

Promoting Information Seeking and Questioning in Science

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One of the hallmarks of interest is active pursuit of more information about topics of interest. Therefore, information seeking, specifically asking questions, could be used as a behavioral indicator of interest. The interest and ability to independently seek science knowledge in response to current events or personal concerns is one of the fundamental goals of the science literacy movement. This chapter focuses on learners' questions to explore how they may be used to reveal learners' interests in science. It addresses the rationale and main findings from the measurement of interest in science on the basis of information-seeking behavior in three increasingly unstructured science-learning environments:

- *Asking anonymous written questions at school: This line of research focuses on the gap between high school students' interests in specific topics in biology and the requirements of the formal curriculum on the same topics. It also explores ways to bridge this gap.*
- *Submitting questions to Ask-a-Scientist sites: This line of research aspires to identify students' spontaneous fields of interest in science and technology and to describe how these interests develop and change with age and between genders.*
- *Submitting queries to an online search engine: A series of studies explored how publicly available aggregated data regarding searches performed on Google may be used to investigate the public's interest in science. They also illustrate the significant role played by the media in motivating science information seeking.*

Methodological features and limitations of the three data sources are summarized and contrasted with the traditional method for identifying students' interests on the basis of their responses to questionnaires, suggesting that a behavioral measure such as question asking is an improvement with regard to the authenticity of data over closed-ended self-reports. By enabling a wider repertoire of measures of interest in science, future research may help teachers and science communicators build on the current interests of the wider public and potentially engage current and future citizens in informed decisions about science.

Introduction

This chapter raises the questions, What are students and the wider public interested in knowing about science? and What kinds of information do they seek and questions do they ask about science, and why? This exploratory account addresses the measurement of

interest in science on the basis of information-seeking behavior in three environments: asking anonymous written questions at school, submitting questions to Ask-a-Scientist sites, and submitting queries to online search engines. I discuss the relevance to interest research of data collected in these increasingly unstructured science-learning environments, with an emphasis on the limitations set by the natural setting and incomplete data, along with the studies' contributions to authenticity.

The educational ambition that the public should have a sufficient degree of scientific knowledge is over a century old. In the past 10 years, this goal has developed into an understanding that informed public engagement is important for the long-term preservation of science, society, and democracy (Miller, 2001). Extensive research has been devoted to the question of what people should know about science, the assessment of their knowledge, and an examination of the factors behind the ever disappointing results of students' and the public's science knowledge (e.g., Organisation for Economic Co-operation and Development, 2010; Osborne & Dillon, 2008). However, only a small fraction of this scholarly attention has focused on the question of what people are actually interested in knowing about science.

Research exploring the content of students' interest in science (rather than the existence and intensity of their interest in science; e.g., Greenfield, 1998) broadly uses either quantitative or qualitative methods. Quantitative research usually involves widely distributed questionnaires in which students respond to a list of topics or questions adult researchers deem should be meaningful to them (e.g., the Relevance of Science Education project; Sjøberg & Schreiner, 2002). Qualitative studies of what students do with science and what science they want to know have been conducted mainly among urban groups with low socioeconomic status (e.g., Calabrese Barton & Tan, 2009). Other approaches include focus groups (e.g., Osborne & Collins, 2001), school student- and graduate-led review of the science curriculum (e.g., Murray & Reiss, 2005), and individual and group interviews (e.g., McPhail, Pierson, Freeman, Goodman, & Ayappa, 2000). Common to all of these approaches is their negligible impact on actual mainstream science teaching and learning. So far, there is sparse evidence for the influence of research on either school science pedagogy or content (Jenkins, 2006). Science education, even in informal settings, is usually bounded by an expert view of what should be taught.

This situation creates an immediate mismatch with the paradigm governing science education. Starting in the 1980s, the *science literacy* paradigm recalibrated the goals of science education from teaching more and better scientists to educating informed citizens who will pursue lifelong learning and engage with socioscientific issues affecting their lives. Therefore, increasing students' interest in science is both an educational goal and a means to an end. Interest is a critical cognitive and affective motivational variable that hones attention. It is defined in this context as an individual's focused attention to or engagement with a specific content or object and, in later phases of interest, the predisposition to return to engagement over time (Hidi & Renninger, 2006; Renninger & Hidi, 2011). Interest plays a key role in learning through its contribution to individuals' connections to content; it helps maintain this connection long enough for learning to take place (Ainley, Hidi, & Berndorff, 2002). In

this sense, interest serves conceptual learning. But interest in science is also an educational goal, because interested students are more likely to pursue science-related careers (Tai, Liu, Maltese, & Fan, 2006) and interested citizens are more likely to voluntarily pursue lifelong learning and engage with socioscientific issues. This activity is consistent with the goals of science literacy, defined by the Program for International Student Assessment 2015 framework as “the ability to engage with science-related issues, and with ideas of science, as a reflective citizen” (Osborne, 2012).¹

Involving oneself with science-related issues requires information seeking. Indeed, one of the hallmarks of interest is active pursuit of more information about topics of interest (Schiefele, 2009). Therefore, information seeking could be used as a behavioral indicator of interest. An important form of information seeking is question posing, especially a form central to our purpose: posing curiosity questions. Curiosity questions are questions that might not be novel to those who have more information but are novel for learners and allow them to build knowledge (Renninger, 2000). Learners’ curiosity questions lead them to voluntarily explore and stretch their present understanding, which in turn leads to developing ownership and valuing knowledge as well as a deepening of interest (Renninger, 2000). The importance of curiosity questions for interest development is consistent with the importance of such questions in science education research (for a review, see Chin & Osborne, 2008).

Unfortunately, few students are openly active during traditional classes, and even fewer tend to publicly ask curiosity questions, probably to avoid criticism, embarrassment, or even mockery from peers (Rop, 2003). All these concerns might cause students not to ask questions in class, including those that could help them explore their interests. To address this problem, in recent years, researchers have studied students’ questions that have been sent to Internet sites (e.g., Baram-Tsabari, Sethi, Bry, & Yarden, 2009), magazines (Cakmakci et al., 2011), TV programs (Baram-Tsabari & Yarden, 2005), and academic course sites (Colbert, Olson, & Clough, 2007); questions that were anonymously collected in class (Hagay & Baram-Tsabari, 2011); and science-related search queries submitted to search engines (Baram-Tsabari & Segev, 2011; Segev & Baram-Tsabari, 2012). This type of data collection results in the de facto conceptualization of interest as content one seeks. “What questions do people ask?” is used as a proxy for “What are people interested in knowing?”

Using questions as an indicator of interest is supported by Hidi and Renninger’s (2006) Four-Phase Model of Interest Development and by Krapp’s (2005) “person-object theory of interest,” because these conceptualizations include both cognition and affect. In line with the Four-Phase Model, asking curiosity questions may serve as an indicator of attaching value to content, while the cognitive level of the question may indicate knowledge. Without the development of knowledge, however, a learner is not in a position to develop the types of curiosity questions that lead to reengagement or the value that comes from asking these questions (Renninger & Su, 2012).

In the next section, three exploratory lines of research on science-related curiosity questions in increasingly unstructured science-learning environments are described. The characteristics, affordances, and limitations of the data sources in science interest research are summarized in Table 1.

Table 1. Characteristics of Data Sources Used to Quantitatively Identify Interests in Science in Four School- and Web-Based Learning Environments

	School:	School:	School:	Web:	Web:
Environment	Response to a survey	Students' questions	Ask-a -Scientist site	Search engine	
Data collected	Responses to a closed-ended questionnaire	Written self-generated questions	Questions submitted to Ask-a -Scientist sites (e.g. MadSci Network) ^a	Queries submitted to search engine (e.g., Google Search)	
Unit of analysis	Individual (one questionnaire)	A question	A question	Aggregated data for a given query	
Type of measurement	Self-report	Behavioral measure	Unobtrusive behavioral measure	Unobtrusive behavioral measure	
Ecological validity	Low: Responding to others' ideas (researcher's initiative)	Medium: Prompt to raise questions on certain topics (researcher's initiative)	High: Authentic information seeking (subject's initiative)	High: Authentic information seeking (subject's initiative)	
Time dimension	Cross-sectional or longitudinal study	Cross-sectional or longitudinal study	Cross-sectional study	Cross-sectional study	
Geographic dimension	Relatively easy cross-cultural comparisons	Some level of cross-cultural comparisons	Some level of cross-cultural comparisons	Some level of cross-cultural comparisons	

^a Science questions could also be submitted to TV shows or a magazine, but many of them were not anonymous, and information seeking could also have been motivated by wanting to appear in the media.

Sample characteristics			
Sampling	Selected by the researcher	Selected by the researcher	Self-selecting
Generalizability (population validity)	Potential high generalizability for student population	Potential high generalizability for student population	Low, representative of motivated and sophisticated Web users
Sample size	Hundreds–thousands of questionnaires	50–100 questions per class, relatively easy to reach 1000 questions	Over a billion searches weekly, of which some relate to science
Potential availability of demographics about subjects^b			
Individual identification	Anonymous or identified	Anonymous or identified	Anonymous and aggregated
Age	Yes	Yes	No
Gender	Yes	Prompt to provide	No
Education level	Yes	Yes	No
Country	Yes	Yes	Country and possibly city/region (based on IP address)
Motivation for seeking the information	N/A	Sometimes can be inferred from the wording of the question	Sometimes can be inferred from the wording of the question

^b This is a general description of the potential demographics likely to be collected about subjects in these environments. Specific numbers are not provided, since different studies and information sources (e.g., web sites) are described in this chapter in the context of each environment.

Unique limitations					
Threats to external validity	Random sampling error; survey nonresponse	May exclude the interests of those not proficient in writing	Digital and functional divide	Digital and functional divide	Digital and functional divide
Threats to construct validity	Lack of honesty by respondents on questions that have socially acceptable/unacceptable answers; nonattitudes are being constructed and responded upon while taking the survey	Self-censorship may be exercised when the person expected to answer the question is the teacher	Self-censorship may be exercised when the person expected to answer the question is a scientist	Researcher's decision regarding search query to be studied affects the results; some science concepts are being searched for reasons other than interest in science (e.g. <i>Big Bang Theory</i> is also the name of a popular TV show)	Researcher's decision regarding search query to be studied affects the results; some science concepts are being searched for reasons other than interest in science (e.g. <i>Big Bang Theory</i> is also the name of a popular TV show)
Threats to the measurement	Ceiling effect; difference in participants' readiness to exhibit enthusiasm (i.e., "very interested" on the part of one student corresponds to "interested" for another)	Researcher's interpretation regarding the characterization of question's content, level, etc. may be different from the original intention of the subject	Researcher's interpretation regarding the characterization of question's content, level, etc. may be different from the original intention of the subject	Researcher's interpretation regarding the characterization of question's content, level, etc. may be different from the original intention of the subject	Reports an arbitrary scale system; does not provide the actual volume of searches

Lessons From Three Learning Environments

Anonymous Students' Questions Collected in High School Biology Classes

Interest plays a dominant role in people's drive to learn and study in their daily lives, but in schools, individual interests are largely ignored. The discrepancy between the curriculum and students' natural interests in learning science has been reported for elementary (Baram-Tsabari & Yarden, 2005), middle (McPhail et al., 2000), and high schools (e.g., Baram-Tsabari, Sethi, Bry, & Yarden, 2006; Hagay & Baram-Tsabari, 2011). Even when educators struggle to develop relevant and interesting learning materials, relevance has been traditionally defined with the interests of adults rather than young people in mind (Jenkins, 2006). Here I report on research that addresses the gap between high school students' interests in specific topics in biology and the requirements of the formal curriculum on the same topics. Students' anonymous written questions are used as indicators of their interests and as suggesting ways to bridge this gap. Characteristics of this data source for educational interest research are described in Table 1.

The interests of 343 Israeli high school students in three biology topics were identified on the basis of 563 questions they anonymously wrote in response to the prompt "Please write questions you would like to know the answer to." The results of this exploratory study showed that half of the questions asked by students in the areas of genetics, the cardiovascular system, and the reproductive system are not addressed by the Israeli national curriculum. Students' questions can (a) complement and build on the existing principles in the curriculum (e.g., "If my parents have a tendency to be fat, will I be fat too?"), (b) emphasize specific contexts of existing principles in the curriculum while ignoring others (e.g., students' interest in medical rather than agricultural implications of biotechnology), and (c) refer to different principles that are absent altogether from the curriculum (e.g., "What would happen if a chimpanzee's sperm fertilized a human egg?").

To generalize students' interest in these questions beyond the group of students who originally raised them, 36 representative questions were aggregated into a closed questionnaire, and another 375 students drawn from the same population were asked to rank their interest in them (Hagay & Baram-Tsabari, 2011). The majority of the questions were ranked as interesting by the second sample of students. Female students ranked almost all of the questions as more interesting than male students did.

High school students' ($n = 87$) views regarding the best ways to adapt biological studies to fit their interests were explored using questionnaires with closed- and open-ended items. The closed-ended questions indicated that the participants were very positive regarding their experience as biology learners and highly interested in what they were learning. However, when given the opportunity to voice their opinions in the open-ended questions, students explicitly and implicitly indicated a gap between their interests and the requirements of the curriculum. Sadly, but not unexpectedly, over half of the informants reported that they would give priority to teaching for the matriculation test rather than addressing their own interests (Hagay & Baram-Tsabari, 2012).

Teachers play a central role in translating the intended curriculum into the enacted curriculum. Therefore, Hagay and I then investigated what would prompt 190 high school

teachers from different disciplines to adjust the curriculum to match their students' interests (Hagay, Baram-Tsabari, & Peleg, 2012). Decisions to teach topics that interest students but that are not included in the curriculum were due mostly to reasons related to "civic literacy": preparing future citizens for "real life."² The decision to ignore students' interests that are not included in the curriculum was ascribed mostly to limitations in terms of class time and teachers' knowledge, suggesting a tension between teachers' attempts to provide a student-centered pedagogy and the limitations imposed by the formal system and restricted resources.

To determine how generalizable these findings were across different cultures and countries, we asked 604 high school students from Portugal, Turkey, England, and Israel who chose biology as an advanced subject to rank their interest levels in 36 questions that were originally raised by Israeli students (Hagay, Baram-Tsabari, Ametller, et al., 2012). The findings indicated that students from these four countries showed interest in similar science questions. The most intriguing questions were the ones that dealt with human health and new developments in reproduction and genetics. The responses suggested that students' interest in one context is relevant to the development of interest-based learning materials in a different context. However, despite these similarities, cultural and sociological differences still need to be taken into account. For example, boys and girls ranked more than half of the questions differently. In most cases, girls expressed higher levels of interest than boys, supporting the notion of girls' greater interest in biology, regardless of religious or cultural identity. Questions concerning reproduction were influenced most by gender preferences, because of the higher ranking of girls from all countries. This finding might reflect interests and concerns among girls at this age.

Even if students' interests are identified and to some level generalized, their implementation in a class that is obligated to follow a crammed curriculum is far from straightforward. Hagay and I (2011) suggested a strategy for incorporating students' interests into the formal biology curriculum: Students' questions were used to create a kind of shadow curriculum that mapped students' interests onto the current curriculum. This allowed for the planned incorporation of students' interests in the curriculum, while responding to their questions and their need for information.

In a follow-up, we followed the planned incorporation of students' questions into the curriculum by five teachers in eight high school science classes. The aim of this study was to explore practical means of incorporating students' interest in high school science classes, as experienced by the teachers and students, and to document the development of the questions asked throughout the intervention. The quantitative data included 175 pre- and postintervention questionnaires as well as 918 questions that were asked by students during the intervention. These were analyzed using four different criteria: match between the curriculum and students' questions, psychological distance from the asker, and two measures of cognitive complexity. Cognitive level was based on the method proposed by Shepardson and Pizzini (1991): Input questions require retrieval of information from either memory or the senses ("What are the components of blood?"). Processing questions mandate the organization of some kind of interplay between different parts of the information ("Is it good to drink urine in a state of severe thirst, or will it make the situation even worse?"). Output questions

require going beyond immediate information and using it in different ways (“Will it be possible in the future to choose which genetic traits are passed on to the baby?”). Our epistemological approach mapped questions according to three different ideals of “what knowledge is”: cognition, understanding, and control (by action or manipulation).

Comparison classes did not receive the intervention but learned the same topics. Data included preintervention observations, open-ended questionnaire items, and semistructured interviews with teachers and students. The primary investigation was conducted as action research in one high school biology classroom during one academic year and one additional month of the following year.³ In all classes, students were invited to anonymously write down their questions on certain topics and hand them to the teacher. In the intervention classes, teachers mapped those questions onto the curriculum and addressed them during their teaching (for an example, see Hagay, Peleg, Laslo, & Baram-Tsabari, 2013).

The findings indicated that all questions submitted by students from the intervention classes ($n = 334$) and the comparison classes ($n = 584$) were content-related curiosity questions. No significant differences between questions collected in the intervention and comparison classes were found prior to the intervention, but differences did appear during the intervention. Over 50% of the students' questions from the intervention classes were not addressed by the curriculum, more than their counterparts in the comparison classes. This finding may indicate a higher level of interest in expanding their knowledge among intervention class students. As the school year unfolded, questions asked by students from the intervention class were significantly more concerned with the distant environment, which cannot be directly observed, compared with questions asked by students from the comparison classes. This may indicate an interest in abstract ideas and a shift from the concrete to formal thinking. Finally increased cognitive complexity in the questions students asked in the intervention classes was assessed by cognitive level and an epistemological approach. A similar systematic development was not observed in questions asked by students from the comparison classes. The development in students' ability to raise curiosity questions is an indicator of developing individual interest (Renninger, 2010). Specifically, students were more likely to ask abstract and complex questions that were not addressed by the curriculum. This increase in complexity might be viewed as behavioral evidence for thinking more about biology and indicate an increasing desire to broaden horizons in the topic. Some students' questions may be characterized as evidence for transformative experiences as described by Pugh, Linnenbrink-Garcia, Koskey, Stewart, and Manzey (2010), in which students are motivated to apply what they have learned in class outside the classroom, for example, “Yesterday I saw chimera on the TV show *CSI*. How can this phenomenon of the double DNA be created?” (asked by an 11-year-old student in an intervention class). This ability to use school science knowledge to further inquire about science in everyday events is one of the hallmarks of scientific literacy.

Self-Generated Questions Submitted to Ask-a-Scientist Sites

This line of research aspires to identify students' spontaneous fields of interest in science and technology (S&T) and to describe how these interests develop and change with age and between genders, as reflected by their self-generated questions. It is difficult to use children's questions openly asked in class for research, because they are so rare and seldom give

evidence of genuine intellectual curiosity (Dillon, 1988). However, students do pose science questions in free-choice science-learning environments. Therefore, we used children's self-generated science-related questions submitted to Ask-a-Scientist sites and TV shows as data to probe their scientific interests.

The underlying rationale for this method is that in a free-choice setting, people usually ask questions to obtain information that they are lacking, rather than posing rhetorical questions, suggestive questions, or questions asked to please someone. Therefore, questions asked in a free-choice environment, such as an Ask-a-Scientist site, can help reveal personal interests and informational needs, while enabling a direct flow of reliable scientific information from experts to the nontechnical public, especially children. The questions were analyzed with reference to several coding schemes, such as subject and topic, thinking level, motivation for raising the question, the object of interest and its magnitude of scale, and psychological distance of the object in question from the asker. Demographics of the person who raised the question, such as gender, grade level, and country of origin, were also considered (see Table 1 for characteristics of this data source for educational research).

Development in children's and adolescents' interest in S&T. Key categories of science interests were identified using a cluster analysis of almost 6,000 questions (Baram-Tsabari & Yarden, 2009): Young students' (kindergarteners through sixth graders') questions dealt with diverse science topics, mainly zoology, high and low technology, and astrophysics. These questions were the product of genuine personal interest or need and usually focused on a macroscopic level of organization. Older students' (10th through 12th graders') interests were centered on the three science disciplines they study in school: physics, chemistry, and biology. Over a third of these were imposed by school assignments and were not asked as the result of either spontaneous interest or genuine need. Several reasons might account for the transition in students' interest from nonclassic to school science fields as children grow. Children may naturally lose their interest in earth sciences, astrophysics, and technology, whereas their interest in biology, physics, and chemistry increases as they mature (similar to the changes documented in biology; Baram-Tsabari, Sethi, Bry, & Yarden, 2010). Another, more likely, possibility is that their attention is shaped by the formal school system. Although most of the questions were unique, appearing only once, there were a few questions that seem to interest a significant proportion of young children (e.g., Which is the biggest/fastest/strongest/smallest animal? Who invented the computer? Is there life on other planets? How do I build an Internet site?). These frequently asked questions are not addressed in the conventional science curriculum in those grades (Baram-Tsabari & Yarden, 2005).

An inconsistency was found between students' spontaneous and school-modeled questions (e.g., "My teacher told us to find it"). In all age groups, astrophysics was more prevalent among spontaneous questions. Chemistry, on the other hand, was far more prevalent among school-modeled questions than spontaneous ones. Children asked more school-modeled questions as they got older (Baram-Tsabari et al., 2006).

Development of interest in biological topics with age. As expected from the literature, biology is the most popular science subject for questions among children and adolescents from

dozens of countries. Within the biology questions, the relative frequency of questions asked in the context of animal biology decreased with age, whereas interest in human biology increased, presumably because of the onset of puberty (Baram-Tsabari et al., 2010; Baram-Tsabari & Yarden, 2007). Children's motivation for asking science questions was for the most part nonapplicative (e.g., intellectual curiosity). However, the proportion of questions asked for applicative reasons (health decisions, school assignments, etc.) rose steadily with age. Many of the questions about human biology referred to the asker himself or herself. Girls asked for applicative answers more than did boys (Baram-Tsabari et al., 2010).

Gender-related aspects of science questions in online free-choice environments. Internet-based Ask-a-Scientist sites revealed a surprising dominance of girls' contributions among K–12 students, whereas offline situations are commonly characterized by boys' greater interest in science. This female enthusiasm was observed in different countries and was not correlated with the level of equality in these countries. Iranian girls, for example, turned out to be greater users of the MadSci Network than Iranian boys, although their direct environment does not necessarily promote such interest in science. This may indicate that the Internet plays a potentially empowering and democratic role as a free-choice science-learning environment, which is especially relevant to populations deprived of equal opportunities in learning formal science (Baram-Tsabari et al., 2009).

However, girls' interest in submitting questions to scientists drops all over the world as they grow older, and the stereotypically gendered science interests persist in this environment as well: Physics proves significantly less interesting to girls than to boys, whereas biology is of greater interest to girls than to boys. Although boys develop an interest in physics with age, girls do not develop such an interest to the same degree (Baram-Tsabari & Yarden, 2008). It was also found that the difference between boys' and girls' interests increases over twentyfold between kindergarteners to 3rd graders and 10th to 12th graders (Baram-Tsabari & Yarden, 2010). Furthermore, the gap widens in a highly stereotypical manner, with girls increasingly interested in biology and boys asking more about physics and technology. A study of the science interests of boys and girls from Israel and Arab Middle Eastern countries indicated that although the stereotypical gender gap in interest persists, and significant differences were found between the age groups, no significant differences were found between science questions that were sent by Israelis and Arabs (Baram-Tsabari & Kaadni, 2009).

Topics that appeal to both sexes have also been identified. These include topics such as sickness and medicine, the solar system, microbiology, meteorology, and several subtopics of chemistry. Therefore, it seems possible to teach scientific concepts in the context of topics that are not dominantly preferred by boys but, rather, are preferred by girls or are equally attractive to both genders (Hoffmann, 2002). In this sense, using students' interests as the context of science learning could prove beneficial in the process of mainstreaming science education.

Science-Related Queries Submitted to Google

Americans are now about equally likely to rely on the Internet as on television as their primary source of general S&T information, and the Internet is now the main source of in-

formation for learning about specific scientific issues (National Science Board, 2014). As users become more experienced online, they increasingly become dependent on search engines for finding answers to their information needs. As with questions, keywords entered into search engines can be used to detect people's information needs. Online searches, which reflect a conscious effort to acquire information, have been used successfully to study trends in health, economics, and science information seeking (e.g., Anderson, Brossard, & Scheufele, 2010; Baram-Tsabari & Segev, 2011, 2013; Choi & Varian, 2009; Ginsberg et al., 2009; Segev & Baram-Tsabari, 2012). Characteristics of this environment as a data source for educational research are described in Table 1.

In a series of exploratory studies, we asked how publicly available aggregated data regarding searches performed on Google may be used to learn about the public's interest in science. Google was chosen because it is the most widely used search engine (providing 85.2% of online global searches in August 2012; NetMarketShare, 2012) and because of its advanced features allowing analysis of search data. Two publicly available online tools were used for the data collection:

- Google Trends (GT; <http://www.google.com/trends>) first became available to the public in May 2006 to assist research on searches in Google and news articles collected in Google News. GT analyzes and displays the proportion of searches for terms, compared with the total number of searches made on Google over a defined period of time (between 2004 and the present). GT also shows how frequently topics have appeared in Google News stories and in which geographic regions people have searched for them the most. It also provides popular related searches.
- Google News (<http://news.google.com>) is an automated news aggregator available to the public since January 2006. The exact list of news sources is not known outside of Google, but it consists of over 4,500 English-language news sites. It aggregates several million articles a day and sends about 1 billion clicks each month to news publishers worldwide (Bharat, 2010), which makes it a reasonable proxy for broader media coverage of news.

These Web-based tools can be used to (a) identify interests in science and pseudoscience, (b) conduct cross-national comparisons of popular science- and pseudoscience-related searches, and (c) discover possible motivations when searching for specific terms. On a global scale, we found that the proportion of S&T-related searches decreased between 2004 and 2012, for both general and specific search terms. This general decrease is probably a result of the diversification of users and their interests, which causes the share of specific queries to decrease, rather than indicating an actual decline in public interest in learning more about science concepts (Baram-Tsabari & Segev, 2011). Some science and pseudoscience terms had similar levels of interest on the global level, but their popularity differed greatly among countries. For example, Germans looked relatively more often for *Horoskop* and *Mars* than did British searchers for *horoscope* and *Mars*. The application "related searches" provided clues to the motivations behind science-related searches. Related searches for *DNA* were mostly content- and methodology-related concepts, whereas terms related to

the query *science* were conducted for formal or informal education-related reasons (Baram-Tsabari & Segev, 2011).

For many science-related search queries, media attention and time during the academic year are highly correlated with changes in information-seeking behavior (expressed by changes in the proportion of Google science-related searches). Changes in the volume of searches for general and well-established science terms such as *chemistry* and *DNA* are strongly linked to the education system. By contrast, ad hoc events and current concerns such as *swine flu vaccine* and *greenhouse gas* were better aligned with media coverage (Segev & Baram-Tsabari, 2012).

But how long is this “teachable moment,” the real or fictional science-related event that stimulates public interest and makes the underlying science at least temporarily interesting? In our third study (Baram-Tsabari & Segev, 2013), media attention, as expressed by the Google News reference volume, and changes in information-seeking behavior, as expressed by Google Insights for Search, were used to estimate the length of a teachable moment for science Nobel Prize announcements in the years 2004 to 2011. The average half-life (time until dropping to half of the maximum intensity) of the online searches for names of Nobel laureates was about one week. For media coverage, the average half-life was about 10 days. Using a more permissive threshold equal to 25% of the maximum interest, or two half-lives, the teachable moment lasted 9.5 weeks in the media versus seven to eight days in the public’s online searches. Although both news and searches always concentrated around the announcement period, our findings showed that in general, media coverage was longer than online searches.

To study daily search trends, day-to-day searches of the seven 2011 Nobel laureates were extracted. For six of the seven laureates, the half-life of searches was one day. Six of the seven laureates experienced two to four days of relatively intensive online searches before searches were once again too scarce to be reported by GT (Baram-Tsabari & Segev, 2013). This study illustrated the significant role played by the media in motivating science information seeking. Focused media coverage on current science events and concerns can create a teachable moment that motivates people to independently search for related information. This is particularly true when looking at event-oriented topics that are not part of the school or university curriculum. However, the overall interest in such events appears to be rather short, with the media showing a longer attention span than online searches. The interest and ability to independently seek science knowledge in response to current events or concerns is one of the fundamental goals of the science literacy movement. Success in exploiting the teachable moment rests on the ability of the science communication community to identify and respond to public interests and recognize opportunities to engage them with science.

The rationale and main findings of studies using three types of information-seeking behavior as an indicator of interest have been described. In Table 1, methodological features of the three data sources are summarized and contrasted with the traditional method for identifying students’ interests on the basis of their responses to questionnaires.

Concluding Thoughts

This chapter has addressed the question, What kinds of information do students and the wider public seek about science, and why? I have primarily addressed the commonalities across studies on the basis of information seeking to identify interest. However, it is important to note that these two physical environments offer a different operationalization of interest. Although school-based environments ask students to imagine what they would be interested in knowing, the Web-based environments view interest as action, in that studies attempt to determine what information people are actually seeking. Each conceptualization has its shortcomings: People may well seek science-related information on the Web for reasons other than intellectual curiosity, such as to complete an assignment. On the other hand, people may report interest in content that might not engage them in a real-world experience (see “threats to construct validity” in Table 1). There are conceptual and methodological issues that are raised and issues that need further research.

Conceptual and Methodological Issues

The use of a behavioral measure such as questioning is an improvement over self-reports with regard to the authenticity of data but has its own limitations. For example, even if the basic data collection has better construct validity, the use of questions requires another level of content analysis that can introduce errors of judgment and be affected by intercoder reliability and other factors. Furthermore, people who are not motivated to learn science are probably not represented at all in these self-selecting samples (see “unique limitations” in Table 1). Therefore, the improved ecological validity of this type of data source comes at the cost of potentially unrepresentative samples and partial data. This limits the certainty with which one can infer interests and the motivations behind them and devise recommendations for educational interventions.

That said, new data sources often lead to new conceptual insights. For example, a key distinction between situational interest and individual interest is that an emerging individual interest involves seeking further engagement with content (Hidi & Renninger, 2006). Therefore, information-seeking behavior is an indicator of later phases of interest development (see Renninger & Su, 2012). The huge but short-lived peak of online searches for science-related events (Baram-Tsabari & Segev, 2013) indicates that voluntary information seeking begins in earlier phases of interest development and is also an outcome of situational interest.

Future Research

This chapter focuses on information-seeking behavior to study the measurement of interest in three environments: students asking anonymous written questions at school, students submitting questions to an Ask-a-Scientist site, and online users submitting queries to online search engines. This type of data collection addresses interest as content one seeks. “What questions do people ask?” is used as a proxy for “What are people interested in knowing?” Questions anonymously written at school reveal a large gap between high school students’ interests in specific topics in biology and the requirements of the formal curriculum on the same topics. Questions submitted to an Ask-a-Scientist site help to identify students’

spontaneous fields of interest in science and technology; they point to similarities across and differences between students' interests in science in offline and online environments; and they reveal how these interests develop and change with age and between genders. Queries submitted to Google illustrate the public's interest in science, its triggers, and its duration.

With a wider repertoire of measures of interest in science, future research may better serve underrepresented populations in science by allowing their authentic interests to be heard. Implications for practice include helping teachers and science communicators to build on the current interests of the wider public and potentially to engage current and future citizens in informed decisions about science on the individual and national levels.

The next steps for the research would be to develop and study how students' interests may be used as input for mainstream science teaching. An online collaborative "shadow curriculum" created by communities of students and teachers may inform teachers regarding authentic interests of students in general and of their own students in particular in relation to the syllabus they are required to teach. Whether enriching the syllabus with students' perspectives will translate into actual attention to students' interest in class—and whether such practice will create teachable moments and enhance students' interest and motivation—is yet to be explored.

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Notes

1. The Program for International Student Assessment is operated by the Organisation for Economic Co-operation and Development. It is an international assessment that focuses on 15-year-olds' capabilities.

2. "Civic literacy" rather than "science literacy" is used because many of the teachers in this study were not science teachers.

3. Action research is conducted in the context of focused efforts to improve the quality of an organization and its performance. Typically, it is designed and conducted by practitioners who analyze the data to improve their own practice (see Ferrance, 2000).

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