data were gathered through a viewer/participant survey, interviews, expert reviews, and in-person observations.

Summary Findings

INSPIRATION AND APPEAL: To what extent and in what ways did The Fabric of the Cosmos materials and outreach strategies appeal to and inspire audiences?

Respondents who viewed the NOVA television series were nearly unanimous in reporting that the series provided enjoyment and inspiration about the topics of the series, about Brian Greene’s book in particular, and the work scientists do. Respondents expressed strong sentiments about the quality of NOVA programming and the unique and valuable niche it plays in the lives of the American public. Most viewers had shared information from the series with friends, family, colleagues or students.

The new Cosmic Cafés, while involving far fewer people, also served to inspire people about the topics of the Cafés and the work of scientists through presentations by scientists and interactive live discussions.

CONTRIBUTIONS TO KNOWLEDGE: To what extent and in what ways did the Fabric of the Cosmos materials and outreach strategies contribute to audiences’ understanding and knowledge?

For the most part, respondents reported that the NOVA series enhanced their understanding of the concepts and the ways that scientists investigate the cosmos; some wanted even clearer understanding about some concepts and greater insight into how scientists generate understanding and theories. For respondents who do not have specialized science background, the many visuals and animations the series used played an important role in promoting understanding. Viewers also responded very positively to Brian Greene's and the other scientists' engaging narration.

A majority of participants in Cosmic Cafés reported that the experience enhanced their understanding of the scientists' work and the topics presented, which were often related to (but not necessarily the same as) the topics in the NOVA series. Cosmic Cafés also have the derivative benefit of providing those who host them with new science communication opportunities and skills.

A relatively small proportion of the study's respondents had visited the NOVA website, but those who did found the resources on the site valuable in promoting understanding of concepts; some wished there were links to even more resources.

EFFECTIVENESS: How effective were the different resources and outreach strategies? In what ways were they effective?

For general (non-science) audiences, the reliably high production quality of NOVA, as well as their familiarity with Brian Greene and the engaging narrative that he presents, were what made the series so effective in inspiring and educating them. Respondents who are science specialists were divided in their perspective on whether the science is appropriately vs. overly "dumbed down" for the general viewer.

It turns out that Cosmic Café audiences perceived little connection between the NOVA series and the cafés. Thus, the effectiveness of the cafés did not hinge on a connection to the series but rather on the quality of the café experience itself. The quality of the café experience tended to rely on the experience and skill of the organizer. Café organizers reported that the resources on the Cosmic Café website were helpful, with newer organizers giving higher ratings than experienced organizers. The webinar provided to new organizers was not well used: most people who participated in it did not organize a café.

The website provided a valuable option for viewers to view the series again or as an alternative to television. The interactives and other supplementary resources on the website were not frequently accessed by those viewers and café participants we surveyed; however, those who engaged with these resources found them engaging and helpful. Expert reviewers were also very impressed with the quality of the web resources and proposed improvements to chunking and navigation.

VALUE-ADDED: To what extent and in what ways did the Cosmic Cafés and web resources work interactively to add value, amplify or extend the experience and impact of the NOVA series?

For the respondents who accessed and used them, the web resources provided more substantive support for their understanding of the NOVA topics specifically than the Cafés. We learned that the website (along with the television series) also enhanced people's experience of reading Brian Greene's book of the same name and their understanding of its concepts.

Most Cosmic Café participants did not watch the series. While the cafés enhanced participants' understanding of the science concepts the cafés focused on, the cafés did not motivate participants to watch the series or buy the book. That is, the cafés served as an independent and unrelated avenue to public understanding of some of the same concepts, rather than having a value-added effect.

Final reflections

While relatively few survey respondents (fewer than half) found the website, the web resources were more directly tied to the series and enhanced viewer understanding more than the cafés. The web is increasingly the go-to place for information; thus, we believe that investing in the website (its content and its usability) seems very worthwhile as a way to reinforce and extend programming experience and public science understanding more generally.

The fact that this first experimental round of Cosmic Cafés did not strongly connect to and enhance the reach and impact of the NOVA series does not mean they had no value. Particularly for those science cafés that have developed a "following"—often they are associated with informal science institutions such as museums, whose mission is to educate the general public—cafés that are "themed" to NOVA series play a role in enhancing public understanding of those topics, even if the cafés do not drive participants to the series and *vice versa*. Further studies of NOVA-themed cafés over time may reveal closer links. Furthermore, continuing to invest in SPS students as café organizers has the long-term potential to enhance physicists' interest in and capacity to engage with and educate the general public about science; this would provide a direct benefit to the public and derivative benefit to NOVA.

Finally, beyond the questions we asked them, participants in *Fabric of the Cosmos* study told us that this kind of programming serves as a desperately needed vehicle for educating the public (youth in particular) within the existing pop- and reality-TV culture. Participants also expressed deep thanks to NOVA and to PBS, and expressed the hope that this kind of programming will continue.

The Fabric of the Cosmos

Summative Evaluation Report

I. INTRODUCTION

This evaluation study is designed to assess the ways in which and the extent to which *The Fabric of the Cosmos* NOVA project develops participants' awareness, interest, knowledge of, and appreciation for the science topics of the NOVA series (time, space, quantum and multiverse). The evaluation focuses on the series shown on NOVA in November 2011 and the attendant activities and resources, particularly the Cosmic Cafés and web-based materials. Study of the Cosmic Cafés includes an assessment of the mutual benefits of the collaboration between NOVA and the Society of Physics Students (SPS) for the purpose of promoting the Cosmic Cafés and involving SPS members as Café organizers, *Fabric* viewers and participants.

The Fabric of the Cosmos NOVA series, a four-part PBS television series based on the book of the same name by Dr. Brian Greene, aired last Fall. NOVA designed and produced accompanying web-based materials and outreach events (Cosmic Cafés) aimed at adding value to the publics' viewing experiences and promoting community-based face-to-face engagement of public audiences with local scientists researching topics related to time, space, quantum and multiverse.

Inverness Research Inc., an independent and national educational research and evaluation organization (<http://www.inverness-research.org/>), was commissioned to do the summative evaluation of the program and outreach strategies. The aim of the evaluation was to assess the ways in which and the extent to which *The Fabric of the Cosmos* project developed participants' interest in and awareness of the science topics, their knowledge and understanding of the key concepts; and their appreciation of scientific work and discovery. The evaluation focused on the series and the attendant activities and resources, including the Cosmic Cafés and the web-based materials.

This evaluation study identified and queried different sectors of the general public who engaged with *The Fabric of the Cosmos* programming (general public, students, science enthusiasts, educators); and also documented the experiences and perspectives from groups of those sectors who experienced different aspects of the programming (television series, website visitors, and/or Cosmic Café goers). This report includes key findings aligned with our research questions, and conclusions and implications that may support NOVA in its ongoing efforts to bring cutting-edge science to public awareness and understanding through programming with concurrent outreach strategies.

In this summative evaluation report, we describe our research activities and data sources, report on key findings aligned with our research questions, and generate conclusions and implications that may support NOVA in its ongoing efforts to bring cutting-edge science to

public awareness and understanding through programming with concurrent outreach strategies.

II. SUMMATIVE EVALUATION QUESTIONS AND METHODS

This evaluation study identified and queried different sectors of the general public who engaged with *The Fabric of the Cosmos* programming (general public, students, science enthusiasts, educators)¹; and also documented the experiences and perspectives from groups of those sectors who experienced different aspects of the programming (television series, website visitors, and/or Cosmic Café goers).

An interest in learning from and about the work of NOVA with a young scientist organization, in this case the Society of Physics Students, steered certain data analyses to compare SPS student and other participants' experiences and perspectives.

Evaluation Questions

Inverness Research investigated four central evaluation questions related to the television series and the accompanying outreach strategies. These questions were:

- *To what extent and in what ways did The Fabric of the Cosmos materials and outreach strategies inspire and appeal to audiences?*
- *To what extent and in what ways did the Fabric of the Cosmos materials and outreach strategies add to the knowledge of audiences about the topics of space and time, quantum, and multiverse, and to their understanding of the processes and practices of science?*
- *How effective were the different resources and outreach strategies for different audiences? In what ways were they effective, or not?*
- *What did we learn about how the resources and strategies worked together to add value, amplify or extend the program viewing experience?*

Evaluation Approach: Mixed Methods

The evaluation employed a mixture of qualitative and quantitative research strategies to investigate the evaluation questions for the different audiences. This mixed method approach² enhances construct validity and results in a more complete view of the impacts and outcomes of an intervention, program, event, etc. Methods included online surveys, field observations, structured phone interviews, and expert website reviews. These methods were used in a set of evaluation activities that engaged defined sets of participants (study samples)³.

¹ In this report we refer collectively to these sectors of the general public as "publics."

² Brannen, Julia. 2005. Mixing Methods: The Entry of Qualitative and Quantitative Approaches into the Research Process. *International Journal of Social Research Methodology* 8:173-184.

³ Participants in all evaluation activities were offered modest incentives for being involved in the study.

III. EVALUATION ACTIVITIES, DATA SOURCES, AND STUDY PARTICIPANTS

In this section we describe in some detail each evaluation activity, as well as selected findings regarding key characteristics of the study samples (participants) associated with each activity. Additional findings about impacts on the various study samples in relation to the evaluation questions types are reported within the Findings sections of this report.

Online Participant Survey

One purpose of our study was to ascertain in what ways and to what extent the NOVA television series (*The Fabric of the Cosmos*), the Cosmic Cafés, and the web interactives impact viewers and participants. We were interested in how each experience—viewing the series, participating in a Café, interacting with the website resources—impacts viewers, and how various combinations of experiences impact them. To answer these questions, we created an online survey⁴ that documented the kinds of experiences participants have and how those experiences affect them in terms of their awareness, interest, knowledge of, and appreciation for the science topics of the NOVA series and the work of scientists, and their overall belief in the importance of science.

We launched the online survey on November 1, 2011 and closed the survey on December 12. We employed several strategies for recruiting potential viable survey-takers. These included:

- posting invitations on the Science Café website
- advertising on NOVA Facebook page
- advertising on NOVA twitter (for a very short time)
- disseminating information at Cosmic Cafés (through the café organizers). In some cases café organizers used their own information dissemination strategies (e.g., science café listserves, Facebook pages or emails).

We learned that over a third (37%) of the respondents say they found out about the survey through some connection to their science café or a cosmic café (including the café organizers' Facebook pages). Twelve percent named Facebook⁵. Twenty-nine percent of the respondents learned about the survey on the NOVA website (no SPS member respondents indicated this); 8% through twitter; 7% learned about the survey from the NOVA newsletter; 4% found out through a friend, colleague or relative; and 2% named "other" means.

The first wave of survey responses came in quickly after the twitter link was posted in early November. Examination of a sample of individual responses indicated that a high

⁴ The online survey instrument and interview protocols are included in Appendix A.

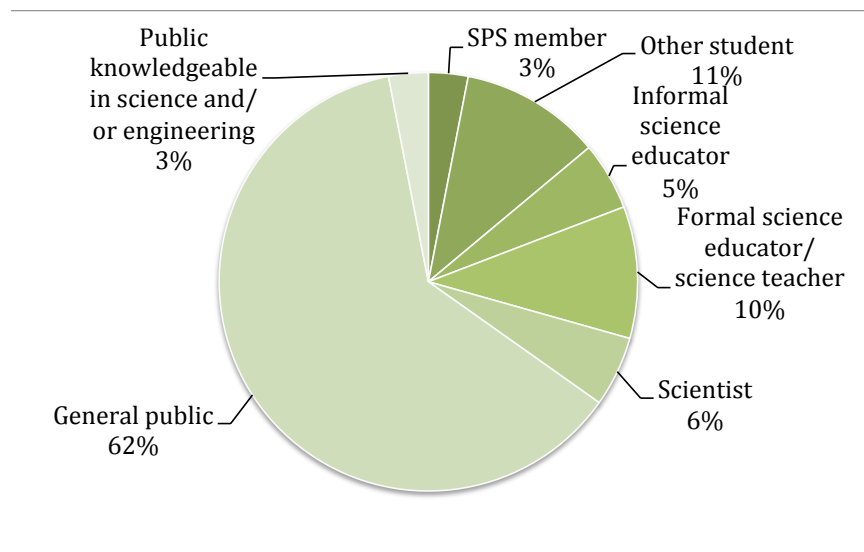
⁵ We suspect that many respondents confounded the two Facebook options, and that more learned of it on the NOVA Facebook page and fewer via a Café page.

proportion of responses were spurious, simply random checking of response options to qualify for the advertised Amazon certificate. Indicators of spurious response included surveys reporting that multiple episodes were watched although only the first episode had aired, clear mismatch between gender and name, ratings for experiences that survey takers checked earlier to indicate they had not experienced, etc. As data came in via Facebook links, additional spurious surveys were identified; we then closed the Twitter and Facebook survey links that were producing these. We received 1479 total responses. After the data were reviewed and cleaned carefully, we were left with 589⁶ surveys that we deemed legitimate. It is from these responses we report results.

Survey results included in this report are presented for the entire set of valid responses, and as noted earlier, in some cases they highlight interesting comparisons of the SPS member respondents and the general respondent pool.

Survey participants demographics and levels of science education/knowledge: Sixty-two percent of the 589 respondents self identified as members of the general public, 15% were either formal or informal science educators, 14% were students, and 8% were scientists or engineers. Three percent (18 individuals) identified themselves as SPS members (included in the 14% that identified themselves as students).

Figure 1. Demographics of Survey Respondent Pool (n=589)



⁶ Despite our best efforts to guarantee the quality of data, an alert scammer could have submitted a survey that looked legitimate. We suspect that 5-10% of the surveys we include in our analysis may be spurious, and there is no way to know which ones. Therefore, we advise readers not to make too much of small differences across respondent types.

Sixty percent were male, 39% female, and 1% declined to indicate. The largest age groups were 20-40 (44%) and 41-64 (44%), with 8% indicating they were 65 or older and 3% indicating they were 19 years of age or younger.

Forty-six states were represented in the responses, with the greatest numbers of surveys submitted from California, Washington State, Texas, New York and Massachusetts.

In terms of their *highest level of science education*, 1/5 had high school level classes; 1/3 college level; 1/5 indicated they had earned a Bachelors of Science, and approximately 1/5 reported graduate or postgraduate level education in science. Just over half (53%) described their knowledge of science as quite a lot or expert, 35% indicated the same for math, and 34% indicated the same for general physics. SPS respondents had a different response rate in terms of describing their levels of knowledge about science (39% quite a lot or expert), math (56% a lot or expert) and general physics (50% quite a lot or expert).

The survey respondents indicated they engage with science informally in numerous ways, with viewing NOVA specials and other TV programs the most common avenues (Table 1). SPS members report attending informal science events and using “new media” much more often than other respondents.

Table 1. Percentage of survey respondents who informally engage in science often or very often

	<i>All respondents (N=564)</i>	<i>SPS members (N=18)</i>	<i>All other respondents (N=546)</i>
Watch NOVA specials or other PBS programs with similar intentions to inform the general public about science	70%	56%	70%
Watch network TV programs or specials with similar intentions to inform the general public about science	53%	39%	53%
Watch video shorts about science, like those on YouTube	39%	61%	38%
Attend informal science events where scientists share their work with the public	18%	72%	16%
Use science-related interactives or animations on the web	29%	50%	28%

Percentages represent respondents who checked 4 or 5 on a 5 point scale where 1 = Never and 5 = Very often.

To determine relationships between program experiences and impacts, we identified participants in the following experience sub groups (Table 2). Survey respondents from these categories who indicated in the survey they would be willing to participate in a phone interview constituted our participant interview sample.

Table 2. Experience Categories of Survey Respondents

Experiences with Television Program and Outreach	% Non-SPS (N=571)	% SPS members (N=18)
1. Viewed the NOVA series (or parts) only	56%	11%
2. Viewed the NOVA series and interacted with the web materials	27%	11%
3. Viewed the NOVA series and participated in a Cosmic Café	3%	28%
4. Viewed the NOVA series, participated in a Café, and interacted with web materials	3%	17%
5. Participated in a Café only	6%	22%
6. Participated in a Café and interacted with web materials	1%	6%
7. Interacted with web materials only	5%	6%

Cosmic Café Observations

As part of their sciencecafes.org effort⁷, NOVA collaborated with the Society of Physics Students (SPS) to host and promote a version of their NOVA sponsored science cafes based on *The Fabric of the Cosmos*. These were called “themed cafés,” and the intention was to promote awareness and public engagement with a NOVA program or topic through their existing science café network.

In order to develop our own independent assessment of the nature and quality of Cosmic Cafés, their links to the NOVA series, their impacts on participants, and the benefits that accrue to the organizers, we observed five Cosmic Cafés in five states, three in the western region, one central, and one eastern. Researchers who observed a café communicated with the organizer in advance about attending, generated field notes from their visits, and responded to an online observation debrief protocol. Observation data gathered about the cafés included general information about the café (hosting organization, speaker, audience and audience engagement, etc.) as well as rating scales gauging general effectiveness and success of the event.

Cosmic Cafés Observed: One café was sponsored through a well-established informal science center. The other four were sponsored in association with a college or university. Two of the five cafés were organized through SPS chapters. One café was located in an urban community, two in suburban, and two in small cities (one of which drew audience members from rural areas in the vicinity). All cafés were held at either a pub or restaurant-type venue.

⁷ For more information about NOVA’s Science Cafes visit <http://www.sciencecafes.org/>.

Three of the cafés we observed were organized by established and experienced science cafés organizers, though one of these cafés was a first time café in a new location (the facilitator was experienced with science cafés but was doing the café in a new location for a new audience). Two cafés were organized by SPS members for whom this was their first experience in organizing a science café. For four of the five cafés, the moderator/facilitator for the event was the same person as the organizer of the café. In one case the organizer was also the speaker. The Café organized by the most experienced facilitator/moderator was filmed by the local public television station.

All cafés lasted for at least 60 minutes, most were 90 minutes; and in all cases the audience was invited to stay and talk with the speaker afterwards. Three cafés had 20-30 people in attendance, one had around 70, and one around 100. The established café associated with the informal science institution had the highest attendance.

All of the cafés we observed referenced the NOVA programming, including the PBS series, and three of the five explicitly referenced the website; all made the informational drink coasters available to audience members. Three of the five cafés used video clips or *The Fabric of the Cosmos* trailer. In one case the moderator showed the series trailer before the speaker came on. Another speaker showed a clip of physicist Jim Gates talking about what is left if we get rid of all matter (he was running short of time and almost skipped a discussion of Schrodinger's cat, but the audience hooted and clapped until he spent time to discuss it.)

Moderator/facilitators at the three first-time cafés used more of the NOVA toolkit/resource materials than the experienced cafés (such as the checklist, the template provided for their flyer). Prizes including raffles and incentives were offered in three of the cafés, and included NOVA hats, *The Fabric of the Cosmos* book, an Elegant Universe DVD, gym bag, and discount cards to shop online. These seemed to bolster audience enthusiasm and attention and inserted a fun factor to the event.

Three cafes had 20-30 people in attendance, one had around 70, and one around 100. We did not gather café participant demographic information. In two cases, one café organized by an SPS student and one by an experienced café organizer not affiliated with SPS, the audience was primarily academic (college students and faculty). In the other three cases there was a good mix of ages that included the general public and academics in the audiences.

Cosmic Café participants were invited to participate in the online participant survey⁸. The majority of Cosmic Café goers who responded to the survey attended cafés where Inverness researchers were present to urge participation in the survey. One in seven (14%) of survey respondents attended a Cosmic Café, and another 3% were not sure if they did. Respondents reported attending one of 12 different Cosmic Cafés and 9 other Science Cafés that we were not aware of (Table 3).

⁸ At the Cosmic Cafés participants were invited to visit the website at their convenience and take the online survey. NOVA provided coasters with QR codes that led to *The Fabric of the Cosmos* website, where they were prompted to take the survey, and café organizers were encouraged to provide the direct link to the survey. Some café-goers were also invited through email invitation if we had their contact information.

Table 3. Cafés attended by survey respondents

Registered Cosmic Cafés	Other Science Cafes
Arcata , CA *	New York, NY
Cambridge, MA *	Miami, FL
Seattle, WA *	Chicago, IL
Pomona/ Walnut CA	Alamogordo, NM
Eugene OR *	Syracuse, NY
Tacoma, WA	Chattanooga, TN
Kenosha, WI	Mount Juliet, TN
River Falls, WI *	Austin, TX
Washington, DC	Dallas, TX
San Angelo, TX	
Melbourne, FL	
Monterey, CA	
*Café attended by Inverness Researcher	

Cosmic Café Organizer Survey and Structured Interviews

We invited the ten Cosmic Café organizers to take an online survey, and then participate in a structured phone interview with us. All of the organizers completed the online survey (a response rate of 100%), and seven of the ten agreed to be interviewed.

The survey and interviews were designed to add depth to the online participant survey data from participants who had attended a café. In particular we were interested in learning about the following:

- the café organizers' themselves and their experiences with science Cafés or similar kinds of public outreach science events
- the value of Cosmic Cafés to the organizers—primarily the SPS members who are new to science cafés, but also experienced organizers who are new to themed cafés.
- how themed cafés such as Cosmic Cafés help to promote the science topics of NOVA and appreciation of science more generally
- the value and usefulness of the supports provided by NOVA to the organizers (web-based Cosmic Café resources, materials, and café training opportunities).

From the survey and interviews, we learned more details about the organizers and the café characteristics. Of the 10 organizers, 7 were new to offering Science cafés and 3 were experienced. Among the 3 experienced organizers, 1 had done several Cafés within the past year, and the other 2 had done more than 10 cafés over a 2-4 year period. Of the 7 new organizers, 4 were members of SPS. The 3 experienced organizers account for 6 of the cafés reported in the survey. Of the non-SPS organizers, two were college/university faculty, one was a university administrator, two were scientists, and one was an informal science educator.

The 10 organizers had conducted a total of 12 Cosmic Cafés. Of the 12 cafés, 3 were held in a university room (all by the same organizer), 1 in a community public space such as a library, and the remaining 8 were held in restaurants/pubs.

All told, these 12 Cosmic Cafés served 831 participants. Attendance at any one event ranged from 15 to 300. The mean attendance for new organizers (both SPS and other) was in the mid-30's and for the experienced organizers was 146, though the median was 117 (the one café with 300 raised the mean). Clearly, the more experienced organizers serve larger numbers of people. Organizers reported that for 6 of the cafés, participants were new to Science Cafés. For 5, the audience included both new and experienced Café participants, and for 1, the audience was experienced.

Participant Structured Interviews

Structured telephone interviews with participants from various experience groups and public sectors were planned in order to gather more insights and details about participants' experiences with the television program, website and cosmic Cafés, and how accessing the website and/or participating in a science café added value to the experience of watching the television program (though we also asked about this in the online survey).

In order to find people with the various experiences, we drew potential participants from our survey pool, generated a matrix (Table 4) of kinds of experiences and different audiences. We then randomly identified emails of survey participants who met the characteristic for each cell in the matrix (and also indicated they would be willing to participate in a 20 minute telephone interview about *The Fabric of the Cosmos*), inserted their emails, and divvied the potential interviews amongst three researchers.

Table 4. Participant interviews by audience sector and experience group

Experience Group	SPS students	Scientist/Science Enthusiasts	Educators	Gen. Public other students
Program watchers only		3		1
Program watchers + café			1	
Program watchers + website	1	1	1	1
Program watchers + café + website	1			
Café and/or website without watching		1		2

Our goal was to interview 40 participants, at least two from each cell in the matrix. Unfortunately, after multiple efforts to encourage participants in the phone interviews, we ended up with a total of 13 interviews. We think this may be due to the time lag between when the programs aired, when the Cafés were held, our analysis of the survey data, and

when we recruited participants for interviews. Table 5 shows the matrix and the number of interviews we ended up holding for each of the experience types and audience sectors.

Results from these interviews are reported in the other Findings sections of this report.

Website Reviews

Inverness Research identified three website design and review experts who agreed to do a review of *The Fabric of the Cosmos* website.⁹ The reviewers come from different fields and areas of expertise, but all have extensive research experience with website development and usage, and in one case media-based interactives, simulations, tools and games. Reviewers were invited to spend time studying the website, including any videos and interactives, keeping in mind the following areas:

- 1) Content: amount, level (too simple, too deep?), visuals
- 2) Links: other relevant resources, programs, websites
- 3) Interactives: In particular NOVA is interested in their interactives, as they require substantial resources to produce
- 4) Overall appeal and quality
- 5) General design and navigability

⁹ The full reviews are included in Appendix B.

IV. FINDINGS: INSPIRATION AND APPEAL

In this section we present key findings from survey data, interview data, Cosmic Café observations and website reviews. Key findings are reported as assertions, followed by representative samples from data that demonstrate the ways in which and extent to which the television series, the website and its interactives and resources, and the Cosmic Cafés appealed to and inspired different audiences.

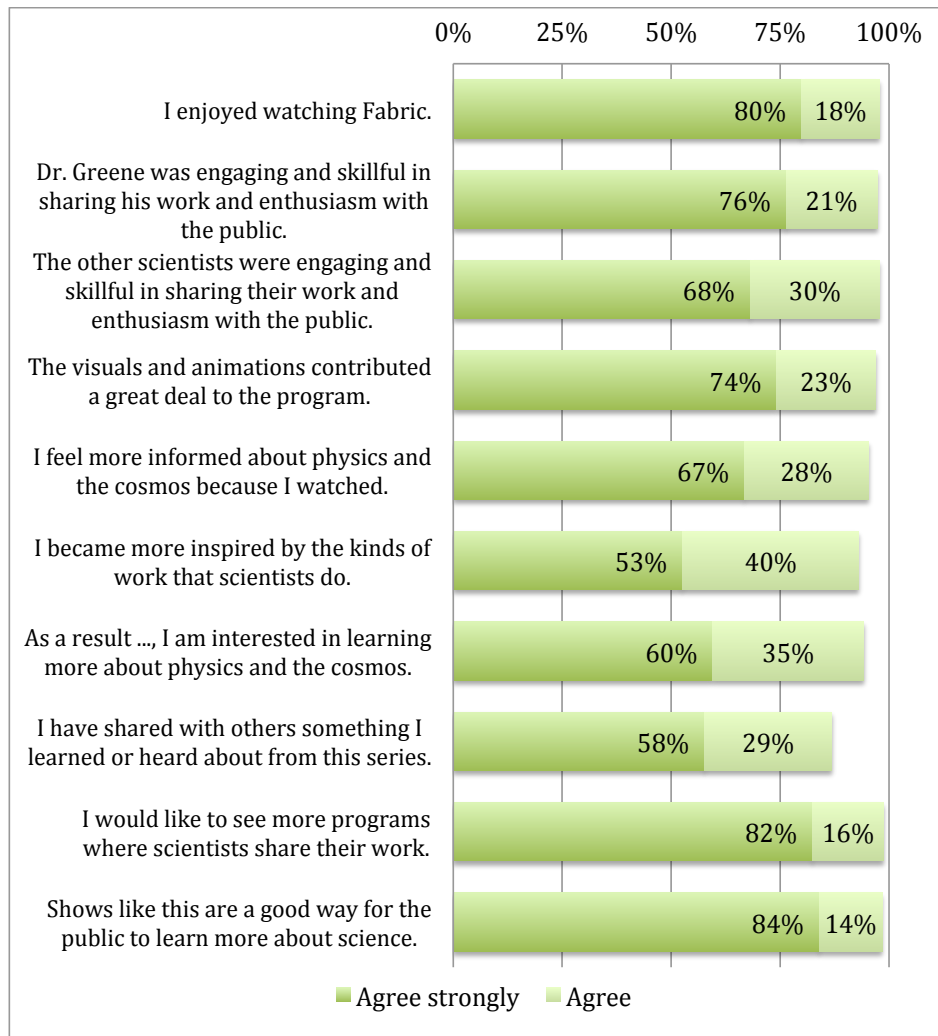
Evaluation Question: To what extent and in what ways did The Fabric of the Cosmos materials and outreach strategies inspire and appeal to audiences?

Television Program

The Fabric of the Cosmos television series held high appeal and was very popular among participants in all aspects of our study. The NOVA episodes are exciting to viewers and strengthen their respect for science, while educating them about challenging topics including the nature of space and time, quantum, and multiverse.

Survey participants who watched at least one of the programs were nearly unanimous in their positive assessment of a range of aspects of the television program (Figure 2), with nearly all audiences indicating they enjoyed watching the program. Of note in the graph is that the majority of high ratings (4's and 5's on a 5-point scale) are ratings of 5 rather than 4; this speaks to a very high level of enthusiasm for the NOVA series.

Figure 2. Percentage of viewers who agree or agree strongly with positive statements about *The Fabric of the Cosmos* and its influence on them



Comments from those that felt positive about the series included recurring references to the excellence of Dr. Brian Greene and the high quality of NOVA programming.

Thank you so much to you, Dr. Brian Greene and everybody else that is a part of FOTC for making these fantastic documentaries! Please, please make more of these based n the works of Dr. Brian Greene! I have learned so much! Your work has increased a lot my passion for science...

Thoroughly enjoyed the shows that I have seen from "The Fabric of the Cosmos". Brian Greene and the animations make it exciting and fairly easy to understand, especially given the complexity of the topic. I can't wait to see more work from Greene and NOVA. I wish that the shows were available when I was in grade school. It would have

inspired me to perhaps choose a scientific career. None the less, it'll be inspirational to my two sons attending engineering at university. Thank you for a great education!

Viewers also acknowledged the unique and valuable niche that NOVA television programs like *Fabric* holds in our culture and in their own personal lives.

NOVA and PBS in general have always served as a valuable resource to get in touch with academic topics that are rarely available to such a great extent in other broadcast companies. The manner by which these shows are presented is professional, concise, and tantalizing.

I get great satisfaction out of watching programs such as this. I have been fascinated by physics and anything having to do with the study of the universe since I was a child. It is frustrating to me that I never completed a degree and sometimes don't feel that I have the capacity to understand the concepts being put forth. But your show is so thorough in its explanations that I find I am able to wrap my uneducated mind around it. I love it! I am enthralled and can't wait to watch the next episode.

*I love having my world view shaken by shows like *Nova* and *Fabric*. Keep it up!*

Many participants indicated the NOVA Brian Greene programs (*The Fabric of the Cosmos* and *Elegant Universe*) are an excellent way to engage more sectors of public audiences (in particular young audiences and “laypersons”). A majority of participants who felt positive about the series indicated they had shared something about the series with others (family members, students, co-workers, etc.).

Cosmic Cafés

As a result of attending a Cosmic Café, 91% of the café survey participants felt more inspired by the kinds of work that scientists do as a result of their experience, and 92% indicated they were interested in knowing more about scientists' work in physics and cosmology. Survey comments from café participants expressed gratitude for the opportunity to participate in the Cosmic Café, shared what they learned, and cited the cafés' contribution to public understanding of and dialogue about physics.

NOVA is a national treasure. We're fortunate to have it -- and the Cosmic Café brings the (television) show and its ideas that much closer to the viewing public. It allows me to participate in the show in a small way.

Thank you very much for offering the opportunity for the public to hear about the work of scientists and meet them in an informal setting. The topic was very interesting and informative!

I don't have the money to return to school at this point, and it is exciting to me to be able to participate in science related events in the community.

I love that I feel like I finally have a grasp of what people are talking about when they say "dark matter" and "dark energy".

A great way to encourage learning and dialog for students and general public. Can't wait for the next one.

Please organize as many of these in the future as humanly possible. Physics needs street-level ambassadors who can make it accessible to the general public.

All cosmic café survey respondents also indicated they would like to attend more events where scientists informally share their work with the public.

Website

The majority of website users of the interactive features reported that they enjoyed using them (98%), found them easy to use (93%), and felt more informed about spacetime because they used the interactives (93%). Seventy-one percent report that they shared the interactives with others.

Website visitors we interviewed did not talk about being inspired by the website, but did mention the visual appeal of the website, noting their appreciation for not being bombarded with advertisements. Expert website reviewers noted the aesthetically pleasing appeal, the “minimalist” clean style of the website, and the production quality and appeal of the content located on the website.

One website reviewer said the appeal and quality of the website was...

Extremely high for this user... the episode videos – yet proves a richer experience for those who want to delve further...

Another reviewer noted,

As I would expect, the video quality (script, characters, visuals) was highly engaging and reminded me of the Sagan series when I was younger.

V. FINDINGS: CONTRIBUTIONS TO KNOWLEDGE

In this section we again present for each venue – television, Cosmic Cafés, and website – and from the multiple data sources related to how *The Fabric of the Cosmos* materials contributed to audiences’ knowledge of spacetime, quantum and multiverse, and to their understanding about the nature of science. Because of their compelling nature, we use many and varied articulate comments that viewers from the different audience sectors were generously willing to provide in the survey and interviews. Though we have attached an appendix with all of the comments, we made a decision to include a substantial number as they convey best their personal engagement and experience with the content of the programs and its relationship to their thinking.

Evaluation question: To what extent and in what ways did the Fabric of the Cosmos materials and outreach strategies add to the knowledge of audiences about the topics of space and time, quantum, and multiverse, and to their understanding of the processes and practices of science?

Television Program

Almost all viewers (98%) said that shows like *The Fabric of the Cosmos* are a good way for the public to learn more about science. The *Fabric* series added to participants’ knowledge of both scientific concepts and current theories related to space and time, quantum, and multiverse, as well as of the processes and practices of science, including the dedication and enthusiasm that scientists bring to their research. For those that had already watched one or more episodes, 95% agreed or strongly agreed with the statement, “I feel more informed about physics and the cosmos because I watched”; and 94% indicated they are interested in learning more about physics and the cosmos in the future.

References to specific episodes

Forty-eight television program viewers provided comments on ways a particular episode (or episodes) added to their knowledge of specific concepts. Specific concepts mentioned by viewers include: what empty space is; what the multiverse is; relativity; the plasticity of time; the wave/particle nature of matter; aspects of quantum mechanics; and the mathematics behind the theories.

Following are selected comments¹⁰, organized by episode, that demonstrate the variety of ways the program connected with and bolstered viewers’ knowledge of certain topics.

Episode 1

That was the one I understood the best, and I think the idea that "empty" space is actually full of "stuff" is fascinating. Quantum Leap and Universe/Multiverse make me think they just have a lot more figuring out to do because, to me, as a completely

¹⁰ There were many more comments, all of which were included in an appendix and provided to NOVA. This selection speaks to the specificity of viewers’ comments about how what they saw or experienced impacted their thinking.

uneducated person in terms of physics or math, those theories sound completely nuts. It must be something else than what they're coming up with because my little brain can't compute what they're talking about. (general public)

The visual effects combined with Dr. Greene's explanations made a complicated topic clear to a general audience. I had students watch the episode for extra credit and they found the topic intriguing and had a higher level of follow-up questions. (scientist)

Episode 2

Although the other programs were just as educational, I believe that Quantum Leap is a real look into how we will travel in the future. Once computers are powerful enough to break it all down and put it back together, it will happen. (other student)

The Illusion of Time explains the relative plasticity of time as dictated by the laws of physics. This is beneficial in deconstructing something that we generally assume to be immutable. (general public)

Episodes 1 and 2

After watching the Illusion of Time, I felt that I had, for the first time in my life, a better understanding of relativity. The first episode was at a level that my children were able to follow and they found it interesting. (general public)

As simply an interested person, with no prior education in physics, I very much appreciate how everything is presented in ways I can understand and begin to apply. As a designer, I process visuals better than other means of transmitting information, so I really appreciate all the visuals... (general public)

Episode 3

Quantum mechanics is not an easy subject to explain to the general public, and I thought the episode did just that. (informal science educator)

The discussion of the wave/particle nature of matter was brilliant! The illustrations were mind-blowing, and the bowling ball demo made this most abstract concept much more accessible to more people. (science teacher)

Episodes 2 and 3

Though such programs don't assume any previous knowledge, it helps to know the fundamentals. [Episodes] 2 and 3 brings you at par and 4th brings you quite above that level. (general public)

I am amazed by the teaching techniques used in this show. I love to watch this kind of programs, because it is a very engaging way of learning a topic that in another environment I probably would not understand. I've liked everything in this program. Very well done! (general public)

Episode 4

Slicing the bread to project multiverse imagery is a powerful tool... reminded me of the UO's annual CG conf. in 1991 (?) when, with few in attendance at the end of the day, a speaker gave a presentation on graphics in math education: the animated Pythagorean theorem received applause! (informal science educator)

Really far out concepts explained well (general public)

It opened my mind to the statistical probability that multiverse is a probable conclusion. Please keep up the good work. (general public)

It was the first time I heard about the multiverse explained in scientific terms. I had always thought it was science fiction. The whole episode was very fascinating. I'm much appreciated how well Dr. Greene explained the whole concept. (general public)

Complex subject presented in an engaging manner. My 11 year old has been discussing it ever since. (general public)

Episodes 2, 3, and 4

All of the ones that I watched were particularly good, in my opinion. These shows showed me that I am not the only one who has these same thoughts. It was nice to be engaged by like-minded individuals, who seemed to understand and think in much of the same way as I do. They (the scientists) seemed to enjoy, pardon me, LOVE it! It is difficult to find people to have intelligent conversation, let alone those who are inspired by and are excited to do so. Your shows validate my thought processes, and are, in a sense, a teacher grading a paper explaining what I missed. To be able to sit in a room with these wonderful minds and participate in a conversation would be an honor I could only imagine. Thank you. (general public)

Episodes 3 and 4

The examples and images used explain complicated theories in layman terms very well. The 'math' involved in these theories was always a roadblock for me to explore them, even though I am interested in the subject. I appreciated the way the theories were explained without excessive calculus theories. (general public)

One viewer's assessment of all the episodes seemed to convey a personal appreciation and sense of place within and for the universe:

FASCINATING! Gives a perspective of who we are, what place we occupy in the scheme of things. Makes me both feel powerful in everything I do, and dwarfed by the magnitude. Gives me a new way of looking at things and a clearer sense of what we know or don't know and how we get there. Really LOVED it. (general public)

Differences across audiences

There some were noteworthy differences among audience sub-groups (general public, viewers with a scientific or engineering background, students, science educators):

Scientists/engineers responding to our survey emerged as a critical, but supportive and attentive audience. In general, scientists/engineer types were more mixed in their reviews of the programs than the other audience sectors. Though mostly positive about the content of the programs (55%), some had mixed or negative reactions to the content of the programs (45%).

For example, eight of the survey respondents who self identified as having scientific/engineering backgrounds and who provided additional comments about their experiences, and one of the three people with science/engineering backgrounds we interviewed were less enthusiastic about the programs' content in terms of adding to their understanding (this is a higher percentage of critical comments and perspectives than any of the other participant audience groups). However, some scientists/engineers returning our survey noted that they had also learned content from watching the show. One we interviewed had this to say when asked what he/she learned from the television program,

The idea of space being a fabric that could be warped by large objects. I suddenly understood gravity and why things moved around large bodies. What brought that home was so entertaining and clear. The one where he is actually holding planets orbiting the sun and he is right in the middle - oh, how did that do that? The technologies behind the videos and what they were able to do with the graphics. Then when I went back to the book it brought it all together.... It "cracked open" the subjects.

One person acknowledged his lack of knowledge gain was because he/she already had a lot of knowledge of and interest in science. Another, who had also communicated his thoughts via the Facebook page, was mixed and he offered a suggestion.

As I mentioned in a comment on NOVA's Facebook: I've read Greene's book and I was hoping to see a little more meat about strings than he offered last night. The waving-of-hands syndrome with string theory is what gets me. The isomorphism of the 5 (last I read) "competing" areas of string theory is, however, cool. So I'd like to see a little more depth, even though it is being presented as "popular" science. A production comment: The reuse of silly graphics to avoid talking heads is almost as bad as talking heads. Do new graphics - or annotate them so they actually enhance the dialog - or just give me the talking head.

Though scientist/engineer types seemed to be more critical of the way the content was determined and presented in the programs, they represented a significant minority of the participants in our study who shared that opinion. It is important to note that only four of the additional 250 online survey comments (less than 2%) from non-scientific viewers (students, general public, science educators) expressed negativity or disappointment about the presentation of the content in relation to their learning experience with the topics.

Science educators (both formal and informal) also emerged as a sub-group whose gains in content knowledge and enthusiasm also related to how they might utilize what they learned with those they educate. About 20% of the survey participants who provided open comments were educators (either science teachers or informal science educators). The majority indicated the television programs enhanced their own learning and enthusiasm for the subjects, and also supported their students' learning of particular topics. They had these things to say,

Space and time are taught separately in school. It was good to learn the latest hypotheses on space-time and how those ideas came to be i.e. general relativity. (science teacher)

The discussion of the wave/particle nature of matter was brilliant! The illustrations were mind-blowing, and the bowling ball demo made this most abstract concept much more accessible to more people. (science teacher)

...The animations are excellent and the shows help explain a difficult area of physics in a simple way. It gives me ideas on how to explain things to my physics classes on a basic level. (science teacher)

One expressed his effort in continuing to struggle with some of the ideas.

I love the series, its goals and its production value. However, even with the very careful explanations by Dr. Greene and the other scientists and the visual design and animations used in the episodes, I'm still finding it difficult to wrap my head around some of the key concepts related to space and time. I realize this is to be expected, as these are highly complex, counter-intuitive concepts that even PhDs in their field are challenged by. However, I can't help thinking that there might be opportunities to make greater efforts to "hold our hands" and walk us (viewers) through these ideas even more slowly to increase the likelihood that we "get it"... I really am very impressed by the two episodes I've seen so far. I just find it frustrating that I keep seeing gaping holes in the ideas related to multiple realities and time travel among others...

One science educator we interviewed talked about his use of the NOVA Brian Greene programs and materials.

I like to engage students in what physicists are really working on right now, bringing cutting edge things to my students. I have shown "What is Spacetime" and "Multiverse" and use the programs as support for the curriculum. Animations are key (for my students)... Brian Greene is phenomenal at taking complex ideas and using every day ideas ... more graphics would have been even better.

Members of multiple audience sectors spoke to a hunger for this kind of informal science opportunity and the success of the episodes in bringing difficult content to themselves, their families, and others. Some commented on how they had discussed aspects of the program with family members and friends.

... I not only enjoyed them (episodes 1 and 2) but also showed them to my family over Thanksgiving and they also found them intriguing. Thanks for these shows... Keep it up! =) (informal science educator).

Excellent work, we love this material and our two young boys have taken an interest as well. You have made complex material accessible, engaging and entertaining. Well done. More scientific literacy in the USA please!

Keep up the great work. The series is terrific. I have discussed topics raised on the program with friends and find myself occasionally daydreaming, trying to wrap my head around some of the obscure ideas. Watching Nova and reading Discover Magazine are my favorite things to do in the little free time that I have. I DVR every episode and watch them when I can. Again, keep it up!

One viewer we interviewed, a physics enthusiast and student, talked at length about the importance of the program (and ones like it) for his family members, old and young. He also mentioned that without his interest, his family would never have come across the program and suggested bolstering the places and ways in which NOVA programs can appear and reach the non-science inclined public.

I was able to find it because I'm into the stuff. For general audiences they would have no idea. I noticed they didn't advertise too much... there have to be ways to hook the public that might not be as motivated as me....

Cosmic Cafés

In this section of the report, we share findings on the impacts of Cosmic Cafés related to conceptual understanding for two key groups: Cosmic Café attendees and organizers.

Cosmic Café goers were highly affirming about the experience in terms of contributing to their knowledge of and appreciation for science. Compared to survey ratings for the NOVA television series, which are primarily 5's on a 5-point scale, the high ratings for the Cosmic Cafés were more evenly divided among 4's and 5's; thus the ratings are very positive but less extremely enthusiastic than those for the series.

Ninety-two percent of the café-goers felt there was a good balance of depth vs. breadth in the discussion (about the topic), and 89% felt more informed about the scientists' work because of attending. Almost all of them (92%) also indicated an interest in learning more about scientists' work in physics and cosmology.

Of the 84 survey respondents who attended Cafés, a small percentage (13) offered comments and one talked specifically about the contribution of the café to his/her knowledge.

I love that I feel like I finally have a grasp of what people are talking about when they say "dark matter" and "dark energy."

Café Organizers reported gaining knowledge about communicating with the public and organizing science cafés. All ten Cosmic Café organizers said the experience of hosting the

café increased their enjoyment of communicating with the public, gave them new opportunities to engage with the public about science, and also had positive effects on their skills and attitudes about communicating with the public about science. All but one organizer said that the experience increased their understanding of the value of communicating with the public about science. Seven agreed (including the 4 SPS organizers) and 2 agreed strongly. One experienced organizer disagreed.

Nine out of 10 organizers agreed or agreed strongly that the experience increased their knowledge of resources for organizing experiences aimed at connecting the public with science. (One new SPS organizer disagreed.) One SPS organizer had this to say,

I learned a lot about promoting events to the public. I have organized conferences before, but I knew how to contact my audience in that regard. With the public, it was a lot harder. I couldn't just email professors I knew, to help me get the word out. I had to go beyond my networks to radio stations and newspapers to advertise the event. (new SPS)

All 10 organizers say the experience of hosting the café increased their enjoyment of communicating with the public. The 4 SPS organizers all “agreed” whereas 2 out of 3 of the two other groups “agreed strongly.”

While not unexpected, I loved how excited people were about the topic. It was one of our largest audiences (132!). (experienced non-SPS)

All 10 organizers agreed or agreed strongly that the experience gave them new opportunities to engage with the public about science. (Three of the 4 new SPS organizers agreed strongly, as did all 4 of the new non-SPS organizers and 1 experienced organizer.)

Interestingly, the only 2 organizers who said that the experience did not increase their skill communicating with the public about science are new SPS organizers. Six said it did increase their skill in this area (1 SPS, 1 new non-SPS, and 2 experienced). Two couldn't say (1 new non-SPS and 1 experienced non-SPS)

In terms of the Café Organizers' sense of the quantity and quality of the science presented at the café, on a scale of 1-4 with (1= Disagree strongly, 4 = Agree strongly), Café Organizers rated the following statements related to the science content presentation for the café(s) they organized:

- The scientist was engaging and skillful in sharing his or her own work and enthusiasm with the public (mean 3.8)
- The topic that the scientist talked about clearly related to the NOVA series (mean 3.8).
- There was a good balance of depth vs. breadth in the discussion (mean 3.2).

Experienced and non-experienced Café organizers had many reflections, suggestions and perspectives on organizing the Cosmic Cafés. We shared details of the majority of these results with NOVA in our January Summative Status Report.¹¹

Website

As with the television series, website visitors indicated their interaction with the materials added to their understanding of physics and cosmology topics and interest in science. A majority of survey respondents who visited the website indicated their visit helped them understand the topics discussed in *The Fabric of the Cosmos* and felt more informed about space-time. They noted the interactives helped them understand topics discussed in *Fabric* (91% of survey participants who visited the website), became more interested in learning more about spacetime (88%), and believe that interactives like the ones on *The Fabric of the Cosmos* website are a good way for the general public to learn more about science (97%).

Website reviewers offered their own detailed insights into how the website content contributed to their own, and potentially other's, knowledge of the topics. One reviewer with little science background noted this about the video content on the website:

The video content is exactly what I would expect and want to see. The quality and educational effectiveness exceeded my expectations. Strong narration, current research scientists providing concise snippets of information and visuals to support their statements, all organized in a well-structured program. The depth of content was adequate to pique my interest and provide me with understandable explanations without overwhelming my non-scientific brain, while the breadth of content gave me enough variety to find multiple items of interest. It was enough to satisfy the initial inquiry, and motivate me to watch the next chapter.

A handful of survey respondents made specific comments about the contribution (or potential contribution) of the interactives to their knowledge of concepts understanding of or appreciation work that scientists do (although one person noted that they could not launch the Heisenberg Humor interactive).

I think they are very helpful for people to understand some of the complicated ideas in the shows... (science teacher)

Interactives were a wonderful way to reinforce the concepts and also make them relevant and understandable! (general public)

Two website visitors we interviewed were very positive and asked for more,

I would like the website to lead you to different sites with more information. Take the interested viewer to other places.

¹¹ Inverness Research produced a detailed Summative Evaluation Status Report for NOVA in January, 2012. This report included results and preliminary findings from the online survey, café observations, and the café organizers' survey.

... I would like more links.... To other websites that also talk about the topics, chat rooms or blogs.

A few educators and one website reviewer made specific suggestions for improving the website (in particular) to serve their students' (and other audiences') learning of the concepts.

The interactives could be better, I have seen better on NOVA sites. I was hoping for more that my students could use, the trip thru space-time is the only one, but rather quick to use. (science teacher)

A website reviewer with an educational technology background also had some specific ideas about how educators could use the web materials for instruction, and suggestions that might bolster learning through the web materials.

... The material I saw made me think that advanced HS and above was the level with the majority accessible to interested adults. As much of the content covered is not part of the traditional K12 standards, I do not think teachers could spend much time on it even though I think students would be very interested, especially in a physics class or a humanities class that ponders the meaning of life. An enterprising HS teacher could assign elements of the website for homework and then have in-class discussions and/or additional writing assignments (that is, if they believe that writing in science is relevant). Fortunately, the new common core math and science standards (coming soon) will value these materials and topics to a greater extent.

...I think that in terms of interactive I was least impressed. While NOVA does not need to recreate the wheel, they could list other existing materials and the few made could have had a greater level of participant interaction - closer to simulations - a simple game could also connect to the grade 4-12 audience. As a developer of interactives/simulations/tools and games I know they are difficult and expensive to produce but I think a couple of interactives with deeper engagement/user input would have been helpful.

Finally, a third website reviewer gave very specific and astute observations about the many links and resources on the web. Though the interactives did not speak to her particularly well as an audience, she acknowledged their likely appeal to younger audiences. In terms of reinforcing content, she noted appreciation for the episode transcripts, as well as the value of the three links to articles by other scientists, in helping to promote understanding of particular concepts.

I loved that the episode Transcript was linked right there on the page! For a science enthusiast like myself, to have the ability to quickly access the transcript so I can more slowly read over concepts (very difficult to grasp concepts) that might have blown by too quickly for me in the episode itself, is fantastic.

VI. FINDINGS: EFFECTIVENESS

Reported in this section are findings related to the effectiveness of the different resources and strategies for participants, and for the Café Organizers. In some cases we report data that describe the intent, purpose or expectation participants had prior to the action or event (watching the television programs, visiting the websites, or attending a Cosmic Café). These expectations, in some ways, clarify how we report on the effectiveness, as the match between what the participant hopes to gain or experience, and what they actually ended up gaining or experiencing, helps indicate the degree of effectiveness. Primarily, however, our assessment of effectiveness ties to how well the approach or resource—or a particular feature of that approach or resource—reflects the project’s goals of communicating science content and public science literacy and interest in science.

Evaluation question: How effective were the different resources and outreach strategies for the different audiences? In what ways were they effective, or not?

Television Program

Why and how viewers tune in

Viewers’ primary reasons for tuning into *The Fabric of the Cosmos* were loving science and being interested in any program related to it (31%), often watching NOVA programs (20%), and wanting to learn more about the subject (15%). Fewer were motivated by “interest in anything Dr. Greene does” (5%) or reading the book (4%). Just a handful are working in the field (1%) and only one person had to watch it for a class.

I love NOVA for its educational value. (general public)

I love to watch this kind of program because it is a very engaging way of learning a topic that in another environment I probably would not understand. (science teacher)

Regardless of when they responded to the survey, nearly all respondents watched or intended to watch the entire series: *What is Space* (94% watched/intend to watch), *The Illusion of Time* (96%), *Quantum Leap* (93%), and *Universe or Multiverse* (94%).

Of the 94% of the survey respondents who indicated they had watched or intended to watch at least one of *The Fabric of the Cosmos* episodes, 42% watched (or said they would watch) on PBS only, 11% watched/would watch online only, and 46% watched/would watch both ways. The general public was much more inclined to only watch the program on PBS (43%), while none of the SPS members indicated PBS would be their sole means of watching the program. Four of five (81%) of the SPS members indicated they had watched or would watch both on PBS and online.

High-quality program with powerful visual effects

The television programming did not disappoint general audiences, science enthusiasts, students, and most scientists – all of whom rated the content and their engagement with the program very highly. Many attributed their high ratings of the program to the high

quality and dependability of NOVA programs, which they said consistently stimulate their own science learning and interests.

Respondents who watched at least one episode were almost unanimous in their positive assessments of the series. They enjoyed watching the episodes (98% agreed or agreed strongly with this statement), they thought Dr. Greene and the other scientists were engaging and skillful in sharing their work and enthusiasm with the public (97%/98%), and they felt the visuals and animations contributed a great deal to the program (97%).

Survey participants and people we interviewed from all audience sectors mentioned their appreciation for the visual effects, some acknowledging they are visual learners and the “CGI” helped them significantly in being able to “wrap their heads” around the topics.

Being a visual learner, I was able to grasp the concepts very easily.

There is a huge difference between talking about space ideas and seeing them acted out. It's great the go to the extra expense to act out the concepts. Even someone like me with a science and engineering background still has a hard time wrapping my head around the concepts. Seeing it happen helps to do that.

I am an ordinary person who later in life developed an interest in physics and cosmology largely in part due to shows like NOVA. Although books and the Internet are a great resource, shows like these make some pretty mind bending science much more accessible. I'm a very visual person and a few seconds of special effects can get me over a hump that I had been struggling with. Instead of reading, scratching my head, re-reading, back and forth, the effects can provide that aha moment. So thank you, thank you, thank you. And please give us more, more, more physics and cosmology.

The visual aids are tremendously helpful in understanding concepts. In last night's program, the slicing of the loaf of bread finally enabled me to grasp the ideas that have been presented in many shows...

More please! The CGI really helps open the mind to accepting complex theories.

... the CGI is very helpful in visualizing difficult concepts. However, during interviews and expository scenes with Dr. Greene, the green-screen effects can be a bit distracting. Thank you for making fascinating and lofty subjects more tangible for those of us interested in understanding our universe, but who lack the training to understand the primary literature.

Ninety-seven percent of survey participants who watched one or more episodes indicated the visuals and animations contributed a great deal to the program. A very few viewers commented on being distracted by them.

During interviews and expository scenes with Dr. Greene, the green-screen effects can be a bit distracting.

For me, the animations and gimmicks were distracting and took time away from the meat of the programs. Perhaps they are necessary to keep multitasking ADD youngsters interested, but I found the gee-whiz as well as the bursts of dots and/or strings irritating and distracting. Brian Greene is so good he doesn't need all of that gimmickry!

I think the program is valuable, and I think you should keep doing this kind of thing. I do think, however, that it could have been better. Having read the book I expected that having animations available would enable Dr. Greene to better explain some of the concepts, but instead I found things very abbreviated and the animations didn't seem to be any better than the diagrams in the book. Keep working on it though!

One viewer who regularly consumes NOVA shows suggested that the effectiveness of the show might be improved if more variation in the images were included:

For those of us who are "regulars" and who use a selection of the NOVA products for instructional purposes, I'd like to see less of the repeated scenes or snippets from one to another, e.g., MUST you use that SAME Newton pic, when there are a lot of others around? Ditto the grid for space-time? A bit more variation would help, even though I'm guessing you're trying to reinforce certain concepts.

One of our expert website reviewers watched all four episodes and summarized the content for many of the survey comments. He had this to say about the content depth and breadth of the programs (video content).

The video content is exactly what I would expect and want to see. The quality and educational effectiveness exceeded my expectations. Strong narration, current research scientists providing concise snippets of information and visuals to support their statements, were all organized in a well-structured program. The depth of content was adequate to pique my interest and provide me with understandable explanations without overwhelming my non-scientific brain, while the breadth of content gave me enough variety to find multiple items of interest. It was enough to satisfy the initial inquiry, and motivate me to watch the next chapter.

Dr. Brian Greene and other featured scientists: "gravitational forces" that draw in NOVA audiences

Twenty-eight survey comments mentioned Dr. Brian Greene, citing him as a familiar scientist, highly respected and regarded for his cutting edge research, books, and engaging narrative style. Some attributed in large part the effectiveness of the program to him, indicating Dr. Greene's communication and narration style, along with other scientists' voices in the program, helped them understand the concepts.

Viewers and website visitors had this to say,

I love when you produce shows on physics/astrophysics/cosmology. They're such fascinating but difficult topics and concepts that really require dynamic, exceptional speakers (de Grasse Tyson, Greene, Filipenko, etc.) and using great visuals to make the

information accessible and exciting. You guys always seem to deliver. I can't think of another topic in science that gets more people talking than these series of shows. I personally don't watch much TV, but when a NOVA program or series on a topic related to space or physics is coming up, I literally rearrange my life around the shows. Thanks! Keep 'em coming!

Very nice program. Layout exceptional. Animations to the point in helping explain difficult concepts. Brian Greene is a very good speaker. I would love to listen to him in person.

It would be fantastic if ALL of Brian Greene's Cosmology series were available as a complete set for purchase for personal or professional use.

Brian Greene's methods of teaching are simply brilliant.

One viewer commented on the importance of including physicists from underrepresented minority groups in the program:

I love science and curiosity, it is my fabric. Please continue bringing these programs to the public. I especially enjoy seeing an African-American physicist in the program. Seeing women and others that are in the field is important. I can only imagine that there are children that can feel the spark ignite, the curiosity, and that they can feel they can 'do this too'. As an African-American woman who has been in computer science for more than 30 years and passionate about math/science I'm grateful that I was touched by a spark that led me to this. I love NOVA and PBS because you are igniting minds, young and old. Thank you!

NOVA programs as venues for educating the public about science

Almost all viewers (98%) agreed that shows like *The Fabric of the Cosmos* are a good way for the public to learn more about science. Some viewers who commented on the survey pointed to NOVA, and “programs like these” as filling a critical and needed niche in the realm of media and TV – to promote public awareness of science by bringing high-quality, informative and educational experiences to the general public, and youth in particular.

Self identified scientists and engineers were the most critical and mixed audiences of the television program, warning about the “dumbing down” of these sophisticated complex ideas for the general public. Interestingly, others commended the program for *not* dumbing down the content.

Cosmic Cafés ¹²

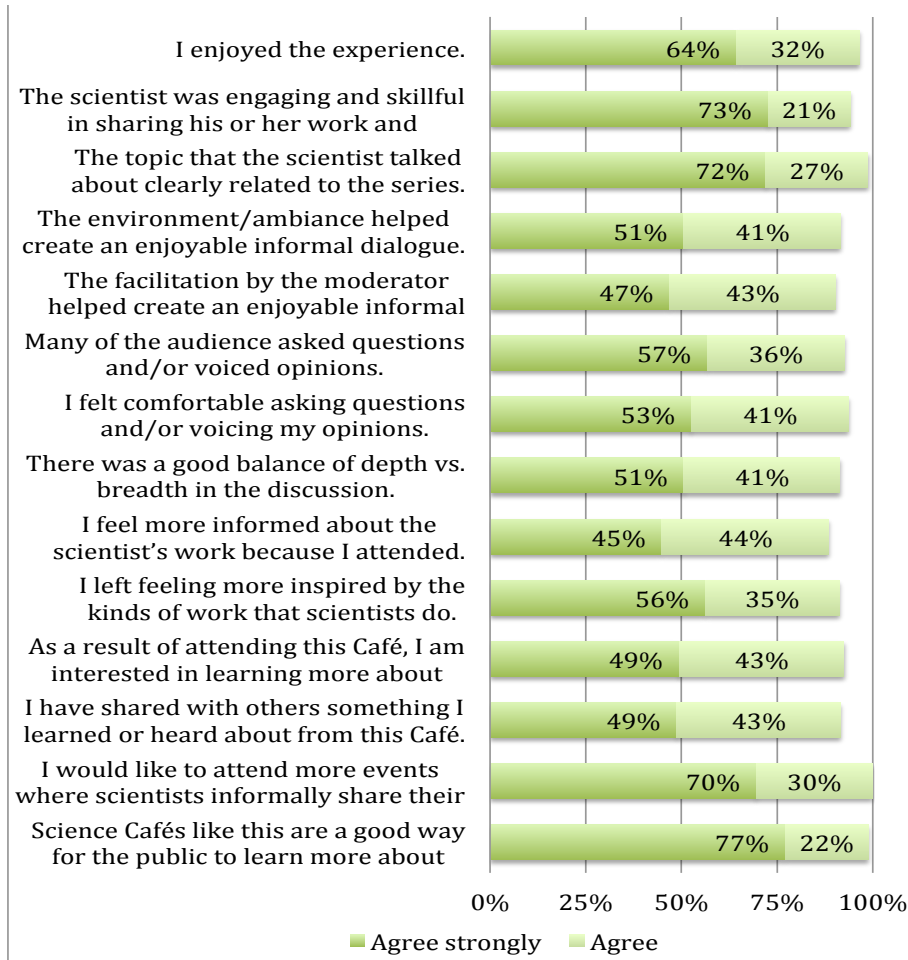
Of the 12 cafés, 3 were held in a university room (all by the same organizer), 1 in a community public space such as a library, and the remaining 8 were held in restaurant/pubs.

All told, these 12 Cosmic Cafés served 831 participants. Attendance at any one event ranged from 15 to 300. The mean attendance for new organizers (both SPS and other) was in the mid-30's and for the experienced organizers was 146, though the median was 117 (the one café with 300 raised the mean). Clearly, the more experienced organizers serve larger numbers of people. Organizers reported that for 6 of the cafés, participants were new to Science Cafés. For 5, the audience included both new and experienced Café participants, and for 1, the audience was experienced.

A great majority, 90+%, of café participants who took the online survey (approximately 10% of the total number who attended cafés) said they enjoyed the experience; rated the scientist, facilitator and venue highly; thought the dialogue was inclusive; and were inspired to learn more (Figure 3). Nearly all, 99%, said that science cafés are a good way for the public to learn about science. Compared to ratings on *The Fabric of the Cosmos* television series, which are primarily 5's on a 5-point scale, the high ratings of cafés were more evenly divided among 4's and 5's; thus the ratings are very positive but less extremely enthusiastic than those for the television series.

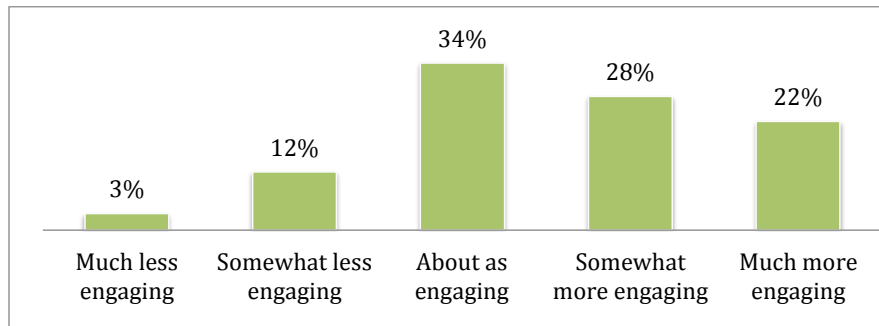
¹² A more detailed discussion of data and findings about the Cosmic Cafés, including results from the Café Organizers' Survey, is found in the January 2012 Summative Evaluation Status Report. We have selected from the status report only some of those findings for purposes of the final report.

Figure 3. Percent of café participants who agree or agree strongly with positive statements about the café and its influence on them.



When asked in the survey to compare Cosmic Cafés with other science café-like events, half of the 58 respondents who had attended similar informal events say that the cafés held in conjunction with *The Fabric of the Cosmos* were more engaging, 34% said that they were about as engaging as other events, and just 15% said they were less engaging (Figure 4).

Figure 4. Comparison of Cosmic Cafés with other science cafés and informal science events where scientists have shared their work with the public (N=58)

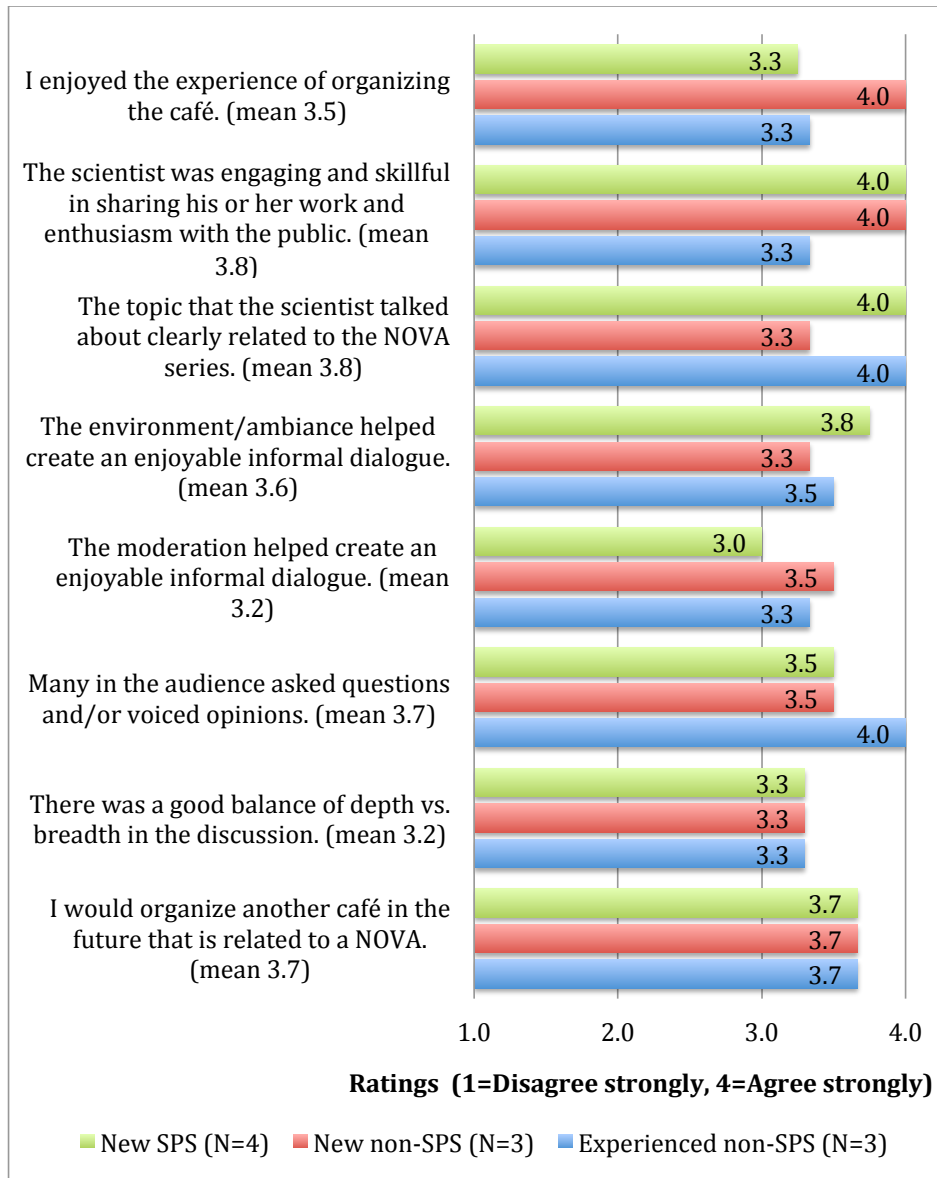


Cafés were effective for survey participants in terms of being enjoyable, and nearly all of the café survey participants said that science Cafés are a good way for the public to learn about science. Perhaps the most telling result related to the effectiveness of the Cosmic Cafés is 100% of the survey respondents who attended a café indicated they would like to attend more events where scientists informally share their work with the public.

We asked café organizers to rate the extent to which they agreed with a series of statements about their Café (1=Disagree strongly, 4=Agree strongly). The organizers' responses were grouped into New SPS, New non-SPS, and Experienced non-SPS (Figure 5). All organizers agreed or agreed strongly that:

- they enjoyed the experience and would be willing to host another NOVA related café
- the scientist was engaging and skillful in sharing his or her work and enthusiasm with the public, and the topic the scientist talked about clearly related to the NOVA series
- the environment/ambiance and moderation helped create an enjoyable informal dialogue
- many in the audience asked questions and/or voiced opinions, and there was a good balance of depth vs. breadth in the discussion.

Figure 5. Organizers’ ratings of their experience related to their Cosmic Café and of the Café’s characteristics



The three groups reported very similar experiences and opinions. The most negative rating came from one new SPS organizer who said that the moderation did not help create an enjoyable informal dialogue.

In addition to the café participants’ and organizers’ data reported above, Inverness Research observed several Cosmic Cafés. With one exception, the speakers were adept at communicating hard science to public audiences and were highly or very highly engaging, explicitly connecting their own passion and research interests to the Fabric topics. Red dwarfs, gravitational lensing, dark matter were just some of the foci for the speakers’ talks. In all cases, the speakers were enthusiastic about the subjects and science. However, we

questioned whether enthusiastic delivery necessarily equated completely with audience engagement and satisfaction. In one case the scientist, though adept at speaking to general audiences, didn't seem to match well his presentation and delivery with the sophistication of the audience – an academic one with many graduate students from the same field. The researcher/observer in this case wondered if the audience understood more than the speaker gave them credit for, commenting,

I think he was enthusiastic but maybe not quite technical enough to really grab their imaginations about how amazing it is that scientists know what they know.

In two cases the speakers' observers were impressed with the speaker's success at using analogies to explain the complexities of particular concepts. One scientist responded to an audience member's question about what "parallel universes" meant by using the handouts to explain how they are separate but very close – can't see one another, and they don't interact. He also discussed how what appear to be conflicting theories could be combined to resolve the apparent conflict. He used analogies, his hands, coasters, papers and the wall to help demonstrate what he was explaining.

Based on our own observation of Cafés in varying contexts it seemed to us those Cosmic Cafés that were facilitated by organizers who had prior experience with science cafés, and in some cases were also associated with a regional Informal Science Education organization, were more effective in terms of appropriate and comfortable accommodations, audience engagement strategies, and recruiting a large and diverse audiences. The SPS-led Cafés, which were obviously led by less experienced facilitators and led for smaller audiences with less familiarity with Cafés, tended to be less effective in these areas.

Though the connection to *The Fabric of the Cosmos* television series existed at the Cosmic Cafés we observed, science topics presented and discussed varied considerably, and the degree the television program was referenced or connected to the café varied from almost none to quite a lot. Although the series served as a focal point and catalyst for the Cafés in terms of general theme, the effectiveness of the Cafés did not hinge on a link to the series. One person, for example, said this:

I like the idea of doing different science cafés based on different programs because NOVA has a broad base of programs. It is interesting to learn about physics one day and bio the next. (The café) was a really good opportunity whether or not you watch the program... to hear someone talk about it and explain things.

Effectiveness of NOVA supports for Cosmic Café Organizers

NOVA produced several supports for Cosmic Café hosts and organizers. These came in the form of actual materials, a website for people interested in hosting a Cosmic Café (http://www.scienceCafés.org/Cosmic_Cafés/cosmic_resources/) and a webinar that provided an outline and suggestions for how to organize a Cosmic Café.

Only one of the 10 organizers participated on the training webinar, and this person was not an SPS member. The person who attended found it very useful for planning the Café. Of

the seven new organizers, all remembered receiving the Cosmic Café toolkit. Of the three experienced organizers, one received it, one did not, and one did not recall. The four SPS organizers who received it were divided in their assessment of its usefulness: one said not at all useful, one said moderately useful, one said very useful, and one said extremely useful. The experienced organizer said the toolkit was moderately useful. Those who commented on the toolkit specified a range of uses. New organizers commented on the credibility afforded by the NOVA logo on the poster template and on the value of the checklist, and an experienced organizer said it was nice to have giveaways for their monthly Café.

All but one of the organizers made use of resources on the Cosmic Café website located on sciencecafés.org. On a 5-point scale, the mean for usefulness was 3.7, with newer organizers tending to give higher ratings (around 4) than experienced organizers (2.5). Comments suggested that experienced organizers simply have less need for help than inexperienced ones. One new organizer, a scientist, commented,

The press release and poster templates were extremely useful. As a physicist, I am not that great with words, so having a template made promoting a breeze. Thanks!

The one Café Organizer who attended the webinar training (a non-SPS member) found it to be very useful for planning the café. The in-person information provided to the SPS students and leaders at their annual meeting seemed to be more effective in promoting SPS-sponsored science Cafés than the webinar café trainings. Given the investment in hosting two of these instructional webinars and only one participant hosting a café, we question the investment in this strategy in the future.

Website

The effectiveness of the website may be considered in terms of its accessibility, navigability, and whether it filled the visitor's purpose. We learned some things about the effectiveness of these characteristics from survey and interview participants and from three "expert" website reviewers. We also learned about ideas they had that could make the website more effective.

Almost all (96%) of the 210 survey respondents who went to the website said they spent time on *The Fabric of the Cosmos* website going to links to help them understand the television program better. Half spent over ten minutes on the links, and another third at least 5 minutes.

The most typical respondent clicked on 3 – 10 links (reported by 48%), 34% clicked on 1 or 2 links, and 11% clicked on at least 11 links. Of those who clicked on links, 45% say they spent at least a minute or two trying *A Trip through Space-time* and 35% at least tried *A Cosmic Crossword* (Table 4). About one in ten say that they completed these activities.

Table 4. Engagement with links on *The Fabric of the Cosmos* website

	I don't recall seeing it	I saw it, but didn't use/watch it	I spent a minute or two trying it	I spent a few minutes using it	I completed / watched it
A Trip through Space-time	26%	29%	14%	19%	12%
A Cosmic Crossword	32%	33%	17%	9%	9%
Heisenberg Humor	44%	27%	NA	NA	29%

The go-to source for NOVA content

The three “expert” website reviewers with different backgrounds studied the *Fabric* website and in their own ways encouraged NOVA to make sure the web competes well with the TV as the major “go-to” source for their programs and the associated science content – not only the “extras” to the programs, but the core content itself. (For complete reviews see Appendix CCC).

They affirmed the production quality and appeal of the content, and the pervasive loyalty to NOVA that we learned from the participant survey. They made some informed and astute observations about what is effective about the website and what could be improved. They said that while the navigability was mostly effective (the minimalist approach was very appealing), the website could use more “consumable chunks” for visitors, meaning availability of more video clips or shorter sections from the programs. As one reviewer said:

My concern about the video content (on the website) is its length. My opinion is that there are two types of online consumption: 1) full length TV replacement and, 2) ‘consumable chunks.’ Many people engage in both types of viewing depending on what device they are using to access the Internet and what they are doing. For example, someone might be watching TV in the background and playing ‘consumable chunks’ of online video from an iPad or laptop. Or someone without a cable TV provider might be using their laptop or TV to access full-length programming and movies. One solution that addresses both my concern about content organization and my ‘consumable chunks’ theory would be to use the logical segments that are created by the existing chapters to allow people the option of viewing individual chapters or view the full length program.

Additional observations and suggestions from reviewers included: clearer navigation paths; the importance of designing for the different ways people interact with TV content on the web (as a whole episode and in targeted chunks); and the potential effectiveness of tying in with pop culture (i.e., *Fringe*). Though the enrichment links were relevant to the content of the show, one reviewer noted the website was missing a “logical consumption path” (what interactive media belonged to particular videos?).

Website visitors we interviewed echoed what we learned in the survey but added some interesting details. Several shared with us that they are also on NOVA’s listserv, Facebook

page, and/or they follow NOVA on twitter. They look to the NOVA website to learn to “find out about what is coming up on NOVA,” enjoy being privy to previews before others, and like the flexibility of watching NOVA online, anytime.

Those website visitors we interviewed that talked about social media modalities had suggestions for including more opportunities to be interactive beyond moving, pointing and clicking the mouse, such as making connections to things like the NOVA physics log and things like the “Quantum Gravity” live scribe pencast; they also encouraged NOVA to beef up their marketing to appear in places that the “non-physics geeks” might visit and see, like posting on “Big Think,” or even Yahoo.

Website accessibility challenges

The website was effective for U.S. participants able to conveniently access it, who were interested in watching the series when it wasn’t available on TV, and who wanted to watch all or parts of the program over again if they wanted to see episodes a second time.

For website visitors from other countries, accessibility to the broadcast programs via the website was problematic. Several survey respondents from Canada and one from another country commented about their inability to access the videos and expressed disappointment with the lack of access to NOVA programs in their location.

Please make NOVA available online to Canadians.

Even though we can subscribe to PBS Boston station, the website videos are inaccessible from Canada.

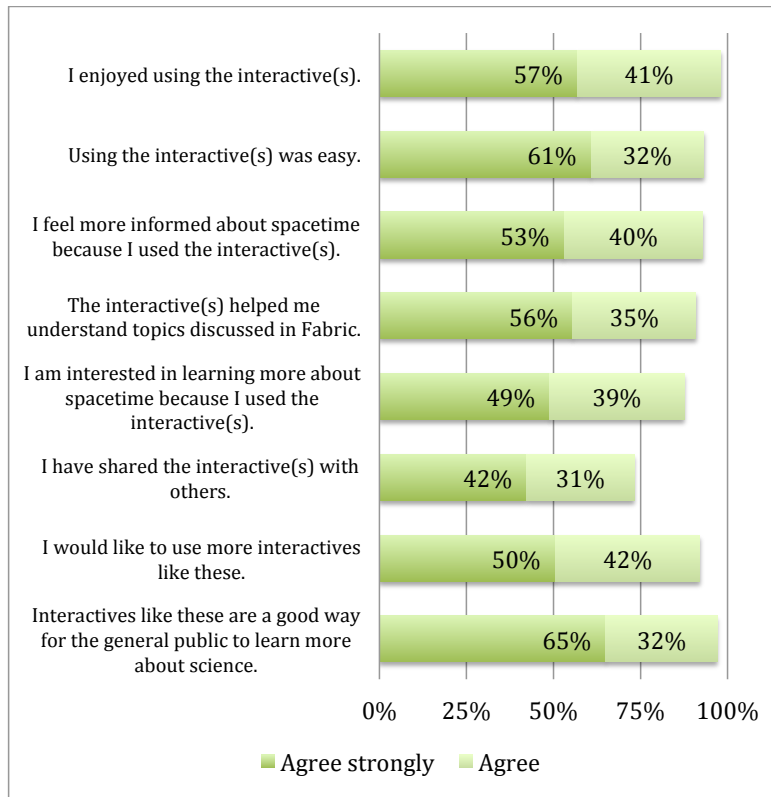
Additionally, one website reviewer using an iPad quickly learned that “the vast majority of the content (on the website) needed the flash player to work.

Tablets are a pleasurable tool for exploring/navigating a website and consuming video. While a limited audience uses them, I think there is a high correlation (of their use) with also watching public television and NOVA.

Interactives effective, when accessed

As mentioned earlier in the Knowledge Findings section, though less than a half of survey respondents who indicated they had visited the website accessed the interactives, they proved effective (Figure 6.)

Figure 6. Percentage of users of interactive features who agree or agree strongly with positive statements about the features and their influence



A handful of respondents commented on the contribution (or potential contribution) of the interactives to understanding of or appreciation for the NOVA series or work that scientists do.

The interactives could be better, I have seen better on NOVA site. I was hoping for more that my students could use, the trip thru space-time is the only one, but rather quick to use. (science teacher)

I think they are very helpful for people to understand some of the complicated ideas in the shows. The only reason that I have not used some of them is that I haven't had time to yet, but will in the future. (science teacher)

Interactives were a wonderful way to reinforce the concepts and also make them relevant and understandable! (general public)

Expert website reviewers had mixed things to say about the interactives. One noted they were high quality and extremely well done, of a consumable size, provided steps that allow a user set pacing, explanations were clear and satisfying, but asked “how will anyone ever find them”? Two other reviewers had lukewarm assessments of the interactives. One thought they were well suited for younger audiences and as an adult with not children did not find them to be of much interest, leaving her “unenthusiastic”. He/she rated *A Trip*

Through Spacetime the stronger than the *Cosmic Crossword*. The last review noted the limited number and indicated he/she was least impressed with them.

While NOVA does not need to recreate the wheel, they could list other existing materials and the few they made could have had a greater level of participant interaction - closer to simulations. A simple game could also connect to the grade 4-12 audience. As a developer of interactives/simulations/tools and games I know they are difficult and expensive to produce but I think a couple of interactives with deeper engagement/user input would have been helpful.

One teacher's comment reinforces these two reviews,

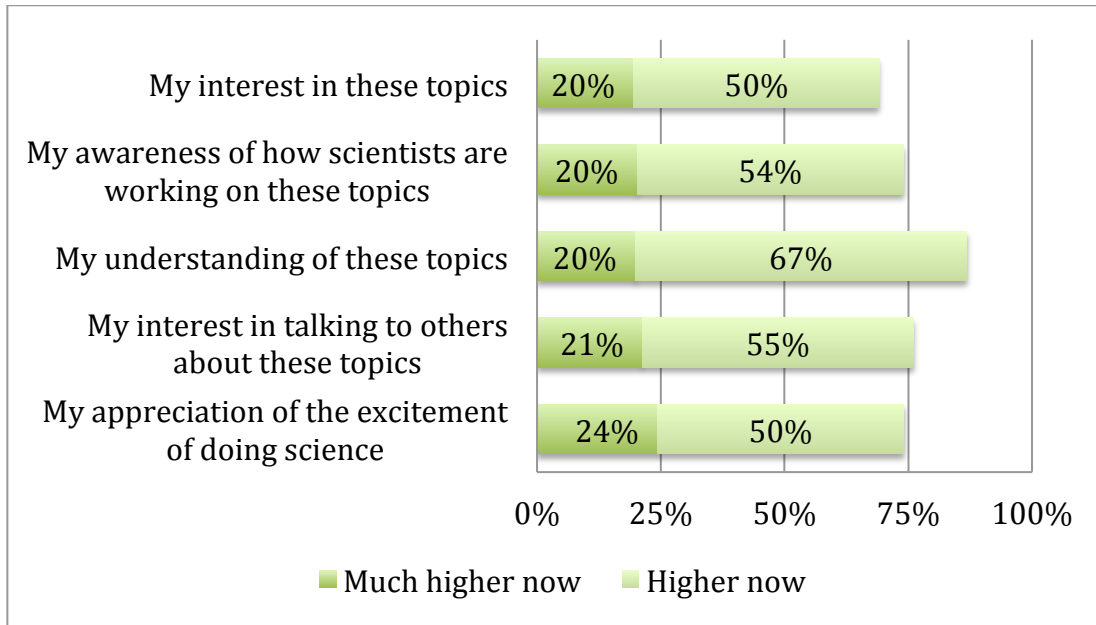
I was hoping or more that my students could use. The trip through spacetime is the only one, but rather quick to use.

We acknowledge that nothing in the original proposal or evaluation plan addressed how this program could support educators (formal or informal). These groups are, however, significant consumers of NOVA programs so we have included their perspectives and suggestions in this report.

Overall effectiveness ratings for *The Fabric of the Cosmos* experiences

In their survey ratings on statements about the overall effect of experiences related to Fabric of the Cosmos (Figure 7), almost one in 4 respondents (24%) say they have much higher appreciation now of the excitement of doing science. About 1 in 5 respondents say they have much greater interest in talking to others about the topics covered by *The Fabric of the Cosmos* (21%), much greater awareness of how scientists are working on these topics, and/or interest in the topics (20% each). If we add in others who gave not quite so strong positive ratings, 87% report that their understanding of the topics covered are higher now. About $\frac{3}{4}$ of survey respondents say that their experiences related to *The Fabric of the Cosmos* made positive contributions to their excitement, interest in talking to others, awareness of scientists' work, and interest in these topics.

Figure 7. Percentage of respondents who agree or agree strongly with positive statements about their overall experiences related to *The Fabric of the Cosmos* and their influence



VII. FINDINGS: VALUE-ADDED

“Value-added” implies there is value to begin with (something of worth or benefit to someone or something), and something adds to that value in a productive way by amplifying, expanding or extending the original worth. In this case, the “value” is the experience of watching one or more episodes of *The Fabric of the Cosmos* and its positive impacts on viewers. In this section we discuss findings related to how and to what extent the additional resources and outreach strategies (*Fabric* website and Cosmic Cafés) interacted with the television program viewers’ experiences, and what if any value they added to that those experiences.

Evaluation question: What did we learn about how the resources and strategies worked together to add value, amplify or extend the program viewing experience?

Website

The greatest proportion of survey respondents only watched the television series (55%); the next greatest proportion (26%) watched the television series and went online to visit *The Fabric of the Cosmos* website. For these program viewer/website visitors, the website offered viewers several resources for adding to, extending or enhancing the television viewing experiences.

Almost all (96%) of the 210 respondents who went to the website said they spent time going to links to help them understand the program better. In the previous Findings section about “Effectiveness” we reported about the access and assessments of the interactive features on the website (*A Trip through Space-time* and *A Cosmic Crossword*). Here we simply reiterate that participants who did access the interactives found they added to their understanding of topics discussed in the program, and that they enjoyed using them, and would like to see and use more interactives. The web experiences thus contribute an important value-added to viewers’ understanding of topics and program viewing experience.

We interviewed six participants who had viewed at least one episode and had visited the website. When asked how, if at all, did the website add to or enhance your viewing of the television program, answers varied and included:

It allows me to go review it again an re-explore some things.

I can watch it at will.

The related links are strictly reading online, and I would read for my own professional development.

It kind of reinforces some of the stuff, things go by you quickly on the TV.

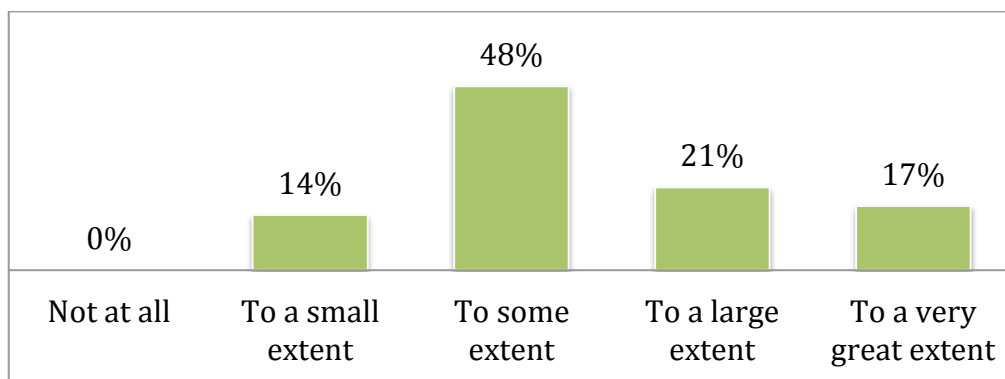
I’m an online person. On TV sometimes I do miss the shows... I usually don’t even watch TV anymore. The website also let me know what’s going on on NOVA.

Cosmic Cafés

It is worth recalling that the number of café and television viewing participants who took the online survey was small ($n = 41$), 5% of the total estimated café participants. Here we report only on the data we were able to gather.

Of this small number who both attended a Cosmic Café and also watched the program, more than 4 in 5 (86%) said café attendance added to or enhanced their experience of watching the show, including 38% who said it enhanced their experience to a large or very great extent (Figure 8).

Figure 8. Extent to which attending the Cosmic Café added to or enhanced the experience of watching one or more episodes of Fabric (N=42)



About half (54%) of the café participants who watched at least one episode said the café made them more aware of and knowledgeable about how Dr. Greene and other scientists are working on these topics, and nearly 60% indicated they had a better appreciation for the excitement of scientific work because of attending the café. Four members of the public explained in interviews how the café enhanced their experience. Attending made them feel more a part of a community of like-minded people and opened up opportunities for discussing content from the series and other emerging ideas in physics:

I was excited to see such a number of community members attending and enthusiastic about the subject. Some of these people I have known from other contexts, but I had no idea that they were into physics. Knowing that they are, I now feel comfortable initiating conversation with them on the latest published ideas in the field.

Got the feeling of being more connected by having an activity I can attend since I'm not a current student or physics person...

I felt at home, allowed to be as enthusiastic as I feel inside about physics.

Being able to ask for further clarification/information was great!

Survey results also indicated, however, that while café attendees knew their café was linked to the television series, the café did not add much to their motivation to view the program: fewer than a quarter of café attendees indicated they turned to the series to learn about topics addressed in the café. Café survey participants were less likely to have also watched the series than those who visited the website. Also, there didn't seem to be any independent relationship between the cafés and the web – one didn't seem to drive people to the other.

In summary, while the café added to the viewing experience for a very small number of people, the café experience primarily contributed to participants' sense of their own community's interest in coming together to engage in challenging, cutting edge science, with real live scientists. We think it is likely that this may reinforce and inspire a continuing, or growing, interest in and awareness of current science topics and research—but on a parallel track with the series, for most café goers, rather than in an interactive value-added way.

There are likely many possible reasons for what seems to be a disconnect between audiences' television program engagement and the Cosmic Café engagement. Though it may be as simple as the marketing pitch given to the program at the Café, we guess there are other more interesting reasons. This may be worth investigating further.

One more added value: The Book

We think it is important to mention here that 11 open-ended comments were made at the end of the survey that mentioned how much the program and website added to respondents' experience of reading Dr. Greene's book, *The Fabric of the Cosmos*. Though not initially considered in our evaluation questions, the NOVA series and website definitely added value to the reading experience for all but one of the participants who had indicated they'd read the book, watched the program and/or visited the website. Additionally, some of the comments indicated that because of *The Fabric of the Cosmos* television program/Cosmic Café/website, they were moved to buy the book.

A vision of synergistic experience

To conclude this section, we offer the comment of one interviewee who had watched the program, attended a café and visited the website, and nicely articulated how the different resources and strategies reinforced one another to generate a rich learning experience.

It's always nice to get things reinforced. The combination of all of these helped me to have a very broad understanding. I hear it on the TV show, see it on the website, hear it again in a different way at the café ... The program was a really great introduction to these ideas, and gave me the opportunity to start thinking about these things and listen to some engaging speakers. With the website, there were a lot of ideas that are really hard to understand and you can go there and watch something again or see an additional interview. And then hearing the additional background in the café was really cool. It all worked together really well.

Her comment helps us envision a kind of ideal synergistic interaction among the multiple modes of interaction and engagement with the topics that the television series, web materials, and cafés. While the results for the larger pool of respondents do not reflect this full an experience, the broader results do point to some valuable interactions among the various resources and suggest ways they add value to one another. Together, these results point to the potential of a synergy among multiple modes of engagement that, if they occur at a larger scale, can make a broad impact on public engagement and understanding.

VIII. CONCLUSIONS AND IMPLICATIONS

In this final section we present a set of key and compelling lessons we learned from this study, and in some cases accompany those lessons with possible implications for NOVA to weigh as it continues to work toward amplifying its television programs through outreach efforts.

- The *Fabric of the Cosmos* program and supporting materials and outreach efforts were rated high by all of the audiences, with the quality of the program's visual effects and engaging nature of the featured scientists receiving the highest accolades.
- Participants who self-identified as "general public" or "students" were most positive about their *Fabric* experiences, asking for more and thanking NOVA and PBS for the quality, reliability, and "validity" of shows like *Fabric of the Cosmos*. Though a significant majority of scientists and educators rated the *Fabric of the Cosmos* high, they had more constructive criticisms and specific suggestions for making the series and media supports work better for the audiences they had in mind.
- Participants in this *The Fabric of the Cosmos* evaluation study expressed deep concern and hopes for this kind of programming in terms of providing a desperately needed venue to educate the public (youth in particular) within the existing pop- and reality-TV culture. Participants also expressed why PBS is so crucial and gave deep thanks to NOVA with hopes that this kind of programming continues.
- Participants from other countries who found the connection to the website and/or survey made requests and suggestions for making the programming more accessible to them and their populace.
- While relatively few survey respondents found the website (less than half), it was highly valued and directly related to the series. As the go-to place for information for so many people, investing in the website as a way to reinforce and extend the programming experience seems very worthwhile.
- Exposing SPS students to science cafés as a structured approach to engaging public audiences in thinking about cutting edge science was worthwhile. The partnership with the SPS to support and offer the Cosmic Cafés was a productive step toward establishing a relationship with an organization that could amplify or expand the NOVA program viewing experiences of publics. Our findings suggest more planning and thought devoted to leveraging the interest and expertise of this organization is needed in order to realize its full potential.
- Informal Science Education organizations such as regional/community-based museums that are experienced at inviting public audiences to science cafés or public outreach forums offer NOVA public-ready and appropriate venues, audiences, and pedagogies for hosting "themed cafés" like Cosmic Cafés. Partnering with more science café or forum-experienced ISE institutions, as well as working with a young-scientist organization like SPS, may result in even more return on the investment in community-based forums or café events that coincide with NOVA programs.

- Our study revealed that because of the range of opportunities public audiences had in this project to engage and interact with the television program through supporting resources and outreach events, *The Fabric of the Cosmos* ignited publics' interest in and stimulated learning about space, time, quantum mechanics, the universe and multiverse. The various media-based and face-to-face community-based opportunities to engage with *The Fabric* topics also spurred NOVA watchers to share information about the program and some of its ideas with family, friends and colleagues, thereby amplifying its reach and potential impact.

We end this report with three of many comments survey-takers offered as their final thought for the funders and producers of *The Fabric of the Cosmos*¹³:

PLEASE present more of this programming! Greene is my children's generation's Carl Sagan. Due to education cuts, a lost educational model which believes that teaching to a test is vital, rather than teaching our students to think critically and creatively, a seeming overall societal shift in "belief." Rather than experimental science, and a grounded space program, our children will have to rely more on "extracurricular" programs to stimulate interest and wonder in these topics. Thank you for funding this series, and please continue to do so. (Scientist/Engineer)

These videos prompted another contribution to PBS that was equal to my yearly donation. I contributed online. (General Public)

Einstein wrote that "one cannot help but be in awe when one contemplates the mysteries of eternity, of life, of the marvelous structure of reality, it is enough if one tries to comprehend a little of the mystery each day." Thank you so much for this major boost in my understanding of this mystery. (General Public)

¹³ All of these 258 comments were provided to NOVA as part of the set of appendices (Appendix C) and data we submitted. Many were used in the content of this report.

IX. APPENDICES

- A: Evaluation Instruments
- B: Expert Website Reviews
- C: Open-ended Survey Comments