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Measuring students' continuing motivation for science learning

David Fortus , Dana Vedder-Weiss

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Abstract

Continuing motivation for science learning may be manifested through engagement in extracurricular science-related activities, which are not the result of school or other external requirements. Very few articles have appeared in the last decade on this important aspect of science learning. This article presents a survey based on seven Likert-type items for measuring adolescents' continuing motivation for science. It describes how the survey was developed, tested, and used to explore the relations between school type, grade, and gender and adolescents' continuing motivation for science learning. Data on the continuing motivation of 2,958 Israeli 5th–8th grade students, from traditional and democratic schools, were collected and analyzed using polytomous Rasch techniques and hierarchical linear modeling. The results indicate that in both types of schools girls had lower continuing motivation for science than boys, and that while the continuing motivation of both boys and girls in traditional schools decreased between 5th and 8th grade, the continuing motivation of students in democratic schools remained constant during this period. J Res Sci Teach 51: 497–522, 2014

Researchers in science education have tended to investigate the affective aspects of learning less than its cognitive ones (Koballa and Glynn, **2007**). Those that have studied affective constructs have focused mostly on the role they play in schools and universities. A search through the websites of the *Journal of Research in Science Teaching* , *Science Education* , and the *International Journal of Science Education* (done on May 18, 2011) revealed that among the 1,800 articles published since the beginning of 2000, only 152 articles dealt with motivation, interests, or attitudes. Only a handful of these 152 articles (about 3%) dealt with students continuing motivation (CM)—students' motivation to engage in science learning in differing contexts on their own initiative (Ford, Brickhouse, Lottero-Perdue, & Kittleson, **2006** ; Halkia & Mantzouridis, **2005** ; Maltese & Tai, **2010** ; Vedder-Weiss & Fortus, **2011**).

As is argued later in this article, much of what we know about the world is derived from our experiences *outside* of school (Dierking, Falk, Rennie, Anderson, & Ellenbogen, **2003**). The study of CM for science learning is important because it may enable a better understanding of ways to support extracurricular learning, and through that to advance science learning in general. The existence of an instrument that assesses science CM will contribute to such research. Thus, the goals of this study were twofold: first, to describe the development of a scale measuring adolescents' CM for science learning and second, to demonstrate the value of this scale by applying it in two contrasting school environments, traditional and democratic schools, revealing the relation between school context and its students' CM for science learning.

What Is Continuing Motivation?

CM is a term coined by Maehr (**1976**) who conceptualized it as a "**behavior** in which the individual, relatively free from external constraints, returns to a task or task area and works on it on his own" (p. 448). Thus, CM may be defined as "(1) a return to a task (or task area) at a subsequent time, (2) in similar or varying circumstances, (3) without visible external pressure to do so, (4) and when other behavior alternatives are available" (p. 448). For example, a student who chooses to engage with science during her free time might be described as displaying CM for science if (1) she chooses to continue engaging in science in the future, (2) across a variety of contexts (e.g., at home while watching TV and reading a magazine while visiting her grandparents), (3) without receiving any rewards or punishments, and (4) when other alternative activities (e.g., watching other TV programs, playing computer games) are also available.

Maehr's definition of CM fits a contemporary conceptualization of motivation "as action" (Schunk, Pintrich, & Meece, **2008**). According to this definition, CM relates to the behavior and not to the motives, attitudes, or interest driving it. Thus CM is distinguishable from other motivation constructs such as intrinsic motivation, interest, attitudes, and mastery goals orientation. For example, intrinsic motivation is the motivation to engage in an activity for its own sake—for the pleasure and satisfaction derived from activity itself (Deci & Ryan, 1985). Since we conceptualize CM as reflecting free will, it is expected that in many cases CM will be intrinsic, yet not necessarily always; a student expressing CM by reading about the latest astronomy discoveries is likely to be intrinsically motivated (i.e., reads because she finds it interesting). She may also be, at least to some extent, extrinsically motivated, meaning she is motivated to engage in this reading as a means to an end (e.g., she reads because she wants to impress her peers). Hence, while one may expect a positive correlation between intrinsic motivation for science learning and science CM, these are distinct constructs. In the same manner, while continuingly motivated, a student may or may not be mastery oriented when reading and her reading behavior may be affected by different interests and attitudes (Azevedo, 2011; Renninger, 2007). Furthermore, a student may find science interesting and have positive attitudes toward it, yet neglect to engage in any concrete activity that involves science content or practice, thus exhibiting low CM.

CM is closer in its conceptualization to "persistence," which also refers to a behavior. CM may be considered as a special case of persistence as both these terms relate to continuing engagement in a task or with content. However, "persistence" relates also to a continuing engagement when the contextual conditions remain the same (such as classwork) or when it is affected by external pressure (such as homework), while CM refers to those instances when a task or a content has been returned to under differing contextual conditions and without visible external pressure (Maehr, 1976). Conceptualizing CM as a behavior, it is important to note that we expect it to be manifested in different modes: active behavior (e.g., seeking), passive behavior (e.g., accepting), and avoiding behavior (e.g., ignoring or rejecting).

Theoretically, classroom motivation may overlap with CM; classroom engagement may theoretically be free from external pressure and involve varying contextual conditions (e.g., a student choosing to surf the web for more information, beyond what was read in the textbook, during class time, without being required or asked to do so). However, since this is not usually the case, CM should be theorized separately from classroom engagement. Furthermore, not only does CM not necessarily align with classroom motivation, it may also conflict with it; instructional approaches that encourage classroom engagement (e.g., test preparation) may simultaneously discourage CM by enhancing negative attitudes toward learning (Maehr, 1976). In contrast, informal science learning settings (be they intentionally designed for learning or not) are usually characterized by a greater contextual variation and more free-will engagement (Dierking et al., 2003). Thus, CM is more likely to be expressed in informal settings than in formal ones.

For a behavior to be considered CM for science, it should be perceived by the student as related to science but it does not necessarily need to be perceived as a learning activity (Maehr, 1976). Hence, CM in science may be manifested through activities such as browsing science-related websites, doing hands-on experiments after school, dismantling apparati to see how they work, watching science-related TV programs, going to science clubs and science centers, looking at the science section in newspapers, etc., as long as these activities are not the result of school or other external requirements. Some researchers argue that science CM may also be manifested by elective enrollment in science courses (Anderman & Weber, 2009).

Theoretically, CM may to some extent characterize a learner and be more or less stable across different domains and contexts. Nevertheless, since it is influenced by many factors, it may vary across domains and contexts (just like many other motivational constructs—see Schunk et al., 2008). In other words, one may have a general motivation to continue learning any subject on one's own initiative. Nevertheless, a person's CM for *science learning* may be affected by contextual factors, resulting in a science CM which is higher or lower than the person's CM for other domains.

To conclude, our definition for CM is: an engagement with scientific content or practices, which is free from external incentives and is manifested across varying contexts when other alternatives are available.

Why Is Continuing Motivation Important?

Researchers have argued that much of what people know about the world is derived from experiences *outside* of school (Dierking et al., 2003) and that experiencing science in out-of-school settings, rather than just learning science in schools, contributes much to budding scientists and to general science literacy (Duschl, Schweingruber, & Shouse, 2007 ; Pascarella, Walberg, Junker, & Heartel, 1981 ; Rennie, Feher, Dierking, & Falk, 2003). For example, in the book *Learning Science in Informal Environments: People, Places and Pursuit* , the Committee on Learning Science in Informal Environments, set up by the National Research Council, stated that the:

> Effort to enhance scientific capacity typically target schools and focus on such strategies as improving science curriculum and teacher training and strengthening the science pipeline. What is often overlooked or underestimated is the potential for science learning in non-school settings, where people actually spend the majority of their time.

> Beyond the schoolhouse doors, opportunities for science learning abound … Informal environments include a broad array of settings, such as family discussions at home, visits to museum, nature centers or other designed settings, and everyday activities like hiking and fishing and participation in clubs … personal hobbies, watching TV, reading books or magazines, surfing the web or helping out on the farm. The committee found abundant evidence that across all venues—everyday experiences, designed settings, and programs —individuals of all ages learn science (Bell, Lewenstein, Shouse, & Feder, 2009 , p. 1).

Since learning science is not done solely in schools, and if we accept the argument that lifelong learning is crucial in the twenty-first century, then students' motivation to engage, of their own initiative, in science learning outside of school (i.e., CM) is highly important.

CM is also important with regard to the disturbing decline in number of students pursuing a science-related career (Lowell, Salzman, Bernstein, & Henderson, 2009). Findings suggest that out-of-school science experiences influence students' science career choices, in particularly among women from low-income families (Fadigan & Hammrich, 2004). Many scientists relate their early interest in science to self-initiated activities rather than to school-related activities (Maltese & Tai, 2010).

Moreover, one may argue that out-of-school science learning can compensate for the negative impact schools often have on students' attitudes and motivation toward science and science learning (Vedder-Weiss & Fortus, 2011, **2011, 2012** ; Yager & Penick, **1986**). For example, Solomon (**2003**) found that children enjoyed engaging in and talking about science at home with their parents, and many of them even made an original contribution to a prescribed activity. The same children were much less fluent in science class and were also reluctant to talk about school science experiences at home. Whenever parents made connections to school science, the children became uncomfortable. Laukenmann et al. (**2003**) found that high achieving students enjoyed learning science in school, while low achieving students preferred pursuing science at home. Thus, pursuing science at home (i.e., CM) may be especially beneficial for students who usually do not connect to school science learning, including underrepresented groups, such as women and minorities (Fadigan & Hammrich, **2004**).

In light of the many potential benefits of CM for science, it should be fostered in all students (Anderman & Weber, **2009**) and it may be viewed as a desired outcome of formal science education. In his study of the experience of two students studying Newton's laws, Pugh (**2004**) stressed "the potential of learning to enrich students' every day, out-of-school experiences." While Pugh referred mainly to the intellectual and emotional experience, our notion expands the effect of school science learning to include also behavior. That is, we argue that school's science learning has the potential to impact students' everyday experiences by enhancing their CM—their engagement with extracurricular science activities.

Prior Research on Continuing Motivation for Science Learning

Despite its importance, not much is known about science CM. As Georghiades (**2000**) pointed out in relation to science education research "Very little interest has been exhibited in what happens *after* learning has taken place" (p. 122). Also the NARST *ad hoc* committee on informal science education stated that "Clearly lacking … are … studies of learning from film, radio, community-based organizations such as scouts, summer camps, home, friends, the workplace, the Internet, and a whole range of other real-world situations" (Dierking et al., **2003** , p. 109).

While there are many publications dealing with informal science education (e.g., Jarvis & Pell, **2005** ; Kisiel, **2005**), these tend to focus on the *learning* of science in physical settings that are outside of the traditional confines of the school and that are designed for science learning, such as museums, after-school clubs, science camps, and enrichment programs (Renninger, **2007**). Only few have focused on the precursors to this learning, on the *motivation* to engage with science in these settings (e.g., Falk & Adelman, **2003** ; Falk & Needham, **2011** ; Falk & Storksdieck, **2010** ; Rennie & Williams, **2002**). Even fewer investigated the motivation for science learning in un-designed settings. Those that did usually did not refer to it as CM. Such studies include, for example, the investigation of students' science reading; Halkia and Mantzouridis (**2005**) compared the formats used to communicate science information by newspapers and by textbooks and found that high school students shy away from articles using graphs and diagrams and prefer articles that use metaphorical and poetic language. Their results indicate that the narrative elements used in popular texts stimulate students' interest and can motivate them to read further. Ford et al. (**2006**) investigated what influences science reading among 3rd grade girls and highlighted the effect of family encouragement.

Zimmerman (2012) investigated science CM in an un-designed setting by describing and analyzing Penelope's engagement in science-related activities at home, revolving around her pets' caring practices. He showed how issues of recognition and identity affected Penelope's everyday science practices. The complex nature of CM was also addressed by Azevedo (2011) in his study of science-related hobbies. He stressed the importance of "understanding persistent engagement in a practice of interest" (p. 151) and exemplified how much might be learned by an in-depth investigation of such a behavior. His findings highlighted the interaction between psychological dimensions (which he named "preferences") and contextual ones (which he named "conditions") in such an engagement and its dynamic manner. Another investigation highlighting the role of contextual factors showed that in general, when classrooms are more teacher-dominated, adolescents tend to have lower science CM (Pascarella et al., 1981).

The investigation of CM is scarce not just in the field of science education. In an essay revisiting CM theory and research, Anderman and Weber (2009) regretfully asserted that there are only few examples of studies investigating CM in all educational fields. They concluded their review by stating that "In 1976, Maehr noted that 'continuing motivation' was not a valued outcome in education, although it should be. Thirty years later, researchers and policy-makers continue to espouse the importance of continuing motivation. In reality, however, little research or active policy emphasizes the importance of continuing motivation" (p. 15).

The study of science CM is of extreme importance since it has the potential of illuminating the role science CM actually plays in science learning and the factors that influence it. If policy makers and educators (at schools, homes, and other informal settings) will have a better understanding of ways to support science CM, they may be able to facilitate the conditions that foster it and thereby advance science learning.

The Measurement of Continuing Motivation

An important way to advance the study of science CM, its antecedents and the role it plays in science learning, is to provide a valid and reliable instrument assessing CM for science. Such an instrument will allow researchers to quantitatively study the construct, generalizing and adding to the understandings that qualitative approaches may yield and identifying areas where additional qualitative research is needed. A quantitative measurement of CM for science may be used to study, for example, the relations between environmental factors (e.g., school culture), individual factors (e.g., age, gender) and CM. This may facilitate the development of a model predicting CM and its development with age, thus offering new insights as to how to support CM.

The only study we found that quantitatively studied students' science CM, as we conceptualize it, was conducted over three decades ago by Pascarella et al. (1981). While they developed an instrument to measure science CM, this instrument did not consider many of the ways in which twenty-first century students may engage with science (such as through the Internet) and did not draw on modern statistical techniques to establish the instrument's validity and reliability. Other quantitative studies investigated only one aspect of CM for science, primarily enrollment in elective science courses (e.g., Bøe, 2012 ; Cavallo & Laubach, 2001 ; Shernoff & Hoogstra, 2001 ; Sjaastad, 2012 ; Tai, Liu, Maltese, & Fan, 2006). Other than that, we have not been able to find in the research literature published in English any instruments that explicitly measure students' CM in science as evidenced by self-initiated engagement. Science motivation questionnaires have been developed (Glynn, Brickman, Armstrong, & Taasoobshirazi, 2011 ; Glynn & Koballa, 2005 ; Glynn, Taasoobshirazi, & Brickman, 2009) as well as a scale assessing students' attitudes toward out-of-school science (Kind, Jones, & Barmby, 2007) but, as explained above, they do not measure students' actual engagement in extracurricular science activities. The website http://www.pearweb.org/atis/tools provides a range of assessment instruments in informal science. None there deal with CM. The only updated measurement we could find which considers aspects of CM (without using that name) is the one used for the Program of International Student Assessment (PISA, 2006). PISA's measures assessed, among other things, participation in out-of-school science-related activities. Students were asked to respond to items that related to science TV and radio programs, science magazines, articles and books, science websites, and science clubs. These items measure some aspects of CM. However, they do not address many additional aspect of CM, such as building or taking apart things, responding to e-mails, talking to family and friends, doing experiments, etc.

In light of the importance of science CM, the paucity of research on it, and the need for a comprehensive updated valid and reliable instrument for its measurement, the study described herein had two goals. The first was to develop a valid and reliable instrument (a survey) measuring science CM. The second was to use this survey to explore the relation between the school context, gender, grade, and students' science CM.

School Context and Continuing Motivation

Although not necessarily their main encounter with science, adolescents do experience science learning at school. For many of them this may not always be a positive experience or a meaningful one. Nevertheless, it is reasonable to hypothesize that this experience and therefore the school context have an effect on their science CM. Furthermore, as discussed above, complex contextual factors, beyond those in the immediate engagement setting (such as teacher and parents), have been found to affect CM (Azevedo, 2011 ; Pascarella et al., 1981). Therefore, in this study, we explored the relation between the school context and students' science CM. We did so by examining how adolescents' science CM changes between grades 5–8 in Israeli traditional and democratic schools.

Most schools in Israel are “traditional”; however, since there is large variability between schools in Israel, so we use the term “traditional” uneasily. We chose this term because these schools follow nationally set curricula, use standardized high-stakes tests as the main measure of success, and serve the vast majority of all secular Israeli students. These are not schools of choice—they tend to serve communities within a given geographical zone. Democratic schools, on the other hand, use this name to identify themselves. There are about 25 such schools in Israel and more than 200 across the world (International Democratic Education Network, 2012). They are schools of choice, but they are supported by public funding. Democratic schools have a few common characteristics, among them: they are democratically co-managed by students, parents and the school staff, students choose how to spend their time at school, and teachers do not necessarily follow the national curriculum. A guiding principle in these schools is that of student autonomy: students' feeling that the impetus of their behavior is internal and that it reflects their needs, desires, and tendencies (Alternative Education Resource Organization, 2013 ; Institute for Democratic Education, 2012 ; International Democratic Education Network, 2012). Thus, in democratic schools, students decide in which classes to participate. In some of these schools, students can decide whether to participate in any classes at all; they may also influence the content and structure of classes. At present, science learning is elective in all Israeli democratic schools at all ages.

Democratic schools explicitly attempt to support students' autonomy, to foster intrinsic rather than extrinsic motivation and to enhance lifelong learning (Institute for Democratic Education, 2012). Because CM is conceptualized as a behavior free from external incentives, it is expected to be related to autonomy support and, as explained earlier, also to intrinsic motivation. Indeed, students' autonomy in science class was found to be related to their science CM (Pascarella et al., 1981). Thus, because students in democratic schools were found to experience more autonomy and to be more intrinsically motivated than students in traditional schools (Vedder-Weiss & Fortus, 2012 ; Zanzuri, 1997), we hypothesize that these students should demonstrate higher levels of CM in comparison to students in traditional schools.

Previous findings show that students' motivation for school science learning in Israeli traditional schools declines toward and after the transition to middle school. In democratic schools such a decline was not found, indicating that the decline in adolescents' motivation for science learning is not inevitable. Data on students' perceptions of their schools and parents, as well as data from teachers and parents, suggest that this decline is related to the school environment (Vedder-Weiss & Fortus, 2011, 2012, 2011-2013). Are these patterns apparent also with regard to CM? Does the school influence the development of science CM the way it affects the development of motivation toward school science learning?

In the second part of this study, we demonstrate the use of the survey we developed by examining the relation between school types (traditional vs. democratic) on students' CM. This enables us to: (A) test our hypothesis that students CM is higher in democratic school than in traditional schools and (B) investigate whether the differences we found before in students' age-driven trends in motivation for school science learning are apparent also in their CM. Answering these questions will allow an initial insight into the school's role in its students' science CM. While doing so, we also look into gender differences, assessing whether gender differences in motivation for science learning are also apparent in science CM and whether the differing school environments are related to this difference.

Science Continuing Motivation During Adolescence

Previous research has found that student attitudes and motivation toward science decline dramatically before and after the transition to middle school (Osborne, Simon, & Collins, 2003 ; Tai et al., 2006 ; Vedder-Weiss & Fortus, 2011, 2011, 2012). At the same time, it appears that middle school years are the time when many develop long-lasting interest in science (Maltese & Tai, 2010 ; Tai et al., 2006). Some argue that such an interest in science develops even earlier, and that for many students, middle school is the last opportunity to develop it. High school might be too late (Lindhal, 2007 ; The Royal Society, 2006). For example, in their study of high school students' science aspiration, Aschbacher, Li, and Roth (2010) reported not finding even a single student who developed a new strong interest in science after 10th grade (out of a diverse sample of 33 students). Since late elementary and middle schools appear to be critical in terms of students' science motivation, we decided to focus our investigation on this age-span. Thus, the scale we developed and its utility were targeted toward late elementary and middle school students.

Part 1: The Development of the Continuing Motivation Survey

Methods

Survey Construction

We developed a series of Likert-type items describing all the different extracurricular science-related activities that fit our definition for CM: they consist of engagement with scientific content or practices, and they are manifested across varying contexts when other alternatives exist and not because they are required by school (or family). The choice of activities was guided by our personal and professional experience with adolescents, literature on science learning in informal settings (Bell et al., 2009) and on CM (Anderman & Weber, 2009 ; Maehr, 1976), as well as previous attempts to measure aspects of science CM (Pascarella et al., 1981 ; PISA, 2006). We only included activities we thought adolescents might be engaged in independently, such as watching science-related TV programs, performing hands-on activities, and talking or reading about science issues. We did not include visiting science, hands-on, or natural history museums because these settings are not available for most Israeli adolescents to visit independently. Zoo visits and nature hikes were excluded for the same reason. Some researchers have argued that enrollment in elective science courses may also be viewed as manifesting CM (Anderman & Weber, 2009); however, since our target population was late elementary and middle school students, this aspect was irrelevant. In Israel, as well as in many other countries, there is usually no elective science learning until high school.

As mentioned before, we hypothesized that CM is manifested in different modes—active, passive, and avoiding behavior. Thus, there were items describing students' active engagement, such as "I browse science-related internet sites," their passive engagement, "If I run into an Internet site that deals with science issues, I read or browse it," and their avoiding behavior, "If I see on the internet something related to science issues, I immediately move on to something else." [1]

All the items have identical categories: not true at all, not so true, somewhat true, true, and very true. While categories indicating the frequency of engagement (i.e., seldom, sometimes, often, all the time) may seem more appropriate for a CM scale, we did not use them because we suspected that the variance in students' interpretations of such categories will be wider. For example, for one student "sometimes" watching a science TV program may mean watching it "only" once a day while for another it may mean once a week. Another, more practical reason was that the survey was administered as part of a larger study which investigated other constructs as well (see Vedder-Weiss & Fortus, 2011, 2011, 2012). These constructs were measured using a battery of scales developed by other researchers. We assumed that it would be easier for the students to respond if all the items used the same categories. This might be true for other researchers who may want to use this scale to study the relations between CM and other constructs using additional scales, as many of the scales used in educational research today use these categories, such as the MSLQ (Pintrich & DeGroot, 1990) or the MATSI (Weinburgh & Steele, 2000).

We tested the items we developed with three science education researchers who are or were science teachers and received suggestions regarding the wording of items and types of extracurricular activities that may have been overlooked. Items were revised accordingly. Then the items were comprehension validated by using the cognitive pre-testing procedure (Karabenick et al., 2007) with three students in grades 5–7. In this procedure, students were interviewed, during which they were asked to read each item out loud, explain what it means, choose the right score for them, and explain why they chose it, while providing concrete examples. In this way, we were able to find out whether students understood the items as we intended them to be understood and whether we understood their scorings as they meant them. Students were also asked to suggest additional science-related activities. According to these interviews, items were revised and tested again with three other students in grades 5–7.

Examples of changes we made following the cognitive pre-testing validation are adding two items related to students' behavior while receiving a science-related e-mail, message, or presentation (one describing engagement and the other describing rejection—see Table 1, items 6 and 15). We also added “science, nature, animals, or environmental issues” in several of the items, because interviewees suggested that students may not be clear about what “science issues” may entail. In addition, we were concerned that the respondents might be viewing or reading fictional accounts of science and animals and that this might bias their responses. The cognitive pre-testing precluded this possibility in all items but the one describing reading science-related books (see Table 1, item 14). While one may argue that reading science fiction indicates a motivation for the science domain, the interviewees did not perceive science fiction as “science.” As we contended earlier, for a behavior to be considered as CM for science, it should be perceived by the student as related to science, which is why we decided to explicitly exclude science fiction reading.

Table 1. Items in continuing motivation for science survey[a]

Item No.	Wording
1	I browse Internet sites which deal with science, nature, animals, or environmental issues.
2	I built or took apart stuff related to science or technology (such as electrical appliances), outside the requirements of science class.
3	If I find or receive on my computer something interesting related to science, nature, animals, or environmental issues, I send them to other people.
4	If I see an article in a newspaper about science, nature, animals, or environmental issues, I read or browse through it.
5	If I see on the Internet something related to science, nature, animals, or environmental issues, I immediately move on to something else.
6	If I receive in an e-mail, a message, or a presentation related to science, nature, animals, or environmental issues, I read or watch it.
7	If I see an article in a newspaper about science, nature, animals, or environmental issues, I immediately turn to something else

	to something else.
8	I watch TV programs which deal with science, nature, animals, or environmental issues.
9	I talk to friends, parents, or other people about science, nature, animals, or environmental issues (outside of science class).
10	I look in newspapers or magazines for articles related to science, nature, animals, or environmental issues.
11	If I run into a TV program which deals with science, nature, animals, or environmental issues, I immediately change the channel.
12	If I run into an Internet site that deals with science, nature, animals, or environmental issues, I read or browse it.
13	I planned or performed science experiments outside of science class.
14	I read books about science, nature, animals, or scientists (not including science fiction).
15	If I receive in an e-mail, a message, or a presentation related to science, nature, animals, or environmental issues, I ignore it.
16	I only browse Internet sites which do not deal with science, nature, animals, or environmental issues.
17	I do not go to any activities out of school that are related to science, nature, animals, or environmental issues.
18	I have a subscription to a magazine related to science, nature, animals, or environmental issues.
19	I participate(d) in a science or nature club.

a All items started with “In this academic year …”

Although the items presented in this paper are in English, the test was developed in Hebrew. To check the quality of our translation we translated the items back from English into Hebrew and received the original Hebrew wording. All the items, translated into English, are presented in Table 1.

We envisioned the items as probing a range of CM in science, from outright rejection of anything extracurricular related to science to active searching of extracurricular activities involving science. The items were organized on a continuum, from the item that we believed indicated more than any other the rejection of extracurricular science activities (negative CM) to the item that indicated more than any other the active embracement of extracurricular science activities. Because of the scarcity of research on CM in science, we could not base our hypothesis on prior evidence but rather had to rely on our common sense. In doing so, we related to the intentionality of the behavior and the effort it takes to accomplish it. We hypothesized that things involving physical effort, such as going to a science club (item 19) or doing experiments at home (item 13) and taking apart appliances (item 2) would require the greatest CM while ignoring things sent to you by friends (item 15) would require the greatest rejection because it involves implicitly recognizing that what is important to your friends is not that important to you. Things that involve active searching for science-related information (items 10 and 18) would require greater CM than following up on things that happened to come your way (items 3, 4, 6, 8, 12, and 14). Reading things (items 4 and 14) requires more CM than just browsing things (items 3, 6, 8, and 12). However, intentionally browsing sites (item 1) involves greater CM than doing so after coming upon such information by chance (items 3 and 4). Talking with other people about science (item 9) would be neutral because it may be that the other people initiated the discussion. All the items involving rejection of activities (items 5, 7, 11, 16, and 17) indicate the existence of negative CM. Doing something involving physical activity (item 17) is easier to reject (less negative CM) than intentional browsing or reading (item 16) which is easier to reject than things involving chance (items 5, 7, and 11).

The hypothesized continuum is shown in Figure 1. It was tested during the Rasch analysis described in the Analysis and Results Section. The hypothesized continuum had no actual role in the statistical analysis, other than theoretically validating the results.

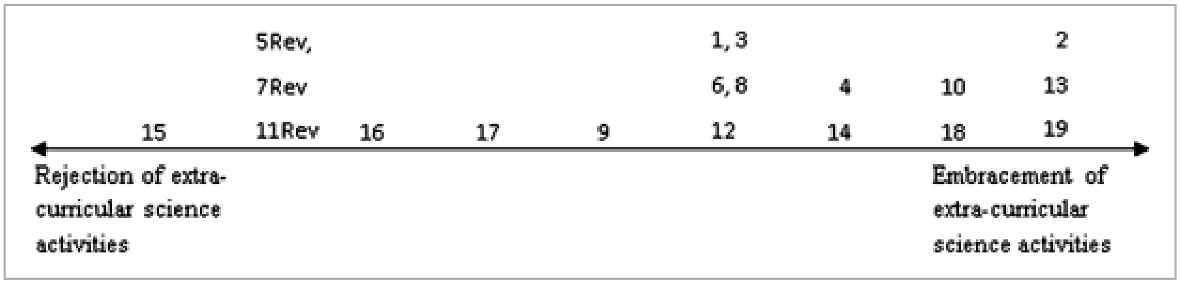

Figure 1.

Open in figure viewer

The predicted location of items on a continuing motivation continuum.

Participants and Data Collection

Two thousand nine hundred and fifty-eight copies of the survey were administered to Israeli Hebrew-speaking students in grades 5–8, from 32 different schools (1,156 copies in 13 democratic schools and 1,802 in 19 traditional schools). Of the participants, 50.5% were girls. Table 2 presents how many students participated from each grade in each school type. The traditional schools drew on families with SESs similar to that of the families that feed most of the democratic schools—upper middle class families. The survey was administered in written form as part of a larger study examining the influence various environmental factors have on students' motivation to learn science, in and out of school (Vedder-Weiss & Fortus, 2011, 2012, **2011-2013**).

Table 2. Number of participants in each grade in each type of school

	Grade				Total
	5	6	7	8	
Traditional	310	418	445	629	1,802

Democratic	318	375	273	190	1,156

Analysis and Results

Constructing a Parsimonious Scale

The survey was developed and tested using polytomous Rasch techniques, which provide an interval scale upon which Likert-type items measuring a single construct and individuals being tested can be placed (Bond & Fox, 2001). Rasch analysis has become the analytical framework of choice for many large-scale projects (e.g., NAEP, TIMMS, PISA), but it is just as applicable to smaller projects (Bond & Fox, 2001): (A) It transforms ordinal data from Likert-type items into interval-based results, a crucial step before performing widely used statistical tests, such as ANOVA and regression; (B) It allows the researcher to determine which items are reliable and necessary, and which are superfluous, thus streamlining an instrument; (C) It allows the researcher to determine if all the items work together to measure a single construct, providing construct validation; (D) The evaluation of the items is independent of the respondents; and (E) It indicates for which respondents the instrument does not provide a reliable measure. The steps in developing the survey followed those suggested by Boone and Townsend (2010).

The participants' written responses were manually keyed into PASW Statistics 18 (the statistical package replacing SPSS). Items 5, 7, 11, 15, 16, and 17 are negatively worded in the survey (e.g., “I don't browse …” instead of “I browse …”). For each of these items we created reverse variables (5Rev for Item5, 7Rev for Item7, etc.). The scores for these reverse variables were equal to 6 minus the score for the original items (e.g., 5Rev = 6 − Item5) so that the range of possible scores remained from 1 to 5 but the higher scores indicated less rejection of extracurricular science activities. While Rasch analysis does not require that negatively worded items be reversed, we did this so that higher scores on all items would reflect higher CM.

Typically a survey is developed and tested on one sample and then applied to others. When that is not possible, the survey is administered to a single large sample, as in this case. Two subsamples are created by randomly dividing the original sample into two. The survey is tested and validated using one subsample and then applied to the second subsample. However, since one of the characteristics of Rasch analysis is that the evaluation of the items is independent of the respondents (Bond & Fox, 2001), this procedure, while possible, was unnecessary in our case.

When data are dominated equally by uncorrelated variables, Smith (1996) recommended using factor analysis as an exploratory technique to identify whether there exists any factor and then to separate the items comprising these factors from the test and to perform a polytomous Rasch analysis on them separately. However, when the data are dominated by highly correlated variables or if one factor dominates, Rasch analysis should be used without separating or removing any items from the test. Supporting Information Table 1 shows the Pearson correlations between the different items. A null hypothesis that the variables were not significantly correlated with each other was rejected for all possible pairs of variables at the $p < 0.01$ level. An exploratory factor analysis revealed one dominant factor with an eigenvalue of 7.95, accounting for 42% of the variance. Since the variables were all significantly correlated and the factor analysis indicated that the data were dominated by a single factor, we decided to perform a Rasch analysis without removing any items from the test.

These data were exported from PASW to ConstructMap 4.6 (a freeware Rasch analysis program available at http://bearcenter.berkeley.edu/GradeMap/download.php). A polytomous Rasch analysis indicated that there were 192 participants (7% of the entire sample) whose normalized outfit[2] was outside of the range $-2 < t < 2$. This means that the Rasch model could not provide an adequate justification for these participants' responses, so they were removed from the sample. The Rasch analysis also indicated that items 2, 3, 6, 12, 16, 18, and 19 had normalized infit values greater than 2. Likewise, this means that the Rasch model's predictions of how the participants should have responded to these items varied greatly from how they actually responded, indicating that these items were of low reliability, so they too were discarded. The Rasch analysis was rerun without these participants and items. Again we discarded any participants whose outfit was outside of the range $-2 < t < 2$; no additional items needed to be removed. This process was repeated seven times until all the remaining participants had acceptable outfits. Altogether 296 participants were removed in this process (11% of the entire sample).

Figure 2 shows a science CM continuum on which each of the remaining items are located according to the calculated level of science CM they measure (whether it measures higher or lower levels of science CM).

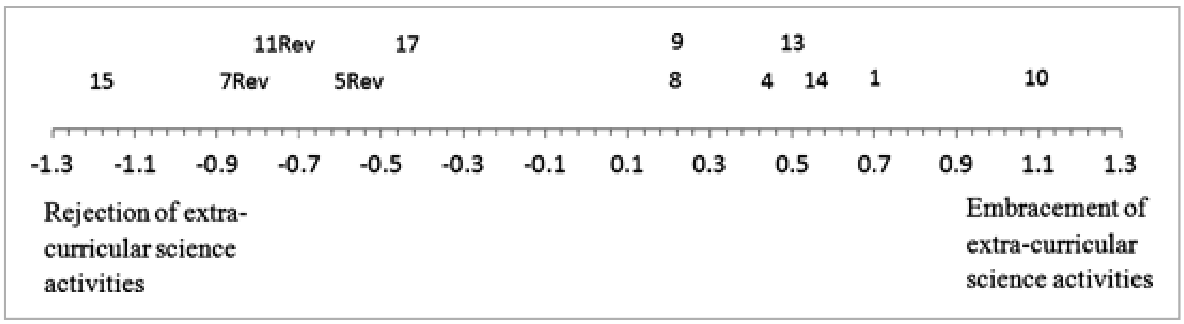

Figure 2.

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The calculated location of items on a continuing motivation continuum.

Comparing Figures 2 and 1 shows that other than item 13, all the items fall roughly at their predicted relative locations, which supports the validation of the survey as measuring a meaningful range of CM. We do not have a successful explanation why item 1 (“I browse internet sites which deal with science, nature, animals, or environmental issues”) measures greater CM than item 14 (“I read books about science, nature, animals, or scientists (not including science fiction)”).

Item 13 “I planned or performed science experiments outside of science class” measures lower levels of CM than predicted. This item measures lower levels of CM than item 10 “I look in newspapers or magazines for articles related to science, nature, animals, or environmental issues.” We originally assumed that item 13 would measure higher levels of CM for science than item 10 because it involved physical activity. It may be that looking in newspapers of magazines for science articles indicates greater CM since many adolescents do not typically read newspapers of magazines.

Generally, these results indicate that students are more likely to engage in everyday science-related activities when these activities happen to come across their way. For example, they are more likely to read or browse a related article if they happen to see one (item 4, 0.45 logits[3]) than to actively look for such an articles (item 10, 1.1 logits). Nevertheless, exposure to such opportunities does not necessarily result in engagement, as student may very well move on (items 5 and 7), change the channel (item 11) and ignore a message even if sent by friends (item 15). Thus the results show that, as we hypothesized, students may be actively engaged in science-related extracurricular activities, they can be passively engaged in it and they can also reject it. In other words, while students' CM may be positive or neutral, it may also be (and often is) negative.

Table 3 is a summary of the levels of CM measured by the items and their infit. Figure 3 shows a Wright map of the results of the Rasch analysis on all the items and participants that had acceptable infit values. The Cronbach's alpha of the survey, based on the levels of CM measured by the items and the student proficiencies, is 0.89.

Table 3. Summary of items' characteristics

Item No.	Difficulty	Infit	Thurstonian Thresholds			
			1→2	2→3	3→4	4→5
1	0.70	1.13	−0.36	0.46	1.04	1.67
4	0.45	1.29	−0.21	0.25	0.64	1.12
5Rev	−0.54	1.20	−1.79	−0.98	−0.27	0.86
7Rev	−0.84	1.19	−2.10	−1.35	−0.53	0.61
8	0.22	1.21	−0.93	−0.10	0.56	1.36
9	0.24	1.18	−0.69	−0.15	0.60	1.20
10	1.10	1.17	−0.07	0.83	1.41	2.22
11Rev	−0.74	1.27	−1.89	−1.21	−0.51	0.64
13	0.50	1.24	−0.32	0.28	0.72	1.31
14	0.57	1.15	−0.27	0.32	0.82	1.41
15Rev	−1.22	1.23	−2.23	−1.59	−1.03	−0.05
17Rev	−0.44	0.97	−1.33	−0.71	−0.25	0.52

Figure 3.

Open in figure viewer

Wright map for Thurstonian thresholds.

The Wright map shows that there are Thurstonian thresholds[4] located almost throughout the entire range in which participants are found, −2.5 to 2.0 logits. In addition, other than at the upper and lower extremes of the map, there are multiple thresholds at almost every level. An item's resolution in measuring a participant's CM increases as the participant level of CM is located closer to the item's threshold. This means that this scale can accurately place any student in the −2.5 to 2.0 logit range.

In fact, since there are multiple thresholds throughout the map, it is possible to remove some items from the scale without impairing its resolution and range. A close inspection shows that items 4, 5Rev, 7Rev, 8, 9, and 14 can probably be removed without decreasing the scale's accuracy, since their thresholds overlap those of other items. Items 4, 7Rev, 8, and 14 deal with reading science in print. If we remove them we still have item 10 which also deals with reading science in print. Removing item 5Rev leaves us with items 12 and 16 that deal with browsing the Internet. Removing item 8 leaves item 11 that deals with TV watching. However, removing item 9 leaves us with no items that deal with talking to people about science. We reran the Rasch analysis, without items 4, 5Rev, 7Rev, and 14. Figure 4 shows a CM continuum, on which each of the remaining items are located according to the calculated levels of CM that they measure.

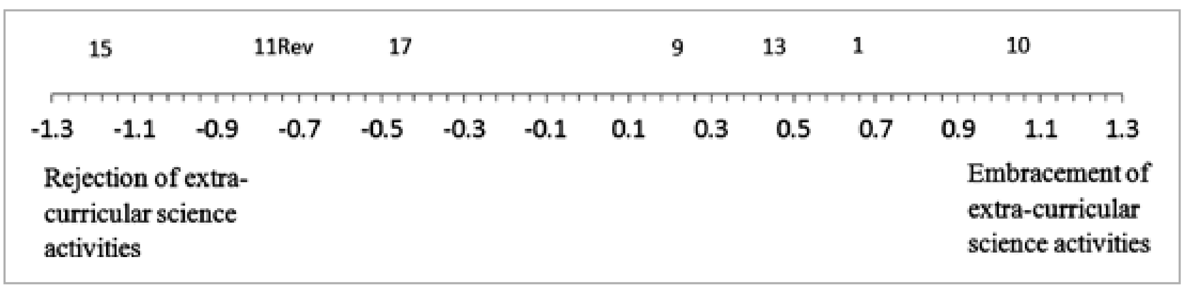

Figure 4.

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The location of items on a continuing motivation continuum.

All the remaining items have the same location relative to one another as before the removal of the superfluous items (Figure 2). Table 4 is a summary of the remaining items' characteristics and Figure 5 is a Wright map for the remaining items. The Cronbach's alpha of the revised survey, based on the levels of CM measured by the items and the student proficiencies, was 0.83.

Table 4. Summary of items' characteristics

			Thurstonian Thresholds

Item No.	Difficulty	Infit	1→2	2→3	3→4	4→5
1	0.66	1.05	−0.38	0.43	0.99	1.62
9	0.21	1.12	−1.08	−0.18	0.58	1.52
10	1.05	1.07	−0.09	0.79	1.36	2.16
11Rev	−0.73	1.10	−1.84	−1.20	−0.53	0.60
13	0.46	1.21	−0.34	0.24	0.68	1.27
15Rev	−1.20	1.15	−2.15	−1.56	−1.03	−0.08
17Rev	−0.46	0.89	−1.32	−0.72	−0.27	0.48

Figure 5.

Open in figure viewer

Wright map for Thurstonian thresholds without items 4, 5Rev, 8, and 14.

The new Wright map shows that there still were Thurstonian thresholds located throughout the entire range in which participants are found; unlike the situation before the superfluous items were removed, there were only few multiple thresholds at the same level. The levels of CM measured by the items and their infits were very similar to their prior values, before we removed the superfluous items. It appears that the new scale, using fewer items than the initial one, can assess students' CM just as well as the initial one, both statistically and theoretically; it is therefore the preferred scale and the following steps in our analysis are based on it.

Collapsing Categories

As mentioned earlier, each item in the instrument has five categories: not true at all, not so true, somewhat true, true, and very true. Bond and Fox (**2001**) recommend evaluating whether this number of categories is indeed necessary or whether it can be reduced, a process which usually improves the quality of measures. They recommend analyzing each item's categories using a few different measures. The first of these measures is the number of times a given category of an item was selected. This measure is called the *observed count* . Each category should be selected at least 10 times for the Rasch analysis to be able to produce reliable characteristics of the category. The second measure is the mean CM of the participants who selected a given category of an item, called the *average measure* . The average measure should increase from lower categories to higher ones, meaning, for example, that the mean level of CM for students who selected “Not so true” in item 1 should be lower than the mean level of those students who selected "Somewhat true" in the same item. The third measure is the Thurstonian threshold for each category, which should increase monotonously from one category to the next. The final measure is the shape of the item probability curves, which should show well-defined maxima for each category.

Table 5 provides the first three measures for each category in each item. The Thurstonian thresholds are presented in Table 3 and the probability curves for each item are available as Supporting Information Figure 1.

Table 5. Summary of each item's categories' characteristics

Item No.	Category Label	Observed Count	Average Measure
1	Not true at all	1,055	−1.00
	Not so true	532	−0.25
	Somewhat true	283	0.09
	True	138	0.52
	Very true	106	1.08
9	Not true at all	673	−1.24
	Not so true	547	−0.55
	Somewhat true	456	−0.14
	True	283	0.29
	Very true	155	0.85
10	Not true at all	1,211	−0.91
	Not so true	534	−0.15
	Somewhat true	213	0.28
	True	100	0.78
	Very true	48	1.45
11Rev	Not true at all	298	−1.78
	Not so true	275	−1.00
	Somewhat true	439	−0.54

	True	595	−0.16
	Very true	471	0.34
13	Not true at all	1,060	−0.96
	Not so true	422	−0.31
	Somewhat true	260	−0.04
	True	176	0.33
	Very true	170	0.79
15Rev	Not true at all	194	−1.98
	Not so true	188	−1.16
	Somewhat true	315	−0.76
	True	592	−0.38
	Very true	795	0.12
17Rev	Not true at all	500	−1.39
	Not so true	343	−0.76
	Somewhat true	337	−0.31
	True	427	−0.15
	Very true	486	0.32

The various requirements are met for all the measures of each item's categories: the minimum observed counts are greater than 10, the average measures increase from one category to the next, the infits are all within the recommended range, the Thurstonian thresholds increase from one category to the next, and the probability curves are all well formed with well-defined maxima. It therefore appears that there is no need to reduce the number of categories in any of the items. We feel that the survey, composed of items 1, 9, 10, 11Rev, 13, 15Rev, and 17Rev, is a valid and reliable instrument.

Since we were interested in comparing changes in the respondents' CM across grades, we analyzed whether there was a differential item functioning at the various grades. The level of CM measured by each item was calculated separately for respondents in grades 5, 6, 7, and 8. ANOVAs were run to compare the various values. No significant differences were identified, meaning that we could use the levels of CM measured by the items that were presented in Table 4 for all four grades. In the next section, we describe how we used the calculated respondents' CM, resulting from the Rasch analysis, to explore the relations between school context, gender, and age and adolescents' CM.

Part 2: Exploring the Relations Between School Context, Grade, Gender, and Continuing Motivation

Methods

Data Collection and Analysis

Addressing the second goal of this study, we used cross-sectional data collected by the CM survey to examine how boys' and girls' science CM in traditional and democratic schools changes between grades 5 and 8. We used the same data that were used to develop the scale.

Because of the nested nature of the data (students nested in schools) we used hierarchical linear modeling (HLM) for this analysis. HLM allowed us to examine which of the tested variables (i.e., school type, grade, and gender) predicted students' CM. In our model, the *i* th student's level of CM is described as a linear function of her grade (5–8) and her gender (0—male, 1—female):

$$\text{Continuing motivzation}_i = \beta_0 + \beta_1 \text{Grade}_i + \beta_2 \text{Gender}_i + r_i$$

The three constants, β_0, β_1, and β_2 are linear functions of the type of school in which student *i* learns. r_i, ϵ_{i0}, ϵ_{i1}, and ϵ_{i2} are residuals:

$$\beta_0 = \gamma_{00} + \gamma_{01}\text{School type}_i + \varepsilon_{i0}$$
$$\beta_1 = \gamma_{10} + \gamma_{11}\text{School type}_i + \varepsilon_{i1}$$
$$\beta_2 = \gamma_{20} + \gamma_{21}\text{School type}_i + \varepsilon_{20}$$

γ_{00} represents students' mean CM beyond school type, grade, and gender. γ_{01} represents the effect of school type on a student's CM, beyond grade and gender. γ_{10} represents grade effect on student's CM, beyond school type. γ_{11} represents the effect of school type on the grade effect on student's CM. γ_{20} represents gender effect on student's CM, beyond school type. γ_{21} represents the effect of school type on the gender effect on student's CM. Gender and School type were entered in the analysis as dummy variables (Gender = 0—male; Gender = 1—female; School type = 0—traditional; School type = 1—democratic).

Results

The results of the HLM analysis are presented in Table 6 and illustrated in Figures 6 and 7.

Table 6. Age-driven trends for boys and girls in traditional and democratic schools

Predictor		School Type Effect	
		Intercept	Slope

Intercept	β_0	−0.458*	γ_{00}	0.108	γ_{01}
Grade	β_1	−0.153**	γ_{10}	0.161***	γ_{11}
Gender	β_2	−0.209**	γ_{20}	0.037	γ_{21}

* $p < 0.001$.
** $p < 0.01$.
*** $p < 0.05$.

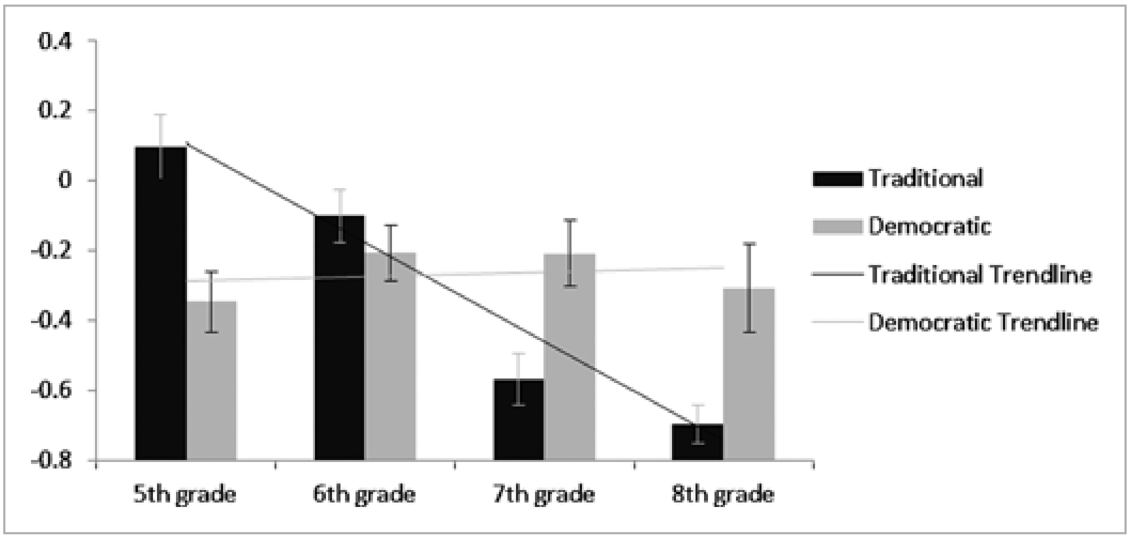

Figure 6.

Open in figure viewer

Boys' continuing motivation.

Figure 7.

Open in figure viewer

Girls' continuing motivation.

These results show that beyond grades and gender, students' CM was not related to the school type (γ_{01} was not statistically significant at the $\alpha = 0.05$ level). This means that ignoring students' grade and gender, on average there was no significant difference in students' CM between democratic and traditional schools. However, the results indicate that beyond school type, CM declined with grade (γ_{10} was negative and significant). In other words, without distinguishing between school types, the total sample exhibited a declining CM with grade. However, this decline was related to school type (γ_{11} was significant). Because in our model traditional schools were coded 0, γ_{10} represents also the grade effect on students' CM in traditional school. Thus, the results indicate that in traditional schools, students' CM decreased as they advanced from 5th to 8th grade ($\gamma_{10} = -0.153$). In contrast, in democratic schools, there was no significant change with age in students' CM ($\gamma_{10} + \gamma_{11} = 0.008$). In other words, the change in CM with grade was related to school type.

Results also indicate that beyond school type, girls had lower CM than boys (γ_{20} was negative and significant) and that the gender effect on CM was not related to school type (γ_{21} was not significant). In other words, girls had lower CM than boys, unrelated to the type of school they attended.

Discussion

Research on the connections between formal and informal environments has tended to go in one direction—investigating how informal activities contribute to school-based learning. In an age where lifelong learning is necessary and therefore CM should be an educational goal (Anderman & Weber, **2009**), we believe it is important to understand the inverse relation as well—how schools can encourage or discourage students to engage with science outside of science classes and how school-based learning supports the learning and understanding of science in non-academic contexts. There have not been enough studies that investigated the factors that influence students' motivation to engage with science after school and on their own initiative (Bell et al., **2009** ; Dierking et al., **2003**).

High quality instruments are crucial to the development of any field of study (Boone & Townsend, **2010** ; Pellegrino, Chudowsky, & Glaser, **2001**). If precise and accurate measurements cannot be made it is impossible to test the quantitative aspects of theories. In this paper, we have presented a survey for measuring students' CM in science and described how it was developed and tested. The survey consists of seven Likert-type items, three which have reverse scales. Each level of science CM measured by each item, their infits and Thurstonian thresholds are provided (Bond & Fox, **2001**). This information should allow researchers, including those who are not experts in Rasch analysis, to easily make use of the survey and provides a basis for making numerical comparisons between the results of different studies.

The results of the Rasch analysis used to develop the scale indicate that students tend to engage more in science-related extracurricular activities if these happens to come their way than if they need to actively seek them. Therefore, if educators wish to enhance students' engagement in such activities, they should think of ways to more widely expose adolescents to them. However, the results also show, that such exposure does not guarantee engagement, thus widening the exposure should be done in ways appealing for adolescents. For example, findings show that adolescents prefer articles that use metaphorical and poetic language, and that the narrative elements used in popular texts stimulates their interest and can motivate them to read further (Halkia & Mantzouridis, **2005**). Thus, creating such readings and distributing them in the media available for adolescents may enhance their science reading.

We demonstrated the use of the new survey by using it to explore the relations between school type and students' science CM in grades 5–8, in traditional and democratic Israeli schools. We hypothesized that because democratic schools' students have been shown to experience more autonomy and to be more intrinsically motivated (Vedder-Weiss & Fortus, **2012** ; Zanzuri, **1997**);

they would also have higher CM. A HLM analysis of the data showed that the relation is more complicated than we initially hypothesized; beyond grade and gender, students' science CM was not related to their school type, meaning that on average, students in traditional and democratic schools do not differ in their science CM. However, while students' CM in traditional schools declined between 5th and 8th grade, it did not change significantly in democratic schools during these years. Thus, it appears that school type is indeed related to students' CM but its effect is different at different ages and becomes apparent as students grow older. This finding aligns with our previous findings which indicated similar age-related patterns in school science motivational constructs (i.e., classroom engagement, mastery goals orientation, and self-efficacy) (Vedder-Weiss & Fortus, 2011, **2011, 2012**). Thus, it appears that not only does the motivation for school science of students in traditional schools decline during adolescence; their CM for science also declines at that time. Data reported elsewhere showed that students' motivation for school science learning at the 5th grade was not higher in democratic schools than in traditional ones, implying that democratic schools do not simply promote pre-existing motivation for science (Vedder-Weiss & Fortus, 2011, **2011, 2012**). Data on students' perceptions of their schools and parents, as well as data from teachers and parents, suggested that these declines are related to both the home and the school environment (Vedder-Weiss & Fortus, 2011, 2012, **2011-2013**). Thus, it is possible that schools play an important role not only in the development of school science motivation, but also in the development of out-of-school science motivation. This expands the responsibility of school science learning beyond the walls of the science classroom. It is important to note that, since these results are based on the analysis of cross-sectional data rather than on longitudinal data, they should be read with caution. Longitudinal studies tracking the development of adolescents' CM are required.

It is beyond the scope of this study to investigate why students' CM declined in traditional schools but not in democratic ones, but it should be subject to further research. For example, what is the role of the school culture in this difference and what is the role of the science classroom culture? Do the different curricula affect students CM or is it the autonomy experienced? As described before, prior research supports the hypothesis that autonomy plays an important role in explaining the difference in CM age-related trends (Pascarella et al., **1981** ; Vedder-Weiss & Fortus, **2012**). If this hypothesis is correct, the results may suggest that autonomy in school has either an accumulating effect on CM (becoming apparent with time) or a differential effect (enhancing CM in older ages but not in younger ones). Either way, this suggests that if middle schools will offer their students more autonomy they might be able to reduce the decline in students' CM for science learning. Researchers in other educational domains have also pointed toward the mismatch between adolescents' developmental needs and the level of autonomy offered to them in middle schools and its detrimental effect on their motivation (Eccles et al., **1993**). Further research is required in order to explore the relations between students' autonomy and their CM and to verify the ways in which such autonomy can be best offered. For example: is autonomy experienced at the whole school level important for students' science CM or is it only the autonomy in science class that matters? Does allowing students to make choices within a given curriculum suffice or is a larger range of choices, such as those offered in democratic schools, required?

School effect on CM may vary between high and low achieving students, since low achieving students were found to prefer pursuing science at home more than high achieving students (Laukenmann et al., **2003**). Perhaps a positive autonomous science learning experience at school has a more dramatic influence on low achieving students, arousing their motivation for continuing science engagement out of school, more than it does for high achieving students? Future studies should look into the possible mediating effect of students' achievements in the relation between school factors and students science CM.

The results of the HLM analysis show that while the school type is related to the difference in CM between age groups it is not related to the difference between genders. Israeli girls tended to have lower science CM than boys, irrespective of their school type and their age. Many studies have shown that girls tend to be less interested in science than boys and also tend to be less motivated than boys to learn science in schools (Buccheri, Gürber, & Brühwiler, 2011 ; Dawson, 2000 ; Miller, Blessing, & Schwartz, 2006). So this finding, while new, is not so surprising. Even more so, it lends support to the validity of our CM scale. Nevertheless, it stresses once again the motivational gap between boys and girls with regard to science learning, showing that this gap is apparent also in everyday extracurricular science activities, starting already at the 5th grade (if not earlier). Future research addressing gender gaps in science education should address this gap also in everyday non-academic settings. Looking closely into gender gaps in adolescents' CM may yield insights into the antecedents of this gap. If it is not related to school type than to what is it related: unequal opportunities (Fadigan & Hammrich, 2004), unequal self-efficacy (Britner & Pajares, 2001), issues of identity (Zimmerman, 2012), or other factors? Shedding light on this question may offer ways to diminish the gender gap in science CM, which may result in higher equity in science learning, science careers, and science literacy.

The survey presented in this manuscript may be further used to investigate the relations between personal (i.e., self-efficacy) as well as contextual (i.e., classroom environment) influences on CM, in order to develop models predicting CM. Such models can inform educators who wish to enhance students' science CM. Actually, the new survey had already been used to develop such a model, in a study reported elsewhere (Vedder-Weiss & Fortus, 2013). The results of that study suggest, for example, that the science teachers' goals emphasis indirectly affects students' science CM, by affecting their goals in science class. The results also suggest that students' perception of their parents' motivational emphasis influences their science CM; however, this effect is higher in elementary grades than in middle school grades.

The new survey may also be used to explore the effect of CM on learning and development, to better understand the role of CM in students' life. It may be used, for example, to study the relation between CM at the middle school years and future career choices.

The CM survey may also be used to evaluate educational programs, curricula and settings (informal as well as formal ones) aimed at fostering students' science learning. Such programs should not limit their evaluation to cognitive learning outcomes, but rather evaluate also affective aspects, in particular CM. We believe that any educational initiative, aiming to advance students' science learning, should consider not only the immediate learning but also the learning that may follow it. The survey we developed may serve to enhance this goal. As the survey addresses not only students' active and passive extracurricular engagement but also their rejection of such activities, it may serve not only to evaluate the positive outcomes of educational interventions but also its possible damage. Thus, if an intervention is found to result in reducing students' CM or even making it negative, one will need to weigh the intervention's immediate benefits against its long-term damage.

It is important to note that the survey may serve as an assessment instrument for studying populations but not as a diagnostic instrument for individuals. A particular student may be engaged in science reading, browsing, and TV watching but not in talking, experimenting, and online communicating. Thus, her CM score in the survey would not be high although she may still be considered continuingly motivated for science. Such a bias in the interpretation of the scores should not occur when sampling populations, since the high reliability of the scale (Cronbach's alpha = 0.83) indicates that, on average, students who tend to engage in reading, browsing, and watching science also tend to engage in talking, experimenting, and communicating science.

Because of previous findings pointing out the critical role of motivation before and during the middle school years (Maltese & Tai, **2010** ; Osborne et al., **2003** ; Tai et al., **2006** ; Vedder-Weiss & Fortus, 2011, **2011, 2012**), the survey was developed for and tested on late elementary and middle school students. Researchers who wish to use the survey to study other age groups should verify its validity and reliability for the other groups. It is possible that the levels of CM each item measures are different for older adolescents and for younger children. For example, hands-on activities may be less common among older children; thus the item assessing it may indicate a higher level of CM among high school students. In addition, if measuring science CM in high schools or college, one might also consider measuring enrollment in science courses and trips to science museums. Finally, the scale was developed and tested using data collected from students from middle to high SES in a developed country. Since Internet was widely accessible and dominant in the participants' culture, it was reasonable to include in the final scale, two items that depend on Internet access. However, using the scale with other populations (such as students from developing countries and/or from low SES background), one needs to consider whether this population indeed has wide Internet access. On the other hand, since digital technology advances so quickly, it would be advisable to update the terms used in the survey so that they align with the common practices among adolescents at the time the survey is administered.

As the survey was developed and tested on Israeli students in Hebrew, using it in English or other languages and in other cultures may also require verifying its validity and reliability. However, previous attempts to apply in Israel motivational scales, which were originally constructed for American students, found the scales to be valid and reliable, in spite of the cultural and linguistic differences (Bereby-Meyer & Kaplan, **2005** ; Kaplan, Lichtinger, & Gorodetsky, **2009** ; Vedder-Weiss & Fortus, 2011, **2011, 2012**). Thus, we expect the scale we developed to be valid and reliable also for students in other countries.

To conclude, as demonstrated, much may be learned by applying the science CM survey we developed. We hope that fellow researchers will recognize the importance of studying the CM for science learning and the role environmental factors play in supporting it. We also hope that researchers will find the survey described above a useful instrument in advancing their investigations.

The authors would like to thank the reviewers and editors of this article for their insightful and constructive comments. The opinions expressed herein are those of the authors and not necessarily those of the ISF.

Notes

[1]Participants were advised not to reply to each of these items if the behavior described was not accessible to them (i.e., they did not have e-mail or Internet access).

[2]Outfit and infit (Bond & Fox, 2001) are measures of the degree to which the predictions of the statistical model fits the replies of a particular respondent to all the items. In general, they are averages of the differences between a participant's actual responses to items and the model's prediction of how the participants should have responded to these items. The same terms are used as a measure of the degree to which the predictions of the statistical model fits the replies of all the respondents to a particular item. Here, infit and outfit are averages of the differences between all the respondents' actual responses to a particular item and the model's prediction of how they should have responded to this item. Infit is a weighted measure while outfit is not. Acceptable normalized values of infit and outfit lie between −2.0 and 2.0.

[3]Logits are the dimensionless unit in which the levels of CM measured by the items, and the levels of CM of the respondents, are given (Wilson, 2005).

[4]Consider any item in the survey we developed. It has five possible responses: Not true at all, Not so true, Somewhat true, True, and Very true. There is a certain level of CM for which there is a 50% probability that a respondent will select the lowest possible response, Not true at all and 50% probability that the respondent will choose the next lowest response, Not so true. This level of CM is called the first Thurstonian threshold for this item. Similarly, there is a higher level of CM for which there is a 50% probability that the respondent will choose the second lowest response and 50% probability that she will choose the next higher response. This is the second Thurstonian threshold for this item. Likewise, there is a Thurstonian threshold lying between the middle response and the second highest one and another threshold lying between the two highest responses. Thus, and item with five possible responses is characterized by four Thurstonian thresholds (Bond & Fox, 2001).

Supporting Information

References

Citing Literature