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Does interest have an expiration date? An analysis of students' questions as resources for context-based learning in formal and informal science learning environments

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Context-based approaches can bridge the gap between abstract, difficult science concepts and the world students live in. However, the relevance of specific contexts to different groups of learners, and its stability over time, have not been extensively explored. This study used four datasets, collected in different formal and informal settings, to examine which types of contexts could capture the interest of many students and remain so for many years. In the formal setting, responses to closed-ended questionnaires in which 4-12[th] graders indicated their interest in studying the answers to science questions were compared. Over 700 questionnaires collected in 2007 were compared to over 1,600 questionnaires collected in 2016. To document the stability of children's interest in informal science learning settings we compared over 1,600 science questions sent to a TV science show in 2004 with over 7,000 science questions submitted to a commercial exhibition in 2014.

Although there were some differences across ages, students' interest in science remained relatively stable over the 10 years. In the formal setting, this similarity was reflected in the significant linear relationship between the two databases (*r*=0.917) with regard to the questions students found interesting. In the informal setting, there was a striking similarity in the proportions of spontaneous questions in biology, astrophysics, Earth Science and chemistry. Based on the findings of this study and the literature we recommended, frequently asked questions are a valuable resource for context-based teaching which can serve to identify contexts that enhance the relevance of science in students' lives.

Keywords: context-based learning, interest, motivation, longitudinal study, science curriculum, student questions,

Rationale

The tight connection between motivation and learning in science education (Potvin & Hasni, 2014) is reflected in student achievement (e.g., Glynn, Bryan, Brickman, & Armstrong, 2015; Sevinc, Ozmen, & Yigit, 2011), and in the choice of a science career (e.g. Ainley & Ainley, 2011; Krapp & Prenzel, 2011; Xie & Reider, 2014). However, studies have repeatedly reported a decline in motivation for learning science with age (Koul, Lerdpornkulrat, & Chantara, 2011; O'Neill & Barton, 2005; Vedder-Weiss & Fortus, 2011). One significant cognitive and affective motivational variable which may prompt students to engage with content and maintain this connection long enough for learning to occur is interest (Ainley, Hidi, & Berndorff, 2002; Glynn et al., 2015).

Within the perspective of motivation and interest, context-based approaches can bring science learning closer 'to the life and interests of students' (Pilot & Bulte, 2006) and bridge the gap between abstract, difficult science concepts and the world students live in (Kortland, 2007). Teaching units grounded in context-based approaches 'must connect relevant contexts, from which questions are derived, and the basic concepts that can be applied to answer such questions'

(Parchmann et al., 2006 p.1046). As Waddington and Feinstein (2016) noted (p.124): '…we know that students at all grade levels struggle to find the value in the numerous abstractions that are presented to them in the science curriculum.' They also suggested a solution: 'An instrumentalist view of science begins and ends in relevance: if science is taught as a means of solving problems that students care about, it is always relevant.'

Teaching content should have some relevance, and should fit with the personal interests or societal context of the student (Sjøberg, 2002). The relevant context refers to the domain of individual relevance ('personal relevance'), which deals with objects from students' everyday lives (Eliks & Hofstein, 2015). For example, Walkington and Bernacki (2014) discussed the ways in which context such as 'Instagram' and 'Frisbee', can personalize mathematics problems and increase students' interest. Thus, knowledge of students' interests can support teachers in teaching science in relevant contexts (Sullivan, 1979).

Interest, Context and their Relationship to Students' Questions

Scholars define interest as both a psychological state and a motivational variable. Renninger and Hidi's (2016 p.8) definition captures the dual meaning of interest 'It refers to the psychological state of a person while engaging with some type of content and also to the cognitive and affective motivational predisposition to reengage with that content over time'. As a motivational variable, interest may be situational, which refers to a reaction to specific content or activity, or individual, which refers to one's tendency to reengage with specific content over time (Renninger & Hidi, 2016). 'Topic interest' is triggered by the presentation of specific themes, and may be influenced by both situational and individual interest.

Topic interest can be measured by a number of methods. In self-report measures participants are required to rate their own interest level for given items using a questionnaire or a survey (Renninger & Hidi, 2011). However, if using this method to identify interesting contexts for science teaching it is crucial to distinguish between measuring interest at the level of the domain (e.g., science) and interest in particular topics (Renninger & Hidi, 2016). For example, Bathgate, Schunn, and Correnti (2014) found a disparity between children's interest in a specific topic and their interest in a larger domain category (e.g. 'oceans' was one of the most popular topics, whereas 'Earth Science' was one of the least interesting domains). Similarly, Aikenhead (2006) suggested that specific themes embedded in students' experiences (e.g. 'rainbows and sunsets'; 'music', etc.) are more interesting than the associated science curriculum topics (e.g. 'light and optics', 'acoustics and sounds', respectively). Häussler and Hoffmann (2002) found differences between genders for interest in a particular physics topic and the particular context in which that topic was presented. For example, girls were more interested in learning about pumps in the context of biology ('how do pumps move blood through an artificial heart?'), whereas boys were more interested in learning about pumps in the context of physics ('how do pumps extract gasoline from great depths?', Hoffmann, 2002).

Since measuring interest in a particular science topic is influenced by the context of the question, using questionnaires may present a limited picture of students' interest in science. Another potential indicator of students' interest is their own questions (e.g., Baram-Tsabari & Yarden, 2005; Chin & Osborne, 2008). When students raise questions, they express scientific concepts in their own words (Baram-Tsabari & Yarden, 2007), thus potentially broadening the range of interest expressed. Moreover, students' questions arise from a desire to extend their knowledge (Chin & Osborne, 2008), and therefore may provide an authentic learning context (Merritt & Krajcik, 2013). This type of personalized context may 'promote connections between domain concepts and students' prior knowledge about their areas of interest' (Walkington &

Bernacki, 2014 p.145). These authentic, personalized contexts are a valuable resource for context- based approaches which view contexts and applications of science as the starting point for the development of scientific ideas (Bennett et. al, 2007 p.348). Thus, in our view, students' questions are expressions of interest that may serve as a resource for choosing relevant starting points for context-based science learning.

Beyond the specific context in which the topic is presented, students' interests may also depend on other factors such as environment or culture (Hagay & Baram-Tsabari, 2011; Schreiner, 2006). Although there are many studies on students’ interests, '…the results are diverse and not always explicit about specific facets of interest in science' (Dierks, Höffler, Blankenburg, Peters, & Parchmann, 2016 p.241). For instance, Dierks, Höffler and Parchmann (2014) found variations in students’ interest in three different learning environments (school, leisure time, and enrichment). However, there is also some evidence for similarities in students' interests in science across different groups of learners. For instance, students from different schools (Swirski, H. & Baram-Tsabari, 2015) and from different cultures (Hagay & Baram-Tsabari, 2011; Sjøberg, 2000) were shown to be interested in the same science questions. Thus, the generalizability of students' interest in a specific context remains unclear.

Variations across groups of learners are not the only obstacle for teachers and decision makers aiming to make the science curriculum more relevant to students' interests. Students' interests can also change over time (e.g., Dawson, 2000). A context that was found interesting and relevant may lose its popularity over years, or even weeks (Baram-Tsabari & Segev, 2013). Hence, to address the issues of interest stability and generalizability the studies described below examined the extent to which students’ interests in different contexts stable over a decade in both formal and informal environments and aimed to determine the contexts that generally capture students' interests across different age groups and genders.

Four datasets were used (Table 1). Study I was conducted in a formal setting, by comparing students' responses to close-ended questionnaires collected in 2007 and almost a decade later in 2015/6. Study II was conducted in informal science learning settings, by comparing children's self-generated science-related questions sent to a TV science show in 2004 and posted at a commercial curiosity exhibition in 2014.

Building on data from both formal and informal settings provides a broader picture of students' interests in science, not only because the environments differ (Fallik, Rosenfeld, & Eylon, 2013) but also because the participants can differ. Combining a closed approach (close-ended questionnaires) with an open approach (data mining of spontaneous questions) is considered to provide insights that each method cannot provide alone (Salganik & Levy, 2015).

Table 1. Research design

Data collection	**Study I: Formal setting (questionnaires)**	**Study II: Informal setting (self-generated questions)**
First wave	2007 (n=744)	2004 (n=1,676)
Second wave	2016 (n=1,608)	2014 (n=7,792)

Research Goals

This study examined the stability of students' interest in different contexts over a decade in a formal and an informal environment, and identify contexts that generally capture students' interests in terms of age groups and gender.

Specifically, we asked:

(1) To what extent are students' interests in different contexts stable over a decade in both formal and informal environments?

(2) What are contexts that generally capture students' interests across different age groups and genders?

In the next sections, the methodology and findings for the formal environment (study I) and the informal environment (study II) are presented. Then a summary and discussion of both studies is provided. Finally, recommendations are made for teachers and decision makers to support student interest in science.

Study 1: Stability and generalizability of students' science interest in a formal setting

Sample. 2,352 questionnaires were collected from 4-12th graders (8-19 years old) in Israel. In 2007, this included 744 students (385 females, 348 males, 11 not indicated) from 8 public schools, and in 2016, 1,609 students (777 females, 739 males, 92 not indicated) from 9 different public schools. Schools were chosen after consenting to take part in this study, which was approved by the Chief Scientist of the Israel Ministry of Education. All schools cater to a secular population characterized by middle or mid-high socio-economic status. Grade level, gender and socio-economic cluster data are presented in Table 2.

Table 2. Study I Sample demographics: Participants' grade level, gender and socio-economic status.

		2007 Eight schools		2016 Nine schools	
		n	**%**	**n**	**%**
Age	Elementary school (ages 8-12)	220	29.5	724	45
	Middle school (ages 13-15)	237	31.8	295	18.3
	High school (ages 16-18)	285	38.3	589	36.6
	Total	744	100%	1608	100%
Gender	Boys	348	46.7	739	45.9
	Girls	385	51.7	777	48.3
	Missing data	11	0.01	92	0.05
	Total	744	100%	1608	100%
Socio-economic status[1]	<6	77	10.3	0	0
	6	339	45.5	489	30.4
	7	77	10.3	1119	69.5
	8	251	33.7	0	0
	Total	744	100%	1608	100%

[1]The socio-economic scale ranks local authorities [i.e., districts] from 1 (lowest socio-economic level) to 10 (highest). The number of people in each cluster is different, with most of the population falling in the mid-clusters (CBS, 2002, 2014).

Method

Closed-ended questionnaire. Students' interest in different contexts in science was examined through responses to a closed-ended questionnaire The questionnaire was constructed in 2007 and administered as hard copy in 2007 and again in 2016 (with minor changes). It was completed during school time, under the supervision of science teachers. The questionnaire required about 15 minutes to complete. The first part was demographic. The questionnaires were anonymous, but students were asked to indicate their gender, grade level and, if applicable, their advanced topic of study (students at the end of tenth grade choose to major in at least one subject, which is tested by the national matriculation examination). Then, they were asked to indicate the extent of their agreement with two statements: 'I am interested in topics that relate to science and technology', and 'In my free time I often read or watch popular science' which was measured on a Likert scale ranging from 1 (highly disagree) to 5 (highly agree). The second part was composed of 32 science questions (listed in figure 1). Students were asked to mark the questions whose answers they wanted to know. The questions were randomly sampled from three different resources (unknown to the students) and included 11 textbook questions (TBQ) sampled from different school science textbooks representing the science curriculum at the junior high school level, Eleven self-generated Questions (SGQ), sampled from a list of science related questions voluntarily sent to popular science and educational TV shows and a magazine science column by audience members, and 10 Frequently Asked Questions (FAQ) that appeared in the SGQ list more than once and were sent to more than one source.

The Cronbach alpha indicated high internal consistency for all questions from the same source (2007: α_{TBQ}=0.821, α_{FAQ}=0.723 and α_{SGQ}=0.793; 2016: α_{TBQ}=0.822, α_{FAQ}=0.692 and α_{SGQ}=0.785).

Statistical analysis. For the questionnaire, a linear relationship analysis was used on the averages. The overall average interest for each student was calculated by dividing the number of questions he or she marked as interesting by the total number of questions (32). The overall average interest levels for each of the 32 questions was calculated by dividing the number of times the question was marked as interesting by the total number of students (2007: 744 students; 2016: 1,609 students).

Limitations. Note that although the questions were randomly ordered, the results could have been influenced by question order since only one version was used. Furthermore, although sampling was random, other specific questions might have resulted in different results. Another methodological limitation was the dichotomous scale used in the questionnaire. Students were asked to mark only those questions whose answers they wanted to know, not to rank their level of interest in each question. As a result of the closed-ended method we do not know whether the marked questions are those that students wanted to know the answer to, or whether they wanted to engage in inquiry to understand the answer.

Findings

Stability of students' interest between 2007 and 2016. Figure 1 presents the average interest levels for each of the 32 questions ranked by their popularity in 2016. Interest level represents the proportion of students that marked it as interesting in each year (2007: n=744; 2016: n=1608). A Pearson's correlation coefficient indicated a significant linear relationship between students' interest in different questions in 2007 and 2016 (r = 0.917).

In both 2007 and 2016, the FAQ 'Is there life on other planets?' was the most popular (2007: M=0.76; STD= 0.426; 2016: M=0.81; STD=0.393). The least popular was the textbook question 'What is the connection between the structure of fabric to its qualities and usage?' (2007: M=0.18; STD=0.388; 2016: M=0.21; STD=0.407).

T-tests for independent samples found significant differences in average interest levels between 2007 and 2016 for 13 questions. However, since statistical significance only provides evidence of a non-zero effect, we also calculated the effect size (Cohen, 1988). The results showed that 11 of these questions had a very low effect size (Cohen's $d<0.2$). A medium effect size ($d<0.5$) was only found for the question 'How does one build a website?', which was significantly more interesting in 2016 than in 2007, and for the question 'Sometimes, a cat suddenly runs frantically from one end of the house to another. Why does it do that?', which was significantly more interesting for the sample in 2007.

Insert Figure 1 about here

Textbook questions were generally the least popular questions out of the three sources (Figure 1). The average interest level in FAQ was significantly higher than the TBQ in 2007 and 2016 with a high effect size (d=0.64). In 2016, it was also significantly higher than SGQ; however, the effect size was very low (d=0.13). This result was supported by data from a multiple response analysis conducted on various subjects to neutralize the effect of the subject within the different types of questions. For example, of the 13 questions in biology in which 5 questions were SGQ, 4 were FAQ and 4 were TBQ, the 4 least popular questions were still the textbook questions.

Generalizability of Interest Level between Genders. In 2007 and 2016 boys expressed a significantly higher interest in science on the self-reporting items than girls (p<0.003), but with a low effect size (d<0.3). Table 3 details the self-reported agreement with two statements on a 1-5 Likert scale. The Spearman's correlation between these two statements was significant (2007: r=0.54 p<0.001; 2016: r=0.51, p<0.001). There was also a significant correlation between each statement and the overall average interest (p<0.001), which was calculated by dividing the number of questions students marked as interesting by the total number of questions (32). Despite these correlations, no significant differences between boys and girls were found in overall average interest in all questions.

Table 3. Boys' and girls' self-reported interest in science in 2007 and in 2016, measured by two statements using a Likert scale from 1 (highly disagree) to 5 (highly agree) and the number of questions marked as interesting.

2007	Boys			Girls					
	n	M	STD	n	M	STD	t	p	d
I am interested in topics that relate to science and technology	346	3.51	1.3	384	3.21	1.28	3.1	0.002	0.23
In my free time I often read or watch popular science	344	2.62	1.36	382	2.34	1.23	2.95	0.003	0.18
Overall interest in scientific questions (32 questions)[1]	348	0.44	0.26	385	0.44	0.22	-	n.s	-

2016	Boys			Girls					
	n	M	STD	n	M	STD	t	p	d
I am interested in topics that relate to science and technology	718	3.56	1.3	755	3.3	1.28	3.75	0.000	0.19
In my free time I often read or watch popular science	706	2.59	1.35	749	2.24	1.31	5.08	0.000	0.26
Overall interest in scientific questions (32 questions)[1]	739	0.48	0.25	777	0.46	0.24	-	n.s	-

[1]Calculated by dividing the number of questions marked as interesting by the total number of questions (32) for each student.

In 2016, there were some significant differences in the average interest level in specific questions between genders, but all had low effect size ($d<0.3$). However, certain questions clearly interested both genders. Table 4 details the 10 most popular questions for boys and for girls in 2016 (in parentheses, the ranking of the same question in 2007). Seven questions from the top ten appear in the lists for both genders (marked in grey).

Table 4. Ten most popular questions for boys and girls in 2016 (number in parentheses indicates ranking of the same question in 2007). Questions selected by both genders are marked in grey. White background marks questions that were popular only among one gender.

Boys (*n*=739)	**Girls (*n*=777)**
1. Is there life on other planets? (1)	1. Is there life on other planets? (1)
2. If there is no oxygen in space, then how does the sun give off heat? (8)	2. Does a jellyfish have a brain? If so, where in its body does it have room for one? If not, how does it move without a brain? (2)
3. What is the strongest animal in the world? (10)	3. Why is it that when you swim the water can be cold and then hot a meter away? (4)
4. Can we combine the genes of humans and animals? Can we combine the genes of two different animals, for example: a crocodile and a gecko? (5)	4. If there is no oxygen in space, then how does the sun give off heat? (11)
5. Why is it that when you swim the water can be cold and then hot a meter away? (9)	5. How do you know if dogs feel bad, sad or scared? (7)
6. Does a jellyfish have a brain? If so, where in its body does it have room for one? If not, how does it move without a brain? (3)	6. Can we combine the genes of humans and animals? Can we combine the genes of two different animals, for example: a crocodile and a gecko? (6)
7. How does the PlayStation light gun work? (7)	7. Why do humans yawn? (8)
8. How do you build a website? (19)	8. Why do bugs die on their backs? (3)
9. Why do bugs die on their backs? (4)	9. What is the strongest animal in the world? (10)
10. How can a submarine stay under the water for such a long time? How does air stay inside, and what is sonar? (13)	10. Why does the water look white when waves break in the ocean? (9)

Generalizability of interest across ages. In 2007 and again in 2016, the overall average interest level was significantly higher for elementary school students (2007: n=222, M=0.528; STD=0.256; 2016: n=724, M=0.526; STD=0.256) than for high school students (2007: n=285, M=0.404; STD=0.207; 2016: n=590, M=0.399; STD=0.233). The average interest level for 24 of the questions was the highest among elementary school students. The average interest level was only the highest for high school students on five questions, including 'Why do humans yawn?'. Only one question - 'Can we combine the genes of humans and animals?' - was more interesting to middle school students than to the other two groups.

Study 2: Stability and generalizability of students' science interests in informal settings based on their self-generated questions

Method

Data source, initial screening of science-related questions, and sample. The sample was made up of 9,468 science-related questions raised at two time points in two informal settings. The first dataset was composed of questions sent by viewers to a children's educational TV program on a cable channel available on subscription. The program broadcast 11 times, of which 4 broadcasts were live, and each included a contest to find information and an 'ask the experts' section. The latter was based on viewers' questions, mostly sent by a companion internet site (no longer active) in which the viewers were invited to send 'any question in the world'. It was announced that the answers would be broadcast. By January 2004, 3,303 questions had been accumulated in an email database. Of these questions, 1,676 were identified as science and technology related questions (Baram-Tsabari & Yarden, 2005). Another 1,627 questions regarding different issues such as art, entertainment, fashion, history, language, politics etc., were not tabulated.

The second dataset was collected during a commercial exhibition for children aged 5-12, in July and August 2014. The exhibition addressed 20 frequently asked 'Why' questions on different topics (e.g. 'Why is yawning contagious?; 'Why doesn't money grow on trees?'; 'Why is the sky blue?'). The answers were presented in various exhibits (e.g. computer simulations; interactive games; etc.). Nine tablets, which were positioned on a big table before the last question in the exhibition, provided the visitors an opportunity to write 'any question that interests them'. They were also asked to provide their first name, city, age and to mark their gender. At the end of the exhibition, they were surprised to see their questions projected on a large wall. By the end of the exhibition on the August 31, 2014, 22,384 items had been accumulated in the database. Of these, 13,186 were identified as unique questions (excluding nonsense and repeated questions by the same person). Of these questions, 355 were technical and related to the exhibition (e.g. 'Why there is no air conditioning here?'; 'Where is the toilet?') and 490 questions were identical to the exhibition questions (e.g. the question 'Why do zebras wear pajamas?' was repeated 87 times). These questions were also removed from the sample, resulting in 12,341 questions.

Due to the structure of the exhibition that stressed 'Why' questions, about 90% of the questions began with 'why'. Thus, it was hard to distinguish between questions aimed at understanding the purpose of a phenomenon or an event, and questions looking for a reason (Melo, Rodrigues, & Nogueira, 2013). For example, the question 'why do animals exist?' can allude to the cause of the animals' existence (a science question), but also to the purpose of their existence (a philosophical question). Given these uncertainties, these questions were classified according to their context: animals, light, allergies etc. were classified as 'Science'; God, the meaning of life etc. were classified as 'Philosophy'.

Based on this classification, 457 questions were classified as philosophy or religion (e.g. 'does God exist?'); 638 questions were school related (e.g. 'Why do I have to go to school?'); 759 questions addressed two significant events which took place at the time of the exhibition (611 questions about a war and 148 questions about the 2014 FIFA World Cup). Another 2,695 questions had to do with human traits (e.g. love, crime, war, money), imaginary creatures (e.g. dragons, fairies), linguistics or historical issues (e.g. 'why do we say 'good-night'?) and were not tabulated. In the end 7,792 questions were identified as science and technology related questions. Participants' age, gender and socio-economic status are presented in Table 5.

Table 5. Study II Sample demographics: Participants' grade level/age, gender and socio-economic status.

		2004 Questions sent to a television program for children		**2014** Questions submitted during a commercial children's exhibition	
		n	**%**	**n**	**%**
Age	Preschool (ages 3-5)	5	0.3	1,285	16.5
	Elementary school (ages 6-12)	1,229	73.3	5,640	72.4
	Middle school (ages 13-15)	200	11.9	205	2.6
	High school (ages 16-18)	19	1.1	27	0.3
	>18	8	0.5	272	3.5
	Missing data	215	12.8	363	4.6
	Total	1,676	100%	7,792	100%
Gender	Boys	644	38.4	3,715	47.7
	Girls	496	29.6	4,077	52.3
	Missing data	536	32	-	-
	Total	1,676	100%	7,792	100%
Socio-economic status[1]	<6	462	27.6	771	9.9
	6	208	12.4	1,562	20
	7	399	23.8	1,212	15.6
	8	390	23.3	2,989	38.3
	9	51	3	823	10.6
	10	4	0.2	27	0.3
	Missing or out of Israel	162	9.7	408	5.2
	Total	1,676	100%	7,792	100%

[1]The socio-economic scale ranks local authorities [districts] from 1 (lowest socio-economic level) to 10 (highest). The number of people in each cluster is different, with most of the population falling in the mid-clusters (CBS, 2002, 2014).

Data analysis: classification of science-related questions. The analysis was based on the topical classification scheme of the data used in 2004 (Baram-Tsabari & Yarden, 2005). The science related questions were assigned to one of the following categories: 'biology', 'physics', 'chemistry', 'Earth Science', 'astrophysics', 'nature of science inquiry' (NOS), and 'technology'. The inter-rater reliability on 6% of each dataset was 89% in 2004 (Baram-Tsabari & Yarden, 2005 p.807) as compared to 90% in 2014. Based on this scheme, the main categories were further divided into subcategories identified in 2004 database (Baram-Tsabari & Yarden, 2005 p. 808). This included the identification of repeated questions. These covered variations on the same questions, e.g., the questions 'Are we alone in the universe?' and 'Is there life on other planets?' were counted as the same FAQ. Examples of the application of the categories and subcategories to the 2014 database are presented in Table 6 (similarly, examples from the 2004 database are presented in Baram-Tsabari & Yarden, 2005 p.808).

Table 6. Examples of classification of questions sent to a commercial exhibition (the 2014 database[1]) according to field of interest.

Topic	Subtopic	Example
Biology	Human physiology	Why do we get old?
	Nutrition	Why is it important to eat vegetables?
	Diseases	Why there is no cure for cancer?
Technology	Innovations	Who invented the car?
Physics	Electricity (classic)	How does electricity go through wires?
	Time travel (modern)	Why can't we travel through time?
Astrophysics	The solar system	Why does the Earth revolve around the sun / rotate on its own axis?
	Big bang	How did the universe begin?
Earth Sciences	Meteorology	Why are there clouds in the sky?
Chemistry	Bonding and structure	Why is it impossible to break a diamond?
	Chemical reaction	How do matches work?
Nature of science		Why do people study different places?

[1]Examples of the classification of the 2004 database are available in Baram-Tsabari & Yarden, 2005 p.808.

Limitations. Although in both environments the participants were asked to write 'any question that interests them', on the TV show, questions were sent by email, such that the questions were not limited to a specific time or length. However, in the exhibition, the visitors could only write their questions in the tablet stage and each was limited to 32 characters. Moreover, the questions could have been influenced by the content and style of the questions that were presented at the exhibition. Thus, a comparison of the frequently asked questions in 2004 to 2014 could only be made for the main topic of the questions (e.g. 'biology'; 'technology' etc.).

Findings

Stability of interest between 2004 and 2014. The categorization of the questions according to fields of interest in both years is presented in Table 7. As in 2004, most of the questions were biological and the percentages of the questions in the fields of physics, astrophysics, and Earth

Sciences were similar. However, using a multiple comparison test with a Bonferroni correction revealed a significant difference (χ^2=456.3, $p<0.001$) in the fields of biology, physics and technology.

In 2004, 45% of the 419 technological questions were related to computers and the internet (e.g. 'I want to know how to build an internet site and if it is difficult'). In 2014, only 13.3% of the 604 technological questions were related to computers but another 19.5% were related to advanced technologies, such as tablets and mobile phones (e.g. 'How does a touchscreen work?'), that were less common or did not even exist 10 years earlier.

Within the biology category in 2004, 72% of the 831 biological questions were essentially zoological (Baram-Tsabari & Yarden, 2005 p.812), whereas only 20% dealt with zoology in the 2014 dataset. However, within the biological questions concerning health issues, cancer remained a major concern for children in 2004 and in 2014, and was the most frequently mentioned disease (e.g., 'Why there is no cure for cancer?'). In the field of astrophysics, issues concerning extraterrestrial life (e.g., 'Is there life in space?'), the Big Bang and star formation were popular in both years.

Table 7. Categorization of questions sent to a TV show in 2004, and questions submitted during a commercial exhibition in 2014, by field of interest.

Field of interest[1]	Example	2004 n	2004 %	2014 n	2014 %
Biology	Why do we need food / water?	831	49.6	4,439	56.9
Technology	Why don't we have hoverboards?	419	25	604	7.7
Physics	Why does gravity always pull down?	71	4.2	766	9.8
Astrophysics	Why do black holes exist?	204	12.2	1,108	14.2
Earth Science	Why do volcanoes erupt?	102	6.1	661	8.4
Chemistry	Why do clothes wear out?	40	2.4	174	2.2
No assigned category	Is there an answer for everything?	7	0.4	30	0.3
Nature of science	Is it possible to study the future of the Earth?	2	0.1	10	0.1
Total		1676	100	7792	100

[1]The ways in which children formulated questions may have been influenced by the questions presented in the TV show (2004) or in the exhibition (2014). Therefore, the comparison between databases only addressed the scientific domain of the questions (e.g. 'biology'; 'technology' etc.).

Generalizability of interest across genders. In the 2004 dataset from the TV show, boys asked 56.5% of the 1140 gender-identified science-related questions (Table 5). In the data from the 2014 exhibition, boys asked 47.6% of the 7,792 science-related questions. There was no significant difference between genders in the number of the science-related questions relative to the total number of questions asked in the exhibition by boys (6,235 questions, 59.6% were science-related) and girls (6,951 questions, 58.7% were science-related).

A chi-square test revealed a significant difference in the fields of interest of questions by genders. Figure 2 presents the distribution of each subject for boys and girls at both time points. 'Chemistry' and 'NOS' categories were not included since the number of questions was too low to enable a meaningful quantitative analysis.

Insert Figure 2 about here

In 2004 boys dominated the 'Physics' category (χ^2=7.48, $p<0.05$), and 'Technology' (χ^2=4.2, $p<0.05$). No significant differences were found in the 'Earth Science' and 'Astrophysics' categories. In 2014, girls dominated the biology category (χ^2=46.83, $p<0.001$) whereas boys still dominated 'Technology' (χ^2=29.49, $p<0.001$), 'Physics' (χ^2=18.72, $p<0.001$) and 'Earth Science' (χ^2=6.02, $p<0.01$). No significant differences were found in the 'Astrophysics' category.

Despite these stereotypical differences, many questions interested both genders. Table 8 details the ten most popular questions for boys and girls in the 2004 exhibition database (in parentheses, the frequency of the questions). Seven questions out of the top ten appeared on the lists of both genders. Note however, that the popular question 'why do we fart?' was asked mostly by boys (34 out of 49 times), and the poplar question 'why do babies cry?' was asked mostly by girls (42 out of 67 times).

Table 8. Ten most frequently asked questions in 2014[1] (number in parentheses indicates frequency). Questions popular for both genders are marked in grey. White background marks questions popular for only one gender.

Boys (*n*=3,715)	**Girls (*n*=4,077)**
1. Why can't we fly like birds? (194)*	1. Why can't we fly like birds? (227)
2. Why do we die / don't we live forever? (94)	2. Why do we die? / don't we live forever? (119)
3. Why do we need to sleep? (72)	3. Why do we need food / water? (90)
4. Why do we need food / water? (63)	4. Why do we need to grow up? (84)
5. Why do we need to grow up? (56)	5. Why are people different from each other? (57)
6. Is there life in space/on other stars? (41)	6. Why is the Earth round? (50)
7. Why is the Earth round? (38)	7. Why are there clouds? (49)
8. Why / How does the Earth rotate? (34)	8. Why do we dream? (48)
9. Why do we fart? (34)	9. Why do babies cry? (42)
10. Why do we dream? (32)	10. Why / How does the Earth rotate? (41)

[1]Most of the questions in 2004 were unique; therefore, only the data from 2014 are presented.

Generalizability of interest across age groups. In both 2004 and in 2014 the relative frequency of questions categorized as 'Zoology' decreased with age, whereas interest in 'human biology' increased (although the initial interest was different at the two time points).

Relative to the number of questions asked by each age group (presented in Table 5), older contributors to the 2014 database asked more questions about babies (e.g., 'Why do babies cry?'), sleeping (e.g., 'Why do we need to sleep?'), and aging (e.g., 'Why does hair turn white when a person gets older?'). A popular subject in the middle school group (ages 12 to 14) was the sober topic of 'death' (e.g., 'Why do we die?'), which made up 4.9% of their questions. This age group had the lowest proportion of questions in almost all subjects. Among the youngest visitors (ages 8 or less), popular subjects were 'teeth' (3.4% of their questions; e.g., 'Why do I have to brush my teeth?'), inventions (1.7% of their questions; e.g., 'Why don't we have hover-boards?'), and 'clouds' (1.4% of their questions; e.g., 'Why do clouds have different shapes?').

Discussion and Implications

The main goal of this study was to examine which types of contexts would be interesting for many students and remain relevant for many years. Using four sets of databases, we examined the stability of interest in science and its similarity across different student groups with regard to gender and grade level. A summary of the findings for both studies is presented in Table 9.

Table 9. Summary of findings of study 1 and study II

	Study I **Formal environment** 2007 / 2016 2,353 questionnaires	**Study II** **Informal environment** 2004 / 2014 9,468 self-generated questions
Stability of interest between decades	A significant linear relationship (*r*=0.917) between students' interest in 32 science related questions.	Similarity between students' interests as expressed in the frequency of spontaneous questions in biology, astrophysics, Earth Science and chemistry.
Generalizability of interest across genders	No significant differences were found in the overall average interest for all questions (32 questions).	No significant difference between genders in the number of science related questions. However, there was a significant difference in the field of interest of questions asked by the two genders.
	In both formal and informal environments, seven out of the 10 most popular questions were asked by both genders.	
Generalizability of interest across ages	The overall average interest level was significantly higher for elementary school students than high school students.	In 2014, relatively to the total number of questions asked by each age group, elementary school students asked the highest percentage of science related questions (59.8%).
	Middle school students had the lowest average interest level.	Relative to the number of questions asked by each age group, middle school students had the lowest proportion of questions in almost all subjects

The findings indicate that although there was some variability, students' interest in science-related questions remained relatively stable over almost 10 years according to data collected in both the formal and informal environments. In Study I, this similarity was reflected in the significant linear relationship between 2007 and 2016 with regard to the questions students marked as interesting to learn about. In Study II, it was reflected by the resemblance between the self-generated questions submitted informally in 2004 and in 2014.

Stability was also related to specific context. For example, the question 'Is there life on other planets?' was the most interesting question in 2007 and in 2016 and was also a popular question in the informal databases from 2004 and 2014. The 'possibility of life outside Earth' context was the most popular topic among 13-year olds in a multi-national study of 21 countries (Sjøberg, 2000) among 1-3rd graders (Gallas, 1995), and among secondary students in Sweden (Jidesjö, 2010) in a study based on the ROSE questionnaire.

Another notable example of the stability of students' interest in a specific context was 'cancer', which was the most frequent disease mentioned in questions regarding health issues in 2014. Cancer was also repeatedly raised in high school students' questions in biology classes (Hagay & Baram-Tsabari, 2011) and also appeared in the top 10 most interesting issues among 15-year old students in an international sample using the closed ROSE questionnaire (Schreiner, 2006).

'Cancer' and 'extraterrestrial life' are only two examples of a stable context which can 'facilitate the integration of the students' worlds of family, friends, schooling, and science' (Costa, 1995 p.331). Costa (1995) suggested organizing science courses around the question 'How does it (chemistry, biology, physics etc.) impact my personal life and society?' She listed 'cancer', along with AIDS, as examples of contexts for the immune system topic.

Although the 'biology' and 'astrophysics' domains were very popular, a real-life context is particularly important in domains such as 'chemistry' and 'NOS', which face the problem of perceived lack of relevance and interest (Gilbert, 2006). Unfortunately, in these exact domains there are not many questions to guide us in choosing interesting contexts (Table 7). However, we can use contexts from frequently asked questions in different domains that are also relevant to chemistry. For example, the FAQ 'why do we fart?' can be used in the context of chemistry for the 'law of conservation of mass and energy' and 'stoichiometry' topics; FAQ such as 'How does a touchscreen work?' can be used in the context of 'electrical conductivity' topic, etc.

Questions provide 'a real-life context to promote students' engagement and interest in learning about scientific ideas to explain phenomena' (Merritt & Krajcik, 2013 p.23). The results here indicate that *frequently asked questions* might also be a potential *stable resource* for choice of contexts for science curriculum topics. Despite the significant differences in students' interests in some of the subjects such as 'technology' (which may be explained by the tremendous changes over the last ten years), the findings indicate (Tables 4 and 8) a stable interest in frequently asked questions across different groups of learners.

Although boys and girls differed significantly in their interest in some of the topics and there are many studies which have emphasized gender differences in science (e.g., Miller, Slawinski Blessing, & Schwartz, 2006), the findings here indicate common interests for both genders in many frequently asked questions. As Schreiner (2006 p.12) noted 'Both girls and boys are interested in learning about enigmas and phenomena science still cannot explain, such as dinosaurs, the origin of life and mysteries in outer space'. Similarly, in the present study, boys and girls were interested in unsolved mysteries such as 'Why don't we live forever?'; 'Why do we dream?' and the biggest question of extraterrestrial life.

Frequently asked questions may also be a potential resource to identify interesting contexts *for each grade level.* For example, in Biology, the findings indicated a similar tendency across different contexts. Consistent with previous studies (e.g. Tamir & Gardner, 1989; Baram-Tsabari, Sethi, Bry, & Yarden, 2010), while interest in 'Zoology' decreased with age, interest in 'Human Biology' increased. The reverse tendency was reported for interest in 'Medicine', 'Genetics' and 'Evolution' (Baram-Tsabari et al., 2010).

The national science curriculum of Israel is based on the Science, Technology and Society (STS) approach (Israeli Ministry of Education, 2013), which emphasizes the relevance of science content to students' everyday life. However, disparities between the curriculum and students' interest have been documented for elementary (e.g. Swirski & Baram-Tsabari, 2014), middle (e.g. Mcphail, Pierson, Freeman, Goodman, & Ayappa, 2000) and high school (e.g. Hagay & Baram-Tsabari, 2011) students. This was also confirmed by the low popularity of textbook questions in Study 1, which are based on the science curriculum and tend to be teachers' primary resource for content (Nicol & Crespo, 2006).

'There is a need for reforms that are context specific, that require multiple approaches and are implemented for long periods of time' Sjøberg (2002 p.307). The context in which information is embedded has an effect on whether or not people pay attention to it (Nahon & Hemsley, 2013). Dawson (2000 p.568) asked:

> If we believe that students' interests are important in supporting achievement and for widening the opportunities for them to eventually participate more fully both in society and in the workplace, how can information about their interests be used to best effect in the classroom?

Naturally, the national science curriculum cannot provide the answers to each and every student's question. However, it may be possible to narrow the gap between students' interests and the science curriculum by using frequently asked questions as a context for learning. Let us consider the extremely unpopular textbook question, 'What processes need to exist in an organism in order for it to be considered alive?' (Study I) and contrast it with the extremely popular question 'is there life on other planets?' It is obvious that the first question can be studied in the context of the latter: students will be more interested in the characteristics of living organisms in the context of extraterrestrial life.

Incorporating frequently asked questions into learning and teaching materials can enhance the relevance of science to students' lives and tap their existing interests in science. This was also shown in Swirski and Baram-Tsabari (2015), which indicated that individual questions from an Ask-An-Expert website could provide the context for relevant and meaningful science teaching. We hope that the evidence presented in this paper will be used to contextualize and personalize some of the formal science curriculum. This would answer a question asked by a fifth grade girl when she submitted her questionnaire in study I: 'do you really believe that it will have an effect so one day we can truly learn what we want?'.

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Figure 1. Students' average interest in frequently asked questions (FAQ), self-generated questions (SGQ), and textbook questions (TBQ) in 2007 and again in 2016 ($r = 0.917$). Questions are listed in their order of popularity (proportion of students marking they would like to know the answer) in 2016. Effect size is detailed where a significant difference between 2007 and 2016 was found.

Figure 2. The distribution of self-generated questions according to science subjects mentioned by boys and girls (relative to the number of question asked by each gender) in two databases: A. questions sent to a TV show in 2004, and B. questions submitted during an exhibition in 2014 (the 'Chemistry' and 'Nature of Science' categories were too small to be included).